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MINERALS YEARBOOK

U.S.
DEPARTMENT
OF THE
INTERIOR

BUREAU
OF
MINES

1991

UNITED STATES DEPARTMENT OF THE INTERIOR • Bruce Babbitt, Secretary

BUREAU OF MINES

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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Foreword

This edition of the Minerals Yearbook discusses the performance of the worldwide minerals industry during 1991 and provides background information to assist in interpreting that performance. Content of the individual Yearbook volumes follows:

Volume I, Metals and Minerals, contains chapters on virtually all metallic and industrial mineral commodities important to the U.S. economy. Chapters on advanced materials and nonrenewable organic materials also were added to the Minerals Yearbook series beginning with the 1989 and 1990 volumes, respectively. A new chapter on nonferrous metals recycling has been initiated in this 1991 volume. In addition, a chapter on survey methods used in data collection with a statistical summary of nonfuel minerals and a chapter on trends in mining and quarrying in the metals and industrial mineral industries are included.

Volume II, Area Reports: Domestic, contains chapters on the minerals industry of each of the 50 States, Puerto Rico, Northern Marianas, Island Possessions, and Trust Territory. This volume also has a chapter on survey methods used in data collection, including a statistical summary of domestic nonfuel minerals.

Volume III, Area Reports: International, contains the latest available mineral data on more than 150 foreign countries and discusses the importance of minerals to the economies of these nations. Beginning with the 1989 review, Volume III is presented as six reports: Mineral Industries of the Middle East, Mineral Industries of Africa, Mineral Industries of Asia and the Pacific, Mineral Industries of Latin America and Canada, Mineral Industries of Europe and Central Eurasia, and Minerals in the World Economy. This year's reports incorporate location maps, industry structure tables, and an outlook section previously incorporated in our Mineral Perspectives Series quinquennial regional books, which are being discontinued.

The U.S. Bureau of Mines continually strives to improve the value of its publications to users. Therefore, constructive comments and suggestions by readers of the Yearbook will be welcomed.

Acknowledgments

The chapters of this volume were written by the State Mineral Officers of the Bureau of Mines, located throughout the country. Preparation of the chapters was coordinated by the Branch of Mineral Land Assessment, Division of Resource Evaluation.

The Survey Methods and Statistical Summary of Nonfuel Minerals chapter and the tabular material covering total State mineral production and mineral production by county were prepared in the Division of Statistics and Information Services.

Compilations contained in this volume were based largely on statistics and other data provided by the minerals industries. The Bureau gratefully acknowledges the willing contribution on these essential data by both companies and individuals.

In the collection of statistical and other mineral-industry information, the Bureau of Mines was also assisted by various State agencies through cooperative agreements. Many of the chapters in Volume II were reviewed by staff members of these agencies; in some instances, the staff members collaborated in preparing the chapters and are shown as coauthors. Our sincere appreciation for this assistance is extended to the following cooperating organizations:

Alabama: Geological Survey of Alabama.
Alaska: Division of Geological and Geophysical Surveys, Alaska Department of Natural Resources.
Arizona: Arizona Department of Mines and Mineral Resources.
Arkansas: Arkansas Geological Commission.
California: California Department of Conservation, Division of Mines and Geology.
Colorado: Colorado Geological Survey.
Connecticut: State Geological and Natural History Survey of Connecticut, Department of Environmental Protection.
Delaware: Delaware Geological Survey.
Florida: Florida Geological Survey.
Georgia: Georgia Geologic Survey, Environmental Protection Division, Georgia Department of Natural Resources.
Hawaii: Department of Land and Natural Resources of the State of Hawaii.
Idaho: Idaho Geological Survey.
Illinois: State Geological Survey, Illinois Department of Energy and Natural Resources.
Indiana: Geological Survey, Indiana Department of Natural Resources.
Iowa: Geological Survey Bureau, Division of Energy and Geological Resources, Iowa Department of Natural Resources.
Kansas: Kansas Geological Survey.
Kentucky: Kentucky Geological Survey.
Louisiana: Louisiana Geological Survey.
Maine: Maine Geological Survey.
Maryland: Maryland Geological Survey.
Massachusetts: Commonwealth of Massachusetts, Executive Office of Environmental Affairs.
Michigan: Geological Survey Division, Michigan Department of Natural Resources.

Minnesota: Minnesota Geological and Natural History Survey.
Mississippi: Office of Geology and Energy Resources, Mississippi Department of Environmental Quality.
Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey.
Montana: Montana Bureau of Mines and Geology.
Nebraska: Conservation and Survey Division of the University of Nebraska (Nebraska Geological Survey).
Nevada: Nevada Bureau of Mines and Geology.
New Hampshire: New Hampshire Department of Environmental Services.
New Jersey: Geological Survey, Division of Water Resources, New Jersey Department of Environmental Protection.
New Mexico: New Mexico Bureau of Mines and Mineral Resources.
New York: New York State Education Department, New York Geological Survey.
North Carolina: Division of Land Resources, North Carolina Department of Environment, Health, and Natural Resources.
North Dakota: North Dakota Geological Survey.
Oklahoma: Oklahoma Geological Survey.
Pennsylvania: Pennsylvania Bureau of Topographic and Geologic Survey, Department of Environmental Resources.
Puerto Rico: Department of Natural Resources, Commonwealth of Puerto Rico.
Rhode Island: Rhode Island Department of Environmental Management.
South Carolina: South Carolina Geological Survey.
South Dakota: South Dakota Geological Survey.
Tennessee: Tennessee Division of Geology.
Texas: Bureau of Economic Geology, The University of Texas at Austin.
Utah: Utah Geological Survey.
Vermont: Agency of Natural Resources, Division of Geology and Mineral Resources.
Virginia: Virginia Division of Mineral Resources.
Washington: Washington Division of Geology and Earth Resources.
West Virginia: West Virginia Geological and Economic Survey.
Wisconsin: Wisconsin Geological and Natural History Survey.
Wyoming: Geological Survey of Wyoming.

L. Michael Kaas
Chief, Division of Resource Evaluation

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SURVEY METHODS AND STATISTICAL SUMMARY OF NONFUEL MINERALS

By Jacqueline A. McClaskey and Stephen D. Smith

Ms. McClaskey, an operations research analyst with 6 years of Government experience, has been with the U.S. Bureau of Mines Branch of Statistics and Methods Development since 1990.

Mr. Smith, industry data analyst in the Section of Industry Data Analysis and Coordination, was assisted in the preparation of the Statistical Summary by Imogene P. Bynum, Chief, Section of Metals Data; Rosa McGee, Chief, Section of Industrial Minerals Data; William L. Zajac, Chief, Section of International Data; and Jim F. Lemons, Jr., Chief, Branch of Materials.

SURVEY METHODS

The U.S. Bureau of Mines Information and Analysis Directorate collects worldwide data on virtually every commercially important nonfuel mineral commodity. These data form the base for tracking and assessing the health of the minerals sector of the U.S. economy.

The Bureau's data collection activity was instituted by the 47th Congress in an appropriations act of August 7, 1882 (22 Stat. 329), which placed the collection of mineral statistics on an annual basis. The most recent authority for the U.S. Bureau of Mines survey activity is the National Materials and Minerals Policy, Research and Development Act of 1980 (Public Law 96-479, 96th Congress). This act strengthens protection for proprietary data provided to the U.S. Department of the Interior by persons or firms engaged in any phase of mineral or mineral-material production or consumption.

Data Collection Surveys

The Bureau begins the collection of domestic nonfuel minerals and materials statistics by appraising the information requirements of Government and private organizations of the United States. Requirements that can be met by collecting data from minerals establishments are posed as questions on U.S. Bureau of Mines surveys. Figure 1 shows a typical survey form.

Specific questions about the production, consumption, shipments, etc., of mineral commodities are structured in the survey forms to provide meaningful aggregated data. Thus, the entire mineral economic cycle from production through consumption is covered by 167 monthly, quarterly, semiannual, annual, and biennial surveys.

After the survey form has been designed, a list of the appropriate establishments to be canvassed is developed. Many sources are used to determine which companies, mines, plants, and other operations should be included on the survey mailing list. Bureau of Mines State Mineral Officers, State geologists, Federal organizations (e.g., Mine Safety and Health Administration), trade associations, industry representatives, and trade publications and directories are some of the sources that are used to develop and update survey listings. With few exceptions, a complete canvass of the list of establishments is employed rather than a sample survey. The iron and steel scrap industry is one of the exceptions where a sample survey is conducted.

The Paperwork Reduction Act requires that any Government agency wishing to collect information from 10 or more people first obtain approval from the Office of Management and Budget (OMB). OMB approves the need to collect the data and protects industry from unwarranted Government paperwork. *(See figure 1.)*

Survey Processing

The Bureau surveys approximately 25,500 establishments. Each year the Bureau mails about 50,000 forms that gather information for 167 different surveys. Each completed survey form returned to the Bureau undergoes extensive scrutiny to ensure the highest possible accuracy of the mineral data. The statistical staff monitors all surveys to ensure that errors are not created by reporting in physical units different from the units requested on the form. Relationships between related measures, such as produced crude ore and marketable crude ore, are analyzed for consistency. Engineering relationships, such as recovery factors from ores and concentrates, are also employed. The totals for each form are verified, and currently reported data are checked against prior reports to detect possible errors or omissions.

For the majority of the surveys, which are automated, the forms are reviewed to ensure that data are complete and correct before entering into the computer. The computer is programmed to conduct a series of automated checks to verify mathematical consistency and to identify discrepancies between the data reported and logically acceptable responses.

The U.S. Bureau of Mines is modernizing and automating all of its survey processing and data dissemination functions. Automated commodity data system functions include computerized

FIGURE 1

A TYPICAL SURVEY FORM

Form 6-1066-M
Fer. (6-91)

A03

O.M.B.No. 1032-0006.
Approval Expires: 12/31/93

INDIVIDUAL COMPANY DATA-PROPRIETARY

Unless authorization is granted in the section above the signature, the data furnished in this report will be treated in confidence by the Department of the Interior, except that they may be disclosed to Federal defense agencies, or to the Congress upon official request for appropriate purposes.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON, D.C. 20241

IRON ORE (Usable ore)

FACSIMILE NUMBER
1-800-543-0661

(Please correct if name or address has changed.)

Public reporting burden for this collection of information is estimated to average 30 MINUTES per response, including the time for reviewing instructions, searching data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to: Bureau of Mines, Branch of Statistics and Methods Development, Washington D.C. 20241; and Office of Information and Regulatory Affairs, Office of Management and Budget, Washington D.C. 20503.

Please complete and return this form in the enclosed envelope by the 15th of the month following the report period. Additional forms are available upon request.

In completing this form, reasonable estimates may be used wherever exact figures are not available. Use zero (0) when appropriate. DO NOT REPORT DECIMALS OR FRACTIONS.

"Collection of non-fuel minerals information is authorized by Public Law 96-479 and the Defense Production Act. This information is used to support executive policy decisions pertaining to emergency preparedness and defense and analyses for minerals legislation and industrial trends. The Bureau relies on your voluntary and timely response to assure that its information is complete and accurate."

SECTION 1. Mine or group covered by this report.

Name _____ State _____ County _____

SECTION 2. Stocks, production, and shipments of usable ore for the report month.
Report only ore products as shipped to consumer, such as direct-shipping ore, concentrates, or agglomerates.
Report ores produced in the United States only; do not include imports.

Usable ore (1)	Code	Weight unit Mark (X) one (2)		Physical inventory Adjustment only (3)	Beginning stocks (4)	Production (5)	Shipments (6)	Ending stocks (7)
		Long tons (4)	Metric tons (6)					
Iron ore (Containing less than 5% Mn, natural)	201							

SECTION 3. Please indicate any mines opened or closed by your company during the month. _____

Remarks:

Name of person to be contacted regarding this report			Tel. area code	No.	Ext.
Address	No.	Street	City	State	Zip

May tabulations be published which could indirectly reveal the data reported above? ☐ (1) Yes ☐ (2) No

Signature	Title	Date

preparation of statistical tables; the use of desktop publishing to integrate text and tables; and the implementation of a microcomputer bulletin board, known as MINES-DATA, for electronic dissemination of minerals data.

Survey Responses.—To enable the reader to better understand the basis on which the statistics are calculated, each commodity annual report includes a section entitled "Domestic Data Coverage." This section briefly describes the data sources, the number of establishments surveyed, the response percentage, and the method of estimating the production or consumption for nonrespondents.

To produce reliable aggregated data, the Bureau employs efficient procedures for handling instances of nonresponse. Failure to return the initial survey form results in a second mailing of the form. If the second form is not returned, telephone calls are made to the nonrespondents. The followup calls provide the necessary data to complete the survey forms and/or verify questionable data entries. Periodic visits to important minerals establishments are also made by Bureau commodity specialists or State Mineral Officers to gather missing data and to explain the importance of the establishment's reporting. By describing the use of the published statistics and showing the impact of nonresponse, the Bureau strives to encourage respondents to give a complete and accurate reply.

The OMB "Guidelines for Reducing Reporting Burden" stipulates that the minimum acceptable response rate shall be 75% of the panel surveyed. In addition, the Bureau strives for a minimum reporting level of 75% of the quantity produced or consumed (depending on the survey) for certain key statistics. Response rates are periodically reviewed. For those surveys not meeting the minimum reporting level, procedures are developed and implemented to improve response rates.

Estimation for Nonresponse.—When efforts to obtain a response to a survey fail, it becomes necessary to employ estimation or imputation techniques to account for missing data. These techniques are most effective when the response rate is relatively high. Some of the estimation methods depend on knowledge of prior establishment reporting, while other techniques rely on external information to estimate the missing data. When survey forms are received after the current publication has been completed, the forms are edited, necessary imputations are made for missing data, and the survey data base is updated. The revised data are reported in later publications.

Protection of Proprietary Data.—The U.S. Bureau of Mines relies on the cooperation of the U.S. minerals industry to provide the mineral data that are presented in this and other Bureau publications. Without a strong response to survey requests, the Bureau would not be able to present reliable statistics. The Bureau in turn respects the proprietary nature of the data received from the individual companies and establishments. To ensure that proprietary rights will not be violated, the Bureau analyzes each of the aggregated statistics to determine if the data reported by an individual establishment can be deduced from the aggregated statistics. If, for example, there are only two significant producers of a commodity in a given State, the Bureau will not publish the State total because either producer could readily estimate the production of the other. It is this obligation to protect proprietary information that results in the "Withheld" or "W" entries in the published tables. However, if a company gives permission in writing, the Bureau will publish the data as long as the data from other producers are protected from disclosure.

International Data

International data are collected by country specialists in the U.S. Bureau of Mines Division of International Minerals with assistance from the Section of International Data. The data are gathered from various sources, including published reports of foreign Government mineral and statistical agencies, international organizations, the U.S. Department of State, the United Nations, the Organization of Petroleum Exporting Countries, and personal contact by specialists traveling abroad. Each February an annual "Minerals Questionnaire" is sent through the Department of State to more than 130 U.S. Embassies asking them to provide estimates of mineral production for the host country for the preceding year. Missing data are estimated by Bureau country specialists based on historical trends and specialists' knowledge of current production capabilities in each country.

Publications

The U.S. Bureau of Mines disseminates current and historical minerals information through a broad range of printed publications.

The Minerals Yearbook summarizes annually, on a calendar-year basis, the significant economic and technical developments in the mineral industries. Three separate volumes are issued each year: Volume I, Metals and Minerals; Volume II, Area Reports, Domestic; and Volume III, Area Reports, International. Chapters in these volumes are issued separately as annual reports before the bound volumes are available. (Volume III country reports appear in bound volume only.)

Volume I of the Minerals Yearbook presents, by mineral commodity, salient statistics on production, trade, consumption, reserves, and other measures of economic activity.

Volume II of the Minerals Yearbook reviews the U.S. minerals industry by State and island possessions.

Volume III of the Minerals Yearbook presents the latest available mineral statistics for more than 170 countries with a summary review of the role of minerals in the world economy.

Mineral Industry Surveys contain timely statistical and economic data on minerals. The surveys are designed to keep Government agencies and the

public, particularly the mineral industry and the business community, informed of trends in the production, distribution, inventories, and consumption of minerals. Frequency of issue depends on the demand for current data. Mineral Industry Surveys are released monthly, quarterly, semiannually, or annually.

Mineral Commodity Summaries, an up-to-date summary of about 90 nonfuel mineral commodities, is the earliest Government publication to furnish estimates covering the previous year's nonfuel mineral industry data. It contains information on the domestic industry structure, Government programs, tariffs, 5-year salient statistics, and a summary of international mining news.

State Mineral Summaries provide estimated data and summaries of mineral activities at the State level for the previous year. These summaries have been prepared in cooperation with State geological surveys or related agencies.

Minerals Today, published bimonthly, provides readers with the latest information about developments, trends, and issues concerning the mining, processing, and use of minerals and materials.

Metal Industry Indicators, published monthly, contains indexes that measure the current and future performance of four U.S. minerals industries. For each of the four industries, a composite coincident index and a composite leading index have been developed based on procedures and data similar to those used to construct the U.S. Department of Commerce's coincident and leading cyclical indicators for the national economy.

Information Circulars are primarily concerned with Bureau economic reviews and interpretative analyses. The series also includes surveys of mining and operating activities, guides to marketing of mineral commodities, and compilations of historical information and statistical and economic data on minerals.

To purchase Volumes I, II, and III of the Minerals Yearbook and Minerals Today, contact the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. For free copies of individual annual reports of the Minerals Yearbook, the Mineral Industry Surveys, the Mineral Commodity Summaries, the State Mineral Summaries, and Information Circulars, contact Publications Distribution, U.S. Bureau of Mines, Cochrans Mill Road, P.O. Box 18070, Pittsburgh, PA 15236. To receive a copy of the Metal Industry Indicators, contact the Branch of Statistics and Methods Development, U.S. Bureau of Mines, MS 9701, 810 7th Street, NW, Washington, DC 20241.

Electronic Data Dissemination

In addition to the Bureau's printed publications, current Mineral Industry Surveys for several commodities and selected annual reports from the Minerals Yearbook are now available through the Bureau's MINES-DATA computer bulletin board. Using this system, the public may obtain information up to 4 weeks before published copies of the reports would arrive in the mail. The MINES-DATA system may be accessed by calling (202) 501-0373 using a modem set to 1200 or 2400 baud, 8 data bits, no parity, and 1 stop bit. Further information on how to use the MINES-DATA system may be obtained from the system operator by calling (202) 501-0406.

STATISTICAL SUMMARY

This annual report summarizes data on crude nonfuel mineral production for the United States, its island possessions, and the Commonwealth of Puerto Rico. Also included are tables that show the principal nonfuel mineral commodities exported from and imported into the United States and that compare world and U.S. mineral production. The detailed data from which these tables were derived are contained in the individual annual reports of Volume I and in the State reports of Volume II of this edition of the Minerals Yearbook.

Although crude mineral production may be measured at any of several stages of extraction and processing, the stage of measurement used in this annual report is what is termed "mine output." It usually refers to minerals or ores in the form in which they are first extracted from the ground, but customarily includes the output from auxiliary processing at or near the mines.

Because of inadequacies in the statistics available, some series deviate from the foregoing definition. For copper, gold, lead, silver, tin, and zinc, the quantities are recorded on a mine basis (as the recoverable content of ore sold or treated). However, the values assigned to these quantities are based on the average selling price of refined metal, not the mine value. Mercury is measured as recovered metal and valued at the average New York price for the metal.

The weight or volume units shown are those customarily used in the particular industries producing the commodities. Values shown are in current dollars, with no adjustments made to compensate for changes in the purchasing power of the dollar.

TABLE 1

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
METALS							
Beryllium concentrates	metric tons	4,592	$5	4,548	e$5	4,339	$5
Copper[2]	do.	1,497,818	4,323,965	r1,587,742	r4,311,204	1,631,078	3,931,305
Gold[2]	kilograms	265,731	3,268,548	r294,527	r3,649,914	289,885	3,385,874
Iron ore (includes byproduct material)	thousand metric tons	58,299	1,839,873	57,010	1,740,925	56,775	1,674,100
Iron oxide pigments (crude)	metric tons	40,202	4,561	37,071	4,615	40,220	4,485
Lead[2]	do.	410,915	356,477	r483,704	r490,771	465,931	343,948
Magnesium metal	do.	152,066	508,668	139,333	433,119	131,288	336,577
Mercury	do.	W	W	W	W	58	206
Molybdenum[3]	do.	61,168	427,477	61,580	r348,256	53,607	249,909
Nickel ore[4]	do.	NA	NA	r330	NA	5,523	NA
Palladium metal[5]	kilograms	4,850	22,454	5,930	21,735	6,050	16,923
Platinum metal[5]	do.	1,430	23,310	1,810	r27,176	1,730	20,635
Silver[2]	metric tons	2,007	354,973	r2,125	r329,329	1,848	240,041
Zinc[2]	do.	275,883	499,103	515,355	847,485	517,804	602,426
Combined value of antimony, bauxite, manganiferous ore (5% to 35%), mercury, rare-earth metal concentrates, tin, titanium concentrates (ilmenite and rutile), tungsten, vanadium, zircon concentrates, and values indicated by symbol W		XX	233,783	XX	r237,468	XX	143,298
Total metals[6]		XX	r11,863,000	XX	r12,442,000	XX	10,950,000
INDUSTRIAL MINERALS (EXCLUDING FUELS)							
Abrasives[7]	metric tons	1,257	189	3,734	231	2,205	161
Asbestos	do.	17,427	W	W	W	W	W
Barite	thousand metric tons	290	12,625	r430	r16,000	448	21,310
Boron minerals (B_2O_3)	metric tons	1,114,007	429,806	1,093,919	436,176	1,240,158	442,531
Bromine[e]	thousand kilograms	175,000	188,650	177,000	97,350	170,000	167,000
Cement:							
Masonry	thousand short tons	3,329	229,441	3,274	225,404	2,637	187,679
Portland	do.	74,202	3,592,255	75,596	3,683,400	68,722	3,343,223
Clays	metric tons	42,254,269	1,515,300	42,904,437	1,619,826	44,091,697	1,505,088
Diatomite	do.	617,164	136,754	631,062	137,982	609,652	139,857
Feldspar	do.	654,313	28,029	630,000	r28,471	580,000	26,000
Fluorspar	do.	e66,000	W	e63,500	W	W	W
Garnet (abrasive)	do.	42,604	4,408	47,009	6,937	50,860	7,534
Gemstones		NA	42,901	NA	52,867	NA	84,386
Gypsum (crude)	thousand short tons	17,624	128,448	16,406	99,567	15,456	94,199
Helium (Grade-A)	million cubic meters	82	106,523	87	113,183	88	174,706
Iodine	kilograms	1,508,000	23,947	1,972,849	30,486	1,998,914	31,389
Lime	thousand short tons	17,152	852,113	17,452	901,549	17,270	890,482
Mica (scrap)	thousand metric tons	119	6,273	109	5,841	103	5,542
Peat	thousand short tons	775	17,636	795	19,200	777	17,887
Perlite	short tons	601,000	16,301	r726,000	r17,443	566,639	15,086
Phosphate rock	thousand metric tons	49,817	1,082,797	46,343	1,075,093	48,096	1,030,913
Potash (K_2O equivalent)	do.	1,595	271,515	1,716	303,337	1,709	304,500
Pumice	metric tons	424,000	8,213	442,848	10,687	401,376	9,190
Salt	thousand short tons	38,356	776,846	40,693	826,659	39,575	801,507

See footnotes at end of table.

TABLE 1—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS (EXCLUDING FUELS)—Continued							
Sand and gravel:							
Construction	thousand short tons	e897,300	e$3,249,100	910,600	$3,249,400	e780,300	e$2,805,500
Industrial	do.	29,205	410,200	28,406	436,200	25,600	390,477
Sodium compounds:							
Soda ash	thousand metric tons	8,995	764,146	9,156	836,188	9,005	835,577
Sodium sulfate (natural)	do.	340	31,104	349	33,748	354	30,903
Stone:[8]							
Crushed	thousand short tons	1,213,400	5,325,800	e1,222,000	e5,591,300	1,102,878	5,186,821
Dimension	short tons	1,206,995	208,311	e1,186,216	e209,691	1,133,992	195,259
Sulfur (Frasch)	thousand metric tons	3,780	378,712	3,676	335,189	3,119	271,598
Talc and pyrophillite	metric tons	1,253,128	W	W	W	W	W
Tripoli	do.	105,229	2,537	94,389	3,188	88,642	3,271
Vermiculite	short tons	293,320	32,550	229,584	19,075	185,103	13,410
Combined value of aplite, brucite, calcium chloride (natural), emery, graphite (natural, 1989), helium (crude), kyanite, lithium minerals, magnesite, magnesium compounds, marl (greensand), olivine, pyrites, staurolite, wollastonite, and values indicated by symbol W		XX	r483,673	XX	473,453	XX	506,275
Total industrial minerals[6]		XX	20,357,000	XX	r20,895,000	XX	19,539,000
Grand total[6]		XX	r32,220,000	XX	r33,337,000	XX	30,489,000

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.

[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2]Recoverable content of ores, etc.

[3]Content of ore and concentrate.

[4]Data series revised to exclude nonnickel ore.

[5]Revised due to the separation of palladium metal from platinum metal.

[6]Data may not add to totals shown because of rounding.

[7]Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

[8]Excludes abrasive stone and bituminous limestone and sandstone; all included elsewhere in table.

TABLE 2

TOTAL U.S. NONRENEWABLE ORGANIC MATERIALS PRODUCTION, BY QUANTITY AND VALUE[1]

(Million metric tons, unless otherwise specified)

Category	1989		1990		1991e	
	Quantity	Value (millions)	Quantity	Value (millions)	Quantity	Value (millions)
Asphalt and road oil	25.52	$2,817	25.02	$3,480	25.69	$2,944
Lubricants, waxes, and miscellaneous products	12.78	1,499	12.51	1,863	12.10	1,506
Petrochemical industries	55.66	6,331	57.75	7,759	65.09	7,455
Petroleum coke and coal	11.47	900	13.05	1,291	13.07	1,058
Total[2]	105.43	11,548	108.33	14,394	115.95	12,964

eEstimated.

[1]Quantities valued at the fossil fuel prices given in the Department of Energy, Energy Information Administration, Annual Energy Review 1991, June 1992, p. 69.

[2]Data may not add to totals shown because of independent rounding.

NOTE.—Nonrenewable organic materials represent all nonfuel uses in physical structure applications. The petrochemical industries category includes feedstocks for the production of plastics, synthetic rubber, synthetic fibers, pesticides, coatings, solvents, fertilizers, and other petrochemicals.

TABLE 3[1]

NONFUEL MINERALS PRODUCED IN THE UNITED STATES AND PRINCIPAL PRODUCING STATES IN 1991

Mineral	Principal producing States, in order of quantity	Other producing States
Abrasives[2]	AR, WY, OH	
Antimony[3]	ID	
Aplite	VA	
Asbestos	CA and VT	
Barite	NV, GA, MO, MT	IL.
Bauxite	AL and GA	
Beryllium concentrate	UT	
Boron minerals	CA	
Bromine[e]	AR	
Brucite	NV	
Calcium chloride (natural)	MI and CA	
Cement:		
Masonry	IN, MI, PA, SC	All other States except AK, CT, DE, LA, MA, MN, MS, NV, NH, NJ, NC, ND, OR, RI, VT, WI, WY.
Portland	CA, TX, PA, MI	All other States except CT, DE, LA, MA, MN, NH, NJ, NC, ND, RI, VT, WI.
Clays	GA, WY, CA, TN	All other States except AK, DE, HI, RI, VT, WI.
Copper[3]	AZ, NM, UT, MT	CA, CO, ID, MI, MO, NV, OR, TN.
Diatomite	CA, NV, WA, OR	
Emery	OR	
Feldspar	NC, CA, OK, GA	CT, ID, SD.
Fluorspar	IL	
Garnet (abrasive)	IN and NY	
Gold[3]	NV, CA, UT, MT	AK, AZ, CO, ID, NM, SC, SD, WA.
Graphite (natural)	(4)	
Gypsum (crude)	MI, OK, IA, NV	AR, AZ, CA, CO, IN, KS, LA, NM, NY, SD, TX, UT, VA, WA, WY.
Helium (crude and Grade-A)	KS, WY, TX, CO	NM.
Iodine	OK	
Iron ore (includes byproduct)	MN, MI, UT, MO	AZ, CA, MT, NM, SD, TX.
Iron oxide pigments (crude)	MO, GA, MI, VA	AZ.
Kyanite	VA	
Lead[3]	MO, AK, ID, CO	AZ, MT, NM, NV, NY, TN, WA.
Lime	MO, PA, OH, KY	All other States except AK, CT, DE, FL, GA, HI, KS, ME, MD, MS, NH, NJ, NM, NY, NC, RI, SC, VT.
Lithium minerals	NC and NV	
Magnesite	NV	
Magnesium compounds	MI, CA, FL, UT	DE and TX.
Magnesium metal	TX, WA, UT	
Manganiferous ore	SC	
Marl (greensand)	NJ	
Mercury	NV and CA	
Mica (scrap)	NC, NM, GA, SC	CA, CT, PA, SD.
Molybdenum	CA, AZ, UT, MT	CA, ID, NM, NV.
Nickel ore	OR	
Olivine	WA and NC	
Palladium metal	MT	
Peat	MI, FL, MN, IL	CO, IA, IN, MA, ME, MT, NC, NJ, NY, OH, PA, SC, WA, WI, WV.

See footnotes at end of table.

TABLE 3[1]—Continued

NONFUEL MINERALS PRODUCED IN THE UNITED STATES AND PRINCIPAL PRODUCING STATES IN 1991

Mineral	Principal producing States, in order of quantity	Other producing States
Perlite	NM, AZ, CA, ID	CO and NV.
Phosphate rock	FL, NC, ID, UT	MT.
Platinum metal	MT	
Potash	NM, UT, CA, MI	
Pumice	CA, OR, AZ, NM	ID and KS.
Pyrites (ore and concentrate)	AZ	
Rare-earth metal concentrates	CA and FL	
Salt	NY, LA, OH, MI	AL, AZ, CA, KS, NM, NV, OK, TX, UT, WV.
Sand and gravel:		
Construction	CA, OH, WA, TX	All other States.
Industrial	IL, CA, TX, NJ	All other States except AK, CT, DE, HI, IA, ME, NH, NM, ND, OR, SD, UT, VT, WY.
Silver[3]	NV, ID, AK, MT	AZ, CA, CO, MI, MO, NM, NY, SC, SD, TN, UT, WA.
Sodium compounds:		
Soda ash	WY and CA	
Sodium sulfate (natural)	CA, TX, UT	
Staurolite	FL	
Stone:		
Crushed	PA, IL, VA, FL	All other States except DE.
Dimension	VT, IN, SD, GA	All other States except AK, DE, FL, HI, KY, LA, MS, NE, NV, NJ, ND, OR, RI, UT, WV, WY.
Sulfur (Frasch)	TX and LA	
Talc and pyrophyllite	MT, NY, TX, VT	AL, CA, NC, OR, VA.
Tin	AK	
Titanium concentrates	FL, NJ, CA	
Tripoli	IL, AR, OK, PA	
Tungsten[3]	CA	
Vanadium[3]	ID	
Vermiculite (crude)	SC, VA, MT	
Wollastonite	NY	
Zinc[3]	AK, TN, NY, MO	CO, ID, IL, MT, NM, NV, OR, WA.
Zircon concentrates	FL and NJ	

[e]Estimated.
[1]This table had been table 2 in previous issues of the Minerals Yearbook.
[2]Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.
[3]Content of ores, etc.
[4]No production reported.

TABLE 4[1]

VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1991

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$539,915	20	1.77	Cement (portland), stone (crushed and broken), lime, sand and gravel (construction).
Alaska	494,064	21	1.62	Zinc, lead, sand and gravel (construction), gold.
Arizona	2,829,123	1	9.28	Copper, sand and gravel (construction), molybdenum, cement (portland).
Arkansas	360,984	26	1.18	Bromine, stone (crushed and broken), sand and gravel (construction), cement (portland).
California	2,532,043	2	8.30	Cement (portland), sand and gravel (construction), boron minerals, gold.
Colorado	338,405	31	1.11	Sand and gravel (construction), molybdenum, cement (portland), stone (crushed and broken).
Connecticut	90,833	43	.30	Stone (crushed and broken), sand and gravel (construction, industrial), feldspar.
Delaware[2]	5,101	50	.02	Sand and gravel (construction) and gemstones.
Florida	1,396,164	5	4.58	Phosphate rock, stone (crushed and broken), cement (portland), sand and gravel (construction).
Georgia	1,298,621	6	4.26	Clays, stone (crushed and broken), cement (portland), stone (dimension).
Hawaii[2]	141,112	39	.46	Stone (crushed and broken), cement (portland), sand and gravel (construction), cement (masonry).
Idaho	297,048	33	.97	Phosphate rock, silver, gold, sand and gravel (construction).
Illinois	673,291	16	2.21	Stone (crushed and broken), cement (portland), sand and gravel (construction, industrial).
Indiana	403,295	24	1.32	Stone (crushed and broken), cement (portland), sand and gravel (construction), stone (dimension).
Iowa	344,032	29	1.13	Stone (crushed and broken), cement (portland), sand and gravel (construction), gypsum (crude).
Kansas	365,679	25	1.20	Helium (crude and Grade-A), salt, stone (crushed and broken), cement (portland).
Kentucky	343,124	30	1.13	Stone (crushed and broken), lime, cement (portland), sand and gravel (construction).
Louisiana	351,802	27	1.15	Salt, sulfur (Frasch), sand and gravel (construction), stone (crushed and broken).
Maine	41,304	46	.14	Cement (portland), sand and gravel (construction), stone (crushed and broken), cement (masonry).
Maryland	348,212	28	1.14	Stone (crushed and broken), cement (portland), sand and gravel (construction), cement (masonry).
Massachusetts	111,597	41	.37	Stone (crushed and broken), sand and gravel (construction), stone (dimension), lime.
Michigan	1,503,268	4	4.93	Iron ore (usable), cement (portland), magnesium compounds, sand and gravel (construction).
Minnesota	1,288,885	7	4.23	Iron ore (usable), sand and gravel (construction), stone (crushed and broken), sand and gravel (industrial).
Mississippi	101,859	42	.33	Clays, sand and gravel (construction), cement (portland), stone (crushed and broken).
Missouri	880,352	12	2.89	Lead, cement (portland), stone (crushed and broken), lime.
Montana	590,297	17	1.94	Gold, copper, cement (portland), silver.
Nebraska	89,392	44	.29	Cement (portland), sand and gravel (construction), stone (crushed and broken), lime.
Nevada	2,392,901	3	7.85	Gold, silver, sand and gravel (construction), diatomite.
New Hampshire[2]	30,392	47	.10	Sand and gravel (construction), stone (crushed and broken, dimension), and gemstones.
New Jersey	204,988	37	.67	Stone (crushed and broken), sand and gravel (construction, industrial), zircon concentrates.
New Mexico	985,563	10	3.23	Copper, potash, sand and gravel (construction), molybdenum.

See footnotes at end of table.

TABLE 4[1]—Continued

VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1991

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
New York	$698,659	14	2.29	Stone (crushed and broken), salt, cement (portland), sand and gravel (construction).
North Carolina	552,898	18	1.81	Stone (crushed and broken), phosphate rock, lithium minerals, sand and gravel (construction).
North Dakota[2]	17,366	48	.06	Sand and gravel (construction), lime, gemstones.
Ohio	683,585	15	2.24	Stone (crushed and broken), sand and gravel (construction), salt, lime.
Oklahoma	275,525	35	.90	Stone (crushed and broken), cement (portland), iodine (crude), sand and gravel (construction).
Oregon	197,928	38	.65	Stone (crushed and broken), sand and gravel (construction), cement (portland), lime.
Pennsylvania	844,001	13	2.77	Stone (crushed and broken), cement (portland), lime, sand and gravel (construction).
Rhode Island[2]	13,263	49	.04	Stone (crushed and broken), sand and gravel (construction), gemstones.
South Carolina	338,145	32	1.11	Cement (portland), stone (crushed and broken), gold, clays.
South Dakota	289,922	34	.95	Gold, cement (portland), sand and gravel (construction), stone (crushed and broken).
Tennessee	547,787	19	1.80	Stone (crushed and broken), zinc, cement (portland), clays.
Texas	1,264,661	8	4.15	Cement (portland), stone (crushed and broken), magnesium metal, sulfur (Frasch).
Utah	1,149,067	9	3.78	Copper, gold, magnesium metal, cement (portland).
Vermont	59,820	45	.20	Stone (dimension, crushed and broken), sand and gravel (construction), talc and pyrophyllite.
Virginia	428,045	23	1.40	Stone (crushed and broken), lime, cement (portland), sand and gravel (construction).
Washington	482,659	22	1.58	Sand and gravel (construction), gold, magnesium metal, stone (crushed and broken).
West Virginia	116,931	40	.38	Stone (crushed and broken), cement (portland), sand and gravel (industrial, construction).
Wisconsin	213,849	36	.70	Stone (crushed and broken), sand and gravel (construction), lime, sand and gravel (industrial).
Wyoming	929,176	11	3.05	Soda ash, clays, helium (Grade-A), cement (portland).
Undistributed	7,386	—	—	
Total[3]	30,489,000	XX	100.00	

XX Not applicable.

[1]This table had been table 3 in previous issues of the Minerals Yearbook.

[2]Partial total, excludes values that must be concealed to avoid disclosing company proprietary data. Concealed values included with "Undistributed."

[3]Data may not add to totals shown because of rounding.

TABLE 5[1]

VALUE OF NONFUEL MINERAL PRODUCTION PER CAPITA AND PER SQUARE MILE IN 1991, BY STATE

State	Area (square miles)	Population (thousands)	Total value (thousands)	Per square mile		Per capita	
				Dollars	Rank	Dollars	Rank
Alabama	51,705	4,089	$539,915	10,442	25	132	16
Alaska	591,004	570	494,064	836	49	867	3
Arizona	114,000	3,750	2,829,123	24,817	4	754	4
Arkansas	53,187	2,372	360,984	6,787	31	152	14
California	158,706	30,380	2,532,043	15,954	12	83	27
Colorado	104,091	3,377	338,405	3,251	43	100	22
Connecticut	5,018	3,291	90,833	18,101	10	28	44
Delaware	2,044	680	2/5,10	2,496	44	8	50
Florida	58,664	13,277	1,396,164	23,799	5	105	21
Georgia	58,910	6,623	1,298,621	22,044	6	196	11
Hawaii	6,471	1,135	2/141,11	21,807	7	124	17
Idaho	83,564	1,039	297,048	3,555	41	286	10
Illinois	56,345	11,543	673,291	11,949	19	58	38
Indiana	36,185	5,610	403,295	11,145	20	72	31
Iowa	56,275	2,795	344,032	6,113	33	123	18
Kansas	82,277	2,495	365,679	4,444	36	147	15
Kentucky	40,409	3,713	343,124	8,491	27	92	25
Louisiana	47,751	4,252	351,802	7,367	29	83	28
Maine	33,265	1,235	41,304	1,242	47	33	43
Maryland	10,460	4,860	348,212	33,290	1	72	32
Massachusetts	8,284	5,996	111,597	13,471	16	19	48
Michigan	58,527	9,368	1,503,268	25,685	3	160	13
Minnesota	84,402	4,432	1,288,885	15,271	13	291	9
Mississippi	47,689	2,592	101,859	2,136	45	39	41
Missouri	69,697	5,158	880,352	12,631	18	171	12
Montana	147,046	808	590,297	4,014	37	731	5
Nebraska	77,355	1,593	89,392	1,156	48	56	39
Nevada	110,561	1,284	2,392,901	21,643	8	1,864	2
New Hampshire	9,279	1,105	[2]30,392	3,275	42	28	45
New Jersey	7,787	7,760	204,988	26,324	2	26	47
New Mexico	121,593	1,548	985,563	8,105	28	637	7
New York	49,107	18,058	698,659	14,227	14	39	42
North Carolina	52,669	6,737	552,898	10,498	24	82	29
North Dakota	70,703	635	[2]17,366	246	50	27	46
Ohio	41,330	10,939	683,585	16,540	11	62	37
Oklahoma	69,956	3,175	275,525	3,939	38	87	26
Oregon	97,073	2,922	197,928	2,039	46	68	35
Pennsylvania	45,308	11,961	844,001	18,628	9	71	33
Rhode Island	1,212	1,004	[2]13,263	10,943	21	13	49
South Carolina	31,113	3,560	338,145	10,868	22	95	24
South Dakota	77,116	703	289,922	3,760	40	412	8
Tennessee	42,144	4,953	547,787	12,998	17	111	19
Texas	266,807	17,349	1,264,661	4,740	35	73	30
Utah	84,899	1,770	1,153,751	13,590	15	652	6
Vermont	9,614	567	59,820	6,222	32	106	20
Virginia	40,767	6,286	428,045	10,500	23	68	34
Washington	68,138	5,018	482,659	7,084	30	96	23

See footnotes at end of table.

TABLE 5[1]—Continued

VALUE OF NONFUEL MINERAL PRODUCTION PER CAPITA AND PER SQUARE MILE IN 1991, BY STATE

State	Area (square miles)	Population (thousands)	Total value (thousands)	Per square mile		Per capita	
				Dollars	Rank	Dollars	Rank
West Virginia	24,231	1,801	$16,931	4,826	34	65	36
Wisconsin	56,153	4,955	213,849	3,808	39	43	40
Wyoming	97,809	460	929,176	9,500	26	2,020	1
Undistributed	XX	XX	7,386	XX	XX	XX	XX
Total[3 4] or average	3,618,700	251,583	30,489,000	8,425	XX	121	XX

XX Not applicable.

[1]This table had been table 4 in previous issues of the Minerals Yearbook.

[2]Partial total, excludes values that must be concealed to avoid disclosing company proprietary data. Concealed values included with "Undistributed."

[3]Excludes Washington, DC (which has no mineral production), with an area of 69 square miles and a population of 598,000.

[4]Data may not add to totals shown because of rounding.

Sources: U.S. Bureau of Mines and Bureau of the Census.

TABLE 6[1]

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ALABAMA							
Cement:							
Masonry	thousand short tons	252	$13,852	262	$15,462	e238	e$14,042
Portland	do.	3,169	130,590	3,585	165,344	e3,937	e181,102
Clays[3]	metric tons	1,878,070	18,537	2,049,776	27,747	2,124,380	22,103
Lime	thousand short tons	1,481	70,361	1,526	70,816	1,510	75,506
Sand and gravel:							
Construction	do.	e10,400	e36,500	14,103	50,243	e12,700	e45,700
Industrial	do.	805	8,092	878	9,075	531	6,133
Stone:							
Crushed and broken[4]	do.	31,737	167,332	e36,100	e202,400	27,145	161,843
Dimension	short tons	W	W	W	W	9,552	2,449
Combined value of bauxite, clays [bentonite, kaolin (1990-91)], gemstones, salt, stone [crushed dolomite and granite (1991), crushed granite (1989-90)], talc and pyrophyllite, zircon concentrates, (1989), and values indicated by symbol W		XX	15,489	XX	r19,493	XX	31,037
Total		XX	460,753	XX	r560,580	XX	539,915
ALASKA							
Gemstones		NA	W	NA	W	NA	5
Gold[5]	kilograms	5,756	70,800	3,232	40,200	3,196	37,331
Sand and gravel (construction)	thousand short tons	e17,000	e48,500	15,100	41,800	e14,000	e39,200
Stone (crushed)	do.	2,900	20,300	e2,700	e19,800	e1,085	e4,688
Combined value of cement (portland), lead, silver, stone [crushed sandstone (1991)], tin, zinc, and values indicated by symbol W		XX	73,752	XX	r474,781	XX	412,840
Total		XX	213,352	XX	r576,581	XX	494,064
ARIZONA							
Clays	metric tons	188,211	2,506	140,162	2,318	228,411	3,830
Copper[5]	do.	898,466	2,593,734	978,767	2,657,649	1,024,066	2,468,255
Gemstones		NA	2,821	NA	2,098	NA	3,173
Gold[5]	kilograms	2,768	34,047	5,000	62,191	2,068	24,159
Iron oxide pigments (crude)	metric tons	W	W	W	W	18	22
Sand and gravel (construction)	thousand short tons	e33,900	e133,900	27,915	92,166	e22,500	e79,400
Silver[5]	metric tons	171	30,186	173	26,836	148	19,212
Stone (crushed)	thousand short tons	6,649	28,552	e5,300	e13,500	7,060	32,842
Combined value of cement, diatomite (1989-90), gypsum (crude), iron ore (usable, 1991), lead (1989, 1991), lime, molybdenum, perlite, pumice (1990-91), pyrites, salt, sand and gravel (industrial), stone (dimension), tin (1989), and values indicated by symbol W		XX	220,594	XX	r207,591	XX	198,230
Total		XX	3,046,340	XX	r3,064,349	XX	2,829,123

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ARKANSAS							
Abrasives[6]	metric tons	W	W	W	W	W	$154
Bromine[e]	thousand kilograms	W	W	177,000	$97,350	170,000	167,000
Clays	metric tons	871,313	$17,391	989,383	21,578	[3]856,582	[3]8,048
Gemstones		NA	4,041	NA	1,503	NA	1,846
Sand and gravel:							
Construction	thousand short tons	[e]7,500	[e]25,500	9,663	35,475	[e]8,300	[e]31,100
Industrial	do.	545	5,507	742	7,209	746	7,738
Stone:							
Crushed[4]	do.	18,791	76,419	[e]17,800	[e]76,900	22,140	101,427
Dimension	short tons	W	W	W	W	13,932	1,128
Combined value of bauxite (1989-90), cement, clays (fire, 1991), gypsum (crude), lime, stone [crushed dolomite and traprock (1991), crushed slate and dolomite (1989-90)], talc and pyrophyllite (1989-90), tripoli, vanadium (1989-90), and values indicated by symbol W		XX	253,051	XX	62,625	XX	42,543
Total		XX	381,909	XX	302,640	XX	360,984
CALIFORNIA							
Boron minerals	metric tons	562,311	429,806	1,093,919	436,176	1,240,158	442,531
Cement (portland)	thousand short tons	10,911	642,020	10,032	604,080	[e]8,702	[e]522,120
Clays	metric tons	2,195,830	39,243	[3]2,163,515	[3]40,217	[3]2,074,707	[3]27,464
Gemstones		NA	2,982	NA	1,501	NA	10,450
Gold[5]	kilograms	29,804	366,595	29,607	368,300	29,873	348,919
Gypsum (crude)	thousand short tons	1,734	13,066	W	W	W	W
Lime	do.	395	24,503	345	19,425	307	20,389
Mercury	metric tons	W	W	(7)	(7)	(7)	1
Pumice	do.	79,000	4,612	71,739	5,088	61,237	4,372
Rare-earth metal concentrates	do.	W	W	W	W	16,465	W
Sand and gravel:							
Construction	thousand short tons	[e]138,300	[e]670,800	132,214	626,000	[e]101,900	[e]489,100
Industrial	do.	2,426	43,863	2,452	48,055	2,104	41,690
Silver[5]	metric tons	21	3,650	21	3,209	W	W
Stone:							
Crushed	thousand short tons	54,887	238,034	[e]42,500	[e]200,600	45,816	216,156
Dimension	short tons	28,829	5,564	[e]30,077	[e]5,213	44,757	5,254
Combined value of asbestos, barite (1990), calcium chloride (natural), cement (masonry), clay [fuller's earth, (1990-91)], copper, diatomite, feldspar, iron ore [byproduct material (1989), usable], magnesium compounds, mica (crude, 1991), molybdenum, perlite, potash, salt, soda ash, sodium sulfate (natural), talc and pyrophyllite, titanium concentrates (ilmenite), tungsten ore concentrates, and values indicated by symbol W		XX	369,664	XX	[r]421,820	XX	403,597
Total		XX	2,854,402	XX	[r]2,779,684	XX	2,532,043

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
COLORADO							
Clays	metric tons	265,435	$2,064	262,292	[3]$1,864	[3]263,866	[3]$1,964
Gemstones		NA	240	NA	66	NA	287
Gold[5]	kilograms	3,448	42,411	[r]2,357	[r]29,176	3,181	37,154
Peat	thousand short tons	W	412	W	W	W	396
Sand and gravel (construction)	do.	[e]25,300	[e]104,000	24,938	86,541	[e]26,400	[e]88,200
Silver[5]	metric tons	W	W	23	3,557	20	2,565
Stone:							
Crushed	thousand short tons	[4]7,261	[4]32,435	[e, 4]7,600	[e, 4]36,100	8,401	41,022
Dimension	short tons	5,310	398	[e]8,490	[e]1,394	W	W
Combined value of cement, clay (bentonite, 1990-91), copper, gypsum (crude), helium (Grade-A, 1990-91), lead, lime, molybdenum, perlite, sand and gravel (industrial), stone (crushed traprock, 1989-90), vanadium (1989-90), zinc, and values indicated by symbol W		XX	275,765	XX	227,586	XX	166,817
Total		XX	457,725	XX	386,284	XX	338,405
CONNECTICUT							
Gemstones		NA	2	NA	2	NA	62
Sand and gravel (construction)	thousand short tons	[e]5,800	[e]24,700	8,542	37,943	[e]5,400	[e]24,800
Stone:							
Crushed[4]	do.	11,480	78,734	[e]10,200	[e]70,600	5,873	52,701
Dimension	short tons	W	W	W	W	17,326	1,739
Combined value of clays (common), feldspar, mica (scrap, 1990-91), sand and gravel (industrial), stone [crushed dolomite and other (1991), crushed granite (1989-90)], and values indicated by symbol W		XX	9,780	XX	9,348	XX	11,531
Total		XX	113,216	XX	117,893	XX	90,833
DELAWARE							
Gemstones		NA	1	NA	1	NA	1
Sand and gravel (construction)	thousand short tons	[e]1,900	[e]6,200	2,184	6,967	[e]1,600	[e]5,100
Total[8]		XX	6,201	XX	6,968	XX	5,101
FLORIDA							
Cement:							
Masonry	thousand short tons	477	31,231	442	27,777	[e]214	[e]13,482
Portland	do.	4,357	207,857	3,954	186,404	[e]3,023	[e]142,081
Clays	metric tons	[3]563,687	[3]46,941	[3]391,334	[3]39,625	363,253	39,150
Gemstones		NA	W	NA	W	NA	6
Peat	thousand short tons	235	4,515	252	4,381	244	3,991
Sand and gravel:							
Construction	do.	[e]17,900	[e]55,500	18,472	59,123	[e]16,000	[e]51,400
Industrial	do.	681	7,768	520	7,024	551	5,989
Stone (crushed)	do.	83,995	341,397	[e]74,000	[e]317,400	[4]59,132	[4]260,901
Combined value of clays (common), magnesium compounds, phosphate rock, rare-earth metal concentrates, staurolite, stone [crushed marl (1991)], titanium concentrates (ilmenite and rutile), zircon concentrates, and values indicated by symbol W		XX	913,054	XX	[r]924,788	XX	879,164
Total		XX	1,608,263	XX	[r]1,566,522	XX	1,396,164

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
GEORGIA							
Clays	metric tons	9,768,312	$1,004,954	9,855,248	$1,060,539	9,518,026	$949,737
Gemstones		NA	21	NA	20	NA	10
Sand and gravel:							
Construction	thousand short tons	e6,100	e18,900	5,158	16,644	e4,700	e14,500
Industrial	do.	537	7,013	W	W	W	W
Stone:							
Crushed	do.	50,417	262,805	e53,000	e317,300	341,339	3222,900
Dimension[3]	short tons	145,545	12,087	e147,068	e12,483	173,892	14,167
Combined value of barite, bauxite (1989, 1991), cement, feldspar, iron oxide pigments (crude), mica (scrap), peat (1989-90), stone [crushed marble (1991), dimension marble], talc and pyrophyllite, and values indicated by symbol W		XX	81,515	XX	88,138	XX	97,307
Total		XX	1,387,295	XX	1,495,124	XX	1,298,621
HAWAII							
Cement:							
Masonry	thousand short tons	10	1,566	12	1,870	e10	e600
Portland	do.	493	40,495	532	46,311	e547	e47,589
Gemstones		NA	44	NA	55	NA	60
Sand and gravel (construction)	thousand short tons	e600	e3,200	438	2,459	e400	e2,300
Stone (crushed)	do.	6,205	46,746	e7,000	e55,400	410,486	490,563
Total[8]		XX	92,051	XX	106,095	XX	141,112
IDAHO							
Clays[3]	metric tons	W	W	W	W	967	W
Copper[5]	do.	2,950	8,516	W	W	W	W
Feldspar	do.	11,612	720	W	W	W	W
Gemstones		NA	500	NA	320	NA	426
Gold[5]	kilograms	3,057	37,602	W	W	3,348	39,107
Lime	thousand short tons	W	W	W	W	150	9,124
Phosphate rock	thousand metric tons	W	W	4,380	r67,978	5,921	86,328
Pumice	metric tons	W	W	31,333	220	36,868	267
Sand and gravel:							
Construction	thousand short tons	e5,800	e18,900	9,222	25,590	e11,600	e31,300
Industrial	do.	459	5,037	552	6,234	W	W
Silver[5]	metric tons	439	77,651	r442	r68,418	337	43,807
Stone:							
Crushed	thousand short tons	3,298	12,609	e4,300	e12,900	3,230	15,057
Dimension	short tons	W	W	—	—	3,596	W
Combined value of antimony, cement, clays, [bentonite (1989), common, kaolin], garnet (abrasive), lead, molybdenum, perlite, vanadium ore, zinc, and values indicated by symbol W		XX	203,075	XX	r195,977	XX	71,632
Total		XX	364,610	XX	r377,637	XX	297,048

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ILLINOIS							
Cement (portland)	thousand short tons	2,776	$117,224	2,842	$116,781	r2,654	r$108,814
Clays[3]	metric tons	142,207	641	598,479	2,516	935,154	38,877
Gemstones		NA	W	NA	W	NA	547
Sand and gravel:							
Construction	thousand short tons	r33,000	r108,900	32,380	104,728	r26,300	r90,400
Industrial	do.	4,582	52,935	4,486	62,531	4,146	57,210
Stone (crushed)[4]	do.	60,829	256,832	r62,700	r283,100	68,586	295,362
Combined value of barite, cement (masonry), clays (fuller's earth 1989-90), copper (1989-90), fluorspar, lead (1989-90), lime, peat, silver (1989-90), stone [crushed sandstone (1989-91), and limestones (1991), dimension], tripoli, zinc, and values indicated by symbol W		XX	96,829	XX	95,478	XX	82,081
Total		XX	633,361	XX	665,134	XX	673,291
INDIANA							
Cement:							
Masonry	thousand short tons	357	24,054	368	27,813	r317	r24,092
Portland	do.	2,364	108,297	2,417	114,414	r2,252	r105,844
Clays	metric tons	871,179	3,836	2,1,051,703	2,3,273	2,929,964	2,3,516
Gemstones		NA	W	NA	W	NA	561
Peat	thousand short tons	34	607	37	W	26	W
Sand and gravel (construction)	do.	r29,600	r99,200	23,879	76,886	r18,100	r60,400
Stone:							
Crushed	do.	4,36,188	4,136,252	r,4,36,700	r,4,147,700	37,924	152,489
Dimension[4]	short tons	198,531	27,212	r194,728	r29,504	187,580	27,491
Combined value of abrasives (1989), clays [ball (1990-91)], gypsum (crude), lime, sand and gravel (industrial), stone [crushed marl and miscellaneous stones (1989-90), dimension limestone and dolomite (1991), dimension sandstone (1989-90)], and values indicated by symbol W		XX	34,657	XX	32,176	XX	28,902
Total		XX	434,115	XX	431,766	XX	403,295
IOWA							
Cement:							
Masonry	thousand short tons	47	4,450	53	5,054	r34	r3,264
Portland	do.	2,072	102,387	2,525	122,466	r2,301	r112,749
Clays	metric tons	439,323	1,773	423,227	1,376	530,477	2,226
Gemstones		NA	10	NA	14	NA	8
Gypsum (crude)	thousand short tons	2,273	16,884	2,192	14,243	2,162	12,285
Sand and gravel (construction)	do.	r12,800	r37,800	14,953	46,432	r17,400	r55,800
Stone:							
Crushed	do.	28,049	111,182	r29,000	r118,600	3,31,057	3,147,815
Dimension	short tons	15,151	613	W	W	W	W
Combined value of other industrial minerals and values indicated by symbol W		XX	7,603	XX	8,185	XX	9,885
Total		XX	282,702	XX	316,370	XX	344,032

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
KANSAS							
Cement:							
Masonry	thousand short tons	42	$2,514	39	$2,011	e30	e$1,530
Portland	do.	1,505	69,390	1,707	76,564	e1,466	e65,970
Clays[3]	metric tons	533,099	2,700	625,969	4,056	607,419	2,828
Gemstones		NA	W	NA	W	NA	527
Helium (Grade-A)	million cubic meters	W	W	W	W	39	76,540
Salt[9]	thousand short tons	1,948	82,212	2,390	92,119	2,316	97,713
Sand and gravel:							
Construction	do.	e13,000	e33,200	10,863	24,170	e9,600	e22,100
Industrial	do.	230	2,690	W	W	W	W
Stone:							
Crushed[4]	do.	15,850	56,976	e20,800	e79,200	16,802	67,249
Dimension	short tons	W	W	W	W	19,651	2,171
Combined value of clay (bentonite, 1989), gypsum (crude), helium (crude), pumice, salt (brine), stone [crushed quartzite (1991), sandstone and quartzite (1989-90)], and values indicated by symbol W		XX	68,449	XX	67,999	XX	29,051
Total		XX	318,131	XX	346,119	XX	365,679
KENTUCKY							
Clays[3]	metric tons	716,990	3,357	826,205	8,282	707,587	2,942
Gemstones		NA	W	NA	W	NA	548
Sand and gravel (construction)	thousand short tons	e5,500	e15,100	8,802	29,581	e7,700	e27,200
Stone (crushed)	do.	[4]48,178	[4]187,849	[4] e50,100	[4] e182,900	46,266	191,893
Combined value of cement, clays [ball fire (1989)], lead (1990), lime, sand and gravel (industrial), silver (1990), stone [crushed dolomite (1989-90)], zinc (1990), and values indicated by symbol W		XX	124,353	XX	138,101	XX	120,541
Total		XX	330,659	XX	358,864	XX	343,124
LOUISIANA							
Clays	metric tons	233,992	6,115	368,322	1,066	360,154	3,646
Gemstones		NA	14	NA	7	NA	27
Salt	thousand short tons	13,218	115,203	14,348	120,827	14,595	130,587
Sand and gravel:							
Construction	do.	e13,600	e54,400	14,589	55,902	e13,300	e48,900
Industrial	do.	572	9,664	559	10,003	W	W
Stone (crushed)	do.	3,206	24,414	e2,100	e16,800	W	W
Sulfur (Frasch)	thousand metric tons	1,334	W	1,337	W	1,063	W
Combined value of gypsum (crude), lime, stone [crushed miscellaneous (1991)], and values indicated by symbol W		XX	169,912	XX	163,313	XX	168,642
Total		XX	379,722	XX	367,918	XX	351,802

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MAINE							
Gemstones		NA	W	NA	W	NA	$174
Sand and gravel (construction)	thousand short tons	e$8,600	e$30,100	7,865	$29,349	e3,900	e14,800
Stone:							
Crushed	do.	1,591	8,801	e1,700	e8,700	1,706	9,899
Dimension	short tons	W	W	W	W	73	88
Combined value of cement, clays (common), peat, and values indicated by symbol W		XX	25,753	XX	24,495	XX	16,343
Total		XX	64,654	XX	62,544	XX	41,304
MARYLAND							
Cement (portland)	thousand short tons	1,871	94,002	1,798	91,172	e1,580	e80,580
Clays	metric tons	351,464	1,882	338,775	1,712	e258,760	e1,141
Gemstones		NA	3	NA	3	NA	3
Peat	do.	3	W	3	W	—	—
Sand and gravel (construction)	do.	e16,900	e84,500	18,271	104,023	e13,000	e72,800
Stone:							
Crushed	do.	30,841	153,375	e30,500	e163,900	25,545	188,001
Dimension	short tons	27,529	2,072	e24,102	e1,751	12,090	967
Combined value of other industrial minerals and values indicated by symbol W		XX	6,216	XX	6,053	XX	4,720
Total		XX	342,050	XX	368,614	XX	348,212
MASSACHUSETTS							
Gemstones		NA	3	NA	1	NA	1
Sand and gravel:							
Construction	thousand short tons	e13,900	e57,000	12,774	51,466	e10,100	e39,400
Industrial	do.	34	601	30	401	30	401
Stone:							
Crushed	do.	11,880	67,768	e9,200	e54,500	7,131	51,362
Dimension	short tons	67,533	10,302	e56,254	e10,992	69,332	11,646
Combined value of clays (common), lime, and peat		XX	8,452	XX	10,138	XX	8,787
Total		XX	144,126	XX	127,498	XX	111,597
MICHIGAN							
Cement:							
Masonry	thousand short tons	255	22,286	272	23,880	e225	e22,440
Portland	do.	5,449	253,324	5,906	263,607	e4,935	e222,075
Clays	metric tons	1,249,198	4,599	1,201,542	4,094	2,061,861	8,770
Gemstones		NA	10	NA	11	NA	10
Gypsum (crude)	thousand short tons	2,089	15,589	2,000	11,511	1,721	13,052
Iron ore (usable)	thousand metric tons	15,045	W	10,034	W	e12,662	W
Lime	thousand short tons	621	32,479	622	30,898	613	30,959
Peat	do.	286	6,082	280	6,264	249	6,442
Sand and gravel:							
Construction	do.	e48,000	e132,000	53,729	153,057	e44,800	e132,200
Industrial	do.	2,865	24,577	2,310	19,285	2,093	18,464
Stone (crushed)	do.	40,905	123,678	e43,100	e129,000	40,989	129,490

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MICHIGAN—Continued							
Combined value of calcium chloride (natural), copper, gold (1989), iron oxide pigments (crude), magnesium compounds, potash, salt, silver, stone (dimension), and values indicated by symbol W		XX	$84,347	XX	$96,516	XX	$19,366
Total		XX	1,598,971	XX	1,438,123	XX	1,503,268
MINNESOTA							
Gemstones		NA	42	NA	46	NA	62
Iron ore (usable)	thousand metric tons	41,044	1,223,909	45,139	1,308,920	e42,966	e1,157,920
Peat	thousand short tons	33	1,415	48	2,972	35	1,910
Sand and gravel (construction)	do.	e33,700	e82,600	33,869	77,502	e24,500	e58,800
Stone:							
Crushed	do.	8,760	30,218	e9,100	e31,900	8,378	30,624
Dimension	short tons	44,605	16,031	e60,195	e20,836	45,795	13,962
Combined value of clays (common, kaolin), lime, and sand and gravel (industrial)		XX	22,022	XX	27,746	XX	25,607
Total		XX	1,376,237	XX	1,469,922	XX	1,503,268
MISSISSIPPI							
Clays[3]	short tons	899,373	23,573	817,828	16,196	1,172,213	34,382
Gemstones		NA	5	NA	1	NA	1
Sand and gravel (construction)	thousand short tons	e15,600	e51,500	13,032	45,817	e9,900	e33,000
Stone (crushed)	do.	1,069	3,994	e1,400	e5,500	1,632	6,603
Combined value of cement [masonry (1989-90), portland], clays [ball, fuller's earth (1990), kaolin (1991)], and sand and gravel (industrial)		XX	28,539	XX	44,799	XX	27,873
Total		XX	107,611	XX	112,313	XX	101,859
MISSOURI							
Cement (portland)	thousand short tons	4,922	182,005	4,481	180,090	e4,276	e171,040
Clays[3]	metric tons	1,479,898	14,665	1,347,558	12,864	2,001,537	11,060
Iron ore (usable)	thousand metric tons	1,060	W	1,002	W	e224	W
Lead[5]	metric tons	366,931	318,320	r380,781	r386,345	351,995	259,841
Sand and gravel:							
Construction	thousand short tons	e10,000	e32,500	9,243	25,097	e7,400	e20,100
Industrial	do.	750	9,972	W	W	W	W
Silver[5]	metric tons	53	9,456	r42	r6,434	35	4,483
Stone (crushed)	thousand short tons	51,754	171,848	e53,100	e190,900	47,938	167,233
Zinc[5]	metric tons	50,790	91,885	48,864	80,355	42,506	49,453
Combined value of barite, cement (masonry), clays (fuller's earth), copper, gemstones, iron oxide pigments (crude), lime, stone (dimension), and values indicated by symbol W		XX	219,236	XX	r220,555	XX	197,142
Total		XX	1,049,887	XX	r1,102,640	XX	880,352
MONTANA							
Clays	metric tons	295,743	21,835	229,741	2193	362,635	11,332
Gemstones		NA	2,500	NA	3,692	NA	2,796
Gold[5]	kilograms	12,434	152,941	13,012	161,861	18,511	216,211
Palladium metal[10]	do.	4,850	22,454	5,930	21,735	6,050	16,923
Platinum metal[11]	do.	1,430	23,310	1,810	r27,176	1,730	20,635
Sand and gravel (construction)	thousand short tons	e5,800	e13,900	5,114	14,319	e4,800	e13,700

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
MONTANA—Continued							
Silver[5]	metric tons	194	$4,367	220	$4,114	222	$8,893
Stone (crushed)	thousand short tons	2,846	9,718	e4,000	e15,300	2,107	5,725
Talc and pyrophyllite	metric tons	453,978	12,718	430,125	18,883	W	W
Combined value of barite, cement, clays [bentonite (1990), fire (1989)], copper, graphite [natural (1989)], gypsum (crude 1989), iron ore (usable), lead, lime, molybdenum, peat, phosphate rock, sand and gravel (industrial), stone (dimension), vermiculite, zinc, and values indicated by symbol W		XX	292,394	XX	r275,944	XX	274,082
Total		XX	566,137	XX	573,024	XX	590,297
NEBRASKA							
Clays	metric tons	224,624	880	227,292	1,685	198,319	909
Gemstones		NA	2	NA	7	NA	1
Sand and gravel (construction)	thousand short tons	e15,200	e41,800	11,453	30,056	e10,100	e27,300
Stone (crushed)	do.	3,978	20,050	e4,000	e21,200	4,861	23,328
Combined value of cement, lime, and sand and gravel (industrial)		XX	41,085	XX	37,381	XX	37,854
Total		XX	103,817	XX	90,329	XX	89,392
NEVADA							
Barite	thousand metric tons	209	3,473	337	5,884	374	11,933
Clays[3]	metric tons	57,264	5,457	34,625	4,098	15,553	3,204
Gemstones		NA	1,402	NA	407	NA	958
Gold[5]	kilograms	153,995	1,894,172	r179,078	r2,216,233	177,312	2,071,009
Lead[5]	metric tons	—	—	830	842	W	W
Mercury	do.	W	W	W	W	57	202
Perlite	short tons	5,000	136	W	W	W	W
Sand and gravel:							
Construction	thousand short tons	e20,000	e70,000	18,377	59,008	e20,300	e69,000
Industrial	do.	718	W	607	W	546	W
Silver[5]	metric tons	625	110,442	r646	r100,146	578	75,050
Stone (crushed)	thousand short tons	1,560	4,638	e1,600	e5,000	1,199	6,527
Zinc[5]	metric tons	—	—	7,889	12,973	W	W
Combined value of brucite, cement (portland), clays [fuller's earth (1990-91), kaolin], copper, diatomite, fluorspar (1989-90), gypsum (crude), lime, lithium minerals, magnesite, molybdenum, salt, and values indicated by symbol W		XX	220,441	XX	r216,820	XX	155,018
Total		XX	2,310,161	XX	r2,621,411	XX	2,392,901
NEW HAMPSHIRE							
Gemstones		NA	51	NA	38	NA	31
Sand and gravel (construction)	thousand short tons	e6,000	e20,400	7,901	26,599	e4,700	e16,200
Stone:							
Crushed	do.	771	4,020	e600	e2,500	1,542	9,148
Dimension	short tons	55,305	8,769	e45,073	e6,029	34,803	5,013
Total[8]		XX	33,240	XX	35,166	XX	30,392

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NEW JERSEY							
Clays[3]	metric tons	18,492	$400	W	W	W	W
Gemstones		NA	3	NA	$3	NA	$3
Peat	thousand short tons	W	638	W	527	W	541
Sand and gravel:							
Construction	do.	e15,200	e68,400	13,862	64,245	e10,300	e47,900
Industrial	do.	1,797	26,138	1,762	26,190	1,634	23,738
Stone (crushed)	do.	20,799	140,998	e21,200	e131,700	4 16,680	4 119,287
Zircon concentrates	metric tons	W	8,988	W	W	W	W
Combined value of clays [common, fire (1990-91)], marl (greensand), stone [crushed sandstone and other (1991)], titanium concentrates [ilmenite and rutile (1991)], and values indicated by symbol W		XX	3,318	XX	6,805	XX	13,519
Total		XX	248,883	XX	229,470	XX	204,988
NEW MEXICO							
Clays	metric tons	31,012	94	3 27,994	3 74	3 27,794	3 74
Copper[5]	do.	259,640	749,540	262,815	713,622	252,859	609,454
Gemstones		NA	279	NA	225	NA	100
Gold[5]	kilograms	1,076	13,231	888	11,041	W	W
Lead[5]	metric tons	W	W	W	W	193	142
Perlite	short tons	487,000	13,080	501,000	r13,181	W	W
Potash	thousand metric tons	1,365	242,619	1,451	245,571	1,469	250,900
Pumice	metric tons	77,000	795	W	W	W	W
Sand and gravel (construction)	thousand short tons	e11,800	e45,400	10,362	39,708	e9,200	e35,900
Silver[5]	metric tons	W	W	48	7,431	W	W
Stone (crushed)	thousand short tons	2,784	11,672	e2,400	e12,800	2,801	13,089
Combined value of cement, clays [fire (1990-91)], gypsum (crude), helium (Grade-A), iron ore [includes byproduct material (1989-90), usable], mica (scrap), molybdenum, salt, stone (dimension), zinc, and values indicated by symbol W		XX	45,593	XX	r59,828	XX	75,904
Total		XX	1,122,303	XX	r1,103,481	XX	985,563
NEW YORK							
Clays	metric tons	531,559	3,429	490,552	2,906	421,003	2,417
Gemstones		NA	350	NA	365	NA	125
Peat	thousand short tons	W	10	W	W	1	21
Salt	do.	5,424	161,427	5,401	162,900	4,998	173,837
Sand and gravel:							
Construction	do.	e31,600	e118,500	29,750	121,525	e23,700	e95,500
Industrial	do.	53	633	W	W	W	W
Stone:							
Crushed	do.	39,851	201,749	e39,900	e207,600	34,871	195,639
Dimension	short tons	23,756	3,575	e23,437	e3,589	18,624	2,978
Combined value of cement, garnet (abrasive), gypsum (crude), iron ore [includes byproduct material (1989)], lead, silver, talc and pyrophyllite, wollastonite, zinc, and values indicated by symbol W		XX	255,495	XX	273,954	XX	228,142
Total		XX	745,168	XX	772,839	XX	698,659

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NORTH CAROLINA							
Clays	metric tons	2,270,384	$15,529	[3]2,179,428	[3]$9,356	[3]2,063,875	[3]$9,015
Feldspar	do.	435,845	14,024	418,402	[r]14,460	402,448	13,027
Gemstones		NA	784	NA	1,057	NA	785
Mica (scrap)	thousand metric tons	73	4,192	65	3,796	64	3,747
Peat	thousand short tons	W	W	13	W	21	W
Sand and gravel:							
Construction	do.	[e]11,200	[e]43,700	11,733	44,872	[e]9,900	[e]35,000
Industrial	do.	1,627	19,902	1,177	15,338	1,174	15,565
Stone:							
Crushed	do.	51,519	257,976	[e]52,900	[e]276,200	[4]46,514	[4]243,920
Dimension	short tons	62,665	10,477	[e]66,531	[e]11,551	32,489	10,128
Combined value of clays [kaolin (1990-91)], lithium minerals, olivine, phosphate rock, stone [crushed volcanic cinder (1991)], talc and pyrophyllite, and values indicated by symbol W		XX	214,984	XX	[r]213,112	XX	221,711
Total		XX	581,568	XX	[r]589,742	XX	552,898
NORTH DAKOTA							
Clays	metric tons	47,903	W	50,485	W	27,825	W
Gemstones		NA	10	NA	10	NA	6
Lime	thousand short tons	107	5,439	82	4,623	98	5,360
Sand and gravel (construction)	do.	[e]3,600	[e]8,100	7,644	17,219	[e]5,000	[e]12,000
Stone (crushed)	short tons	—	—	[e]1,000	[e]4,600	11	W
Combined value of other industrial minerals and values indicated by symbol W		XX	111	XX	116	XX	([12])
Total		XX	13,660	XX	26,568	XX	[8]17,366
OHIO							
Cement:							
Masonry	thousand short tons	128	11,233	124	10,880	[e]109	[e]9,591
Portland	do.	1,446	73,230	1,426	72,883	[e]1,356	[e]69,156
Clays	metric tons	3,519,668	14,983	2,546,151	13,334	2,204,635	11,015
Gemstones		NA	18	NA	W	NA	57
Lime	thousand short tons	1,888	94,157	1,884	92,817	1,783	85,976
Peat	do.	8	182	12	182	9	222
Sand and gravel:							
Construction	do.	[e]44,400	[e]148,700	44,552	165,394	[e]42,300	[e]160,100
Industrial	do.	1,394	24,662	1,349	24,205	1,294	23,462
Stone:							
Crushed	do.	46,426	183,190	[e]48,400	[e]190,900	[4]47,310	[4]184,177
Dimension	short tons	59,923	3,455	[e]61,783	[e]3,468	[4]42,355	[4]2,279
Combined value of abrasives, gypsum (crude), salt, stone [crushed limestone and dolomite (1991), dimension limestone (1991)], and value indicated by symbol W		XX	145,346	XX	154,777	XX	137,550
Total		XX	699,156	XX	728,840	XX	683,585

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
OKLAHOMA							
Cement (portland)	thousand short tons	1,236	$39,360	1,544	$60,457	e1,620	e$63,180
Clays	metric tons	565,956	1,619	631,302	3,156	e824,176	e4,178
Gypsum (crude)	thousand short tons	2,523	14,369	2,184	11,154	2,356	12,925
Iodine (crude)	kilograms	1,505,714	23,947	1,972,849	30,486	1,998,914	31,389
Sand and gravel:							
Construction	thousand short tons	e8,500	e20,000	9,235	21,993	e9,000	e22,300
Industrial	do.	1,216	18,310	1,258	22,984	1,241	20,918
Stone:							
Crushed[4]	do.	23,598	81,969	e25,300	e89,500	25,678	95,509
Dimension	short tons	8,290	762	e8,138	e684	r3,836	r596
Tripoli	metric tons	W	W	18,801	155	15,885	141
Combined value of cement (masonry), feldspar, gemstones, lime, salt (1990-91), stone [crushed dolomite, dimension sandstone (1991)], and values indicated by symbol W		XX	18,695	XX	19,608	XX	24,389
Total		XX	219,031	XX	260,177	XX	275,525
OREGON							
Cement (portland)	thousand short tons	W	W	W	W	e249	e18,675
Clays	metric tons	210,893	875	223,452	1,390	213,356	1,086
Gemstones		NA	1,304	NA	1,683	NA	2,758
Nickel ore[13]	metric tons	NA	NA	330	NA	5,523	NA
Sand and gravel (construction)	thousand short tons	e14,400	e49,700	15,785	60,928	e15,600	e62,800
Stone (crushed)[4]	do.	18,407	81,204	e18,000	e86,600	20,608	89,322
Talc and pyrophyllite	metric tons	204	18	105	10	63	67
Zinc[5]	do.	—	—	—	—	751	873
Combined value of cement [masonry (1989-90)], copper (1991), diatomite, emery, gold (1989-90), lime, pumice, silver (1989-90), stone [crushed dolomite and quartzite (1989-90), crushed slate (1991)], value indicated by symbol W		XX	49,965	XX	r53,984	XX	22,347
Total		XX	183,066	XX	204,595	XX	197,928
PENNSYLVANIA							
Cement:							
Masonry	thousand short tons	349	26,473	303	22,594	e253	e18,975
Portland	do.	5,757	301,980	5,621	286,185	e4,881	e248,931
Clays[3]	metric tons	1,049,973	4,936	840,646	2,900	701,399	2,890
Gemstones		NA	5	NA	5	NA	5
Lime	thousand short tons	1,660	92,139	1,626	92,557	1,695	95,328
Peat	do.	20	746	18	730	10	207
Sand and gravel (construction)	do.	e19,500	e94,600	20,883	97,348	e18,300	e87,800
Stone:							
Crushed[4]	do.	93,123	455,004	e95,800	e502,700	70,334	362,306
Dimension	short tons	44,267	10,032	e43,952	e9,898	38,493	10,077
Combined value of clays [fire (1990), kaolin], mica (scrap), sand and gravel (industrial), stone [crushed granite (1989-90), crushed limestone, dolomite, and quartzite (1991)], and tripoli		XX	14,754	XX	15,125	XX	17,482
Total		XX	1,000,669	XX	1,030,042	XX	844,001

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
RHODE ISLAND							
Gemstones		NA	$2	NA	$2	NA	$1
Sand and gravel (construction)	thousand short tons	e1,100	e3,900	1,969	9,042	e1,300	e6,000
Stone (crushed)	do.	141,208	7,170	e 141,600	e8,800	1,187	7,262
Total[8]		XX	11,072	XX	17,844	XX	13,263
SOUTH CAROLINA							
Cement (portland)	thousand short tons	2,188	99,083	2,464	109,644	e2,215	e99,675
Clays	metric tons	1,596,153	39,075	2,062,824	44,486	1,709,205	25,662
Gemstones		NA	10	NA	10	NA	10
Sand and gravel:							
Construction	thousand short tons	e7,500	e23,300	8,627	24,941	e6,600	e18,900
Industrial	do.	842	16,635	844	15,972	822	16,348
Stone:							
Crushed[4]	do.	24,429	111,656	e26,200	e135,400	18,216	84,260
Dimension	short tons	W	W	W	W	8,829	854
Combined value of cement (masonry), gold, manganiferous ore, mica (scrap), peat, silver, stone [crushed shell (1989-90), crushed dolomite (1991)], vermiculite, and values indicated by symbol W		XX	135,538	XX	119,400	XX	92,436
Total		XX	425,297	XX	449,853	XX	338,145
SOUTH DAKOTA							
Gemstones		NA	150	NA	110	NA	W
Gold[5]	kilograms	16,123	198,318	r17,870	r221,157	16,371	191,217
Lead[5]	metric tons	4	3	—	—	—	—
Sand and gravel (construction)	thousand short tons	e6,400	e20,800	9,689	23,689	e8,700	e20,800
Silver[5]	metric tons	4	705	r10	r1,566	7	944
Stone:							
Crushed	thousand short tons	3,833	14,303	e4,800	e16,800	4,824	19,657
Dimension	short tons	54,623	17,738	e50,688	e12,871	W	W
Combined value of cement, clays (common), feldspar, gypsum (crude), iron ore (usable), lime, mica (scrap), and values indicated by symbol W		XX	32,341	XX	34,310	XX	57,304
Total		XX	284,358	XX	r310,503	XX	289,922
TENNESSEE							
Clays[3]	metric tons	1,137,152	$26,292	1,060,662	$25,776	828,635	$44,572
Sand and gravel (construction)	thousand short tons	e6,100	e21,900	7,619	23,474	e6,700	e21,100
Stone:							
Crushed	do.	52,917	252,785	e54,600	e268,600	44,088	223,561
Dimension	short tons	4,888	437	e10,108	e2,051	3,460	260
Combined value of barite (1989), cement, clays [common (1989,1991), fuller's earth], copper, gemstones, lead, lime, phosphate rock (1989-90), sand and gravel (industrial), silver, and zinc		XX	336,993	XX	r344,627	XX	258,294
Total		XX	638,407	XX	r664,528	XX	547,787

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
TEXAS							
Cement:							
Masonry	thousand short tons	133	$10,735	142	$10,106	W	W
Portland	do.	7,200	286,236	7,678	296,680	e7,498	e$289,341
Clays[3]	metric tons	2,276,629	15,962	2,162,095	14,652	2,265,746	13,247
Gypsum (crude)	thousand short tons	1,993	17,044	1,868	10,166	1,609	9,240
Lime	do.	1,304	60,829	1,337	76,181	1,373	69,400
Salt	do.	7,856	69,934	8,212	75,149	8,935	73,117
Sand and gravel:							
Construction	do.	e43,900	e155,800	46,083	158,080	e38,800	e135,800
Industrial	do.	1,661	29,107	1,849	40,880	1,557	27,002
Stone:							
Crushed	do.	76,823	252,982	e81,800	e285,700	65,813	226,836
Dimension	short tons	81,268	12,449	e84,500	e12,600	W	W
Sulfur (Frasch)	thousand metric tons	2,446	W	2,340	W	2,056	W
Talc and pyrophyllite	metric tons	241,777	4,564	227,138	4,844	212,887	4,561
Combined value of clays [ball (1989, 1991), bentonite (1990-91), fuller's earth (1990-91), kaolin], gemstones, helium (crude and Grade-A), iron ore (usable), magnesium compounds, magnesium metal, sodium sulfate (natural), and values indicated by symbol W		XX	546,812	XX	472,187	XX	416,117
Total		XX	1,462,454	XX	1,457,225	XX	1,264,661
UTAH							
Beryllium concentrates	metric tons	4,592	5	4,548	5	7,339	5
Clays	do.	321,949	2,633	e277,795	e1,774	e210,382	e1,028
Gemstones		NA	659	NA	713	NA	489
Lime	thousand short tons	373	17,974	354	18,878	325	18,634
Salt	do.	1,183	40,421	1,171	50,436	1,326	29,959
Sand and gravel:							
Construction	do.	e14,300	e41,500	13,601	44,881	e14,400	e48,200
Industrial	do.	3	60	2	42	—	—
Silver[5]	metric tons	W	W	147	22,750	W	W
Stone (crushed)	thousand short tons	4,683	19,176	e4,600	e20,200	4,450	18,259
Combined value of cement, clays [bentonite (1990-91)], copper, fluorspar (1990), gold, gypsum (crude), iron ore (usable), magnesium compounds, magnesium metal, mercury (1989-90), molybdenum, phosphate rock, potash, sodium sulfate (natural), vanadium ore (1989-90), and values indicated by symbol W		XX	1,168,065	XX	r1,174,213	XX	1,037,177
Total		XX	1,290,493	XX	1,333,892	XX	1,153,751

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
VERMONT							
Gemstones		NA	$10	NA	$10	NA	$5
Sand and gravel (construction)	thousand short tons	r6,900	r20,400	3,675	11,948	r3,000	r9,900
Stone:							
Crushed	do.	3,119	28,110	r3,700	r35,000	2,685	12,666
Dimension	short tons	100,698	31,413	r99,243	r28,950	92,676	31,013
Combined value of other industrial minerals		XX	8,969	XX	6,046	XX	6,236
Total		XX	88,902	XX	81,954	XX	59,820
VIRGINIA							
Clays[3]	metric tons	1,001,394	6,302	882,383	3,741	723,495	3,248
Gemstones		NA	27	NA	34	NA	70
Lime	thousand short tons	821	38,353	846	39,784	825	39,612
Sand and gravel (construction)	do.	r12,900	r49,700	13,096	48,950	r9,700	r36,900
Stone:							
Crushed	do.	64,061	328,050	r59,400	r320,000	48,861	260,966
Dimension	short tons	W	W	W	W	11,046	3,061
Combined value of aplite, cement, clays (fuller's earth), gypsum (crude), iron oxide pigments (crude), kyanite, sand and gravel (industrial), talc and pyrophyllite, vermiculite, and values indicated by symbol W		XX	86,669	XX	94,766	XX	84,188
Total		XX	509,101	XX	507,275	XX	428,045
WASHINGTON							
Clays	metric tons	233,267	1,591	158,257	1,357	263,374	2,633
Gemstones		NA	208	NA	281	NA	85
Gold[5]	kilograms	W	W	9,620	119,671	9,954	116,260
Sand and gravel (construction)	thousand short tons	r37,800	r124,700	40,251	133,067	40,200	140,700
Stone (crushed)	do.	13,259	55,624	r12,700	r41,900	13,126	59,588
Combined value of cement, diatomite, gypsum (crude), lead (1991), lime, magnesium metal, olivine, peat, sand and gravel (industrial), silver, stone (dimension), zinc (1991), and value indicated by symbol W		XX	298,756	XX	176,953	XX	163,393
Total		XX	480,879	XX	473,229	XX	482,659
WEST VIRGINIA							
Clays	metric tons	251,385	553	164,257	384	134,262	322
Gemstones		NA	1	NA	1	NA	2
Sand and gravel (construction)	thousand short tons	r2,300	r6,700	3,208	14,950	r3,100	r14,300
Stone (crushed)	do.	r4,10,904	r4,42,538	r4,12,000	r4,45,200	10,255	50,505
Combined value of cement, lime, peat (1990-91), salt, sand and gravel (industrial), and stone (crushed granite, 1989-90)		XX	75,706	XX	75,803	XX	51,802
Total		XX	125,498	XX	136,338	XX	116,931

See footnotes at end of table.

TABLE 6[1]—Continued

NONFUEL MINERAL PRODUCTION[2] IN THE UNITED STATES, BY STATE

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
WISCONSIN							
Gemstones		NA	W	NA	W	NA	$542
Lime	thousand short tons	437	$18,129	461	$24,608	536	23,225
Peat	do.	13	309	12	256	9	227
Sand and gravel:							
Construction	do.	e21,700	e56,400	29,572	73,750	e29,600	e77,500
Industrial	do.	1,514	22,399	W	W	W	W
Stone:							
Crushed	do.	26,520	83,664	e26,600	e91,000	r23,676	r80,475
Dimension	short tons	35,587	4,376	e31,316	e3,811	r37,470	r4,347
Combined value of other industrial minerals and value indicated by symbol W		XX	([12])	XX	18,622	XX	27,533
Total		XX	e185,277	XX	212,047	XX	213,849
WYOMING							
Clays[3]	metric tons	2,166,497	74,697	2,523,573	76,082	2,496,361	81,573
Gemstones		NA	157	NA	151	NA	61
Lime	thousand short tons	W	W	W	W	37	2,729
Sand and gravel (construction)	do.	e4,500	e15,400	4,329	14,446	e3,500	e11,900
Stone (crushed)	do.	2,990	12,120	e2,200	e14,000	2,946	12,645
Combined value of cement [masonry (1989-90), portland], clays (common), gypsum (crude), helium (Grade-A), soda ash, and values indicated by symbol W		XX	724,987	XX	806,169	XX	820,268
Total		XX	827,361	XX	910,848	XX	929,176
UNDISTRIBUTED							
Delaware, Hawaii, New Hampshire, North Dakota (1991), Rhode Island, Wisconsin (1989), and Undistributed (1989, 1991)		XX	9,043	XX	5,938	XX	7,386

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data, value included with "Combined value." XX Not applicable.

[1] This table had been table 5 in previous issues of the Minerals Yearbook.

[2] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[3] Excludes certain clays; kind and value included with "Combined value."

[4] Excludes certain stones; kind and value included with "Combined value."

[5] Recoverable content of ores, etc.

[6] Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

[7] Less than 1/2 unit.

[8] Partial total, excludes values that must be concealed to avoid disclosing company proprietary data. Values excluded from partial total included with "Undistributed States."

[9] Excludes salt in brines; value included with "Combined value."

[10] Palladium metal separated from platinum-group metals in 1990: 1989 data revised.

[11] Platinum metal separated from platinum-group metals in 1990: 1989 data revised.

[12] Value excluded to avoid disclosing company proprietary data.

[13] Data series revised to exclude nonnickel ore.

[14] Excludes traprock.

TABLE 7[1]

NONFUEL MINERAL PRODUCTION[2] IN THE COMMONWEALTH OF PUERTO RICO AND ISLANDS ADMINISTERED BY THE UNITED STATES

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
PUERTO RICO							
Cement (portland)	thousand short tons	1,374	$112,318	1,486	$122,027	e1,382	e$110,560
Clays	metric tons	136,873	311	W	W	145,483	355
Lime	thousand short tons	26	3,800	29	3,483	30	4,440
Sand and gravel (industrial)	do.	30	600	55	825	55	825
Stone (crushed)	do.	8,389	46,648	NA	NA	8,828	49,839
Total		XX	163,677	XX	[3]126,335	XX	166,019
ADMINISTERED ISLANDS							
American Samoa: Stone (crushed)	thousand short tons	48	476	—	—	69	756
Guam: Stone (crushed)	do.	1,063	11,133	—	—	2,201	18,038
Virgin Islands : Stone (crushed)	do.	312	3,159	—	—	W	W
Total		XX	14,768	XX	—	XX	18,794

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

[1]This table is a compilation of previous Minerals Yearbook tables 6 and 7.

[2]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[3]Total does not include value of item withheld.

TABLE 8

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS					
Aluminum:					
Aluminum oxide (alumina)	thousand metric tons	1,263	$425,712	1,351	$408,367
Crude and semicrude	metric tons	1,659,124	3,294,938	1,762,287	3,356,065
Manufactures	do.	1,696,203	3,429,659	1,824,468	3,557,070
Speciality compounds (aluminum sulfate, aluminum oxide abrasives, and various fluorine-base compounds)	do.	20,722	19,428	39,200	45,630
Antimony:					
Metal, alloys, waste and scrap	do.	588	1,143	694	1,138
Oxide (antimony content)	do.	7,142	13,962	3,752	7,404
Bauxite (dried and calcined)	thousand metric tons	74	12,644	44	9,148
Beryllium [alloys (wrought or unwrought), and waste and scrap]	kilograms	45,227	4,831	33,122	2,690
Bismuth metal (alloys, waste and scrap)	do.	121,677	878	74,597	641
Cadmium metal (alloys, dross, flue dust, residues, and scrap)	metric tons	385	1,174	158	218
Chromium:					
Chemicals	do.	22,500	26,449	23,237	30,514
Chromite ore and concentrate	do.	6,321	1,488	8,759	2,041
Metal and alloys	do.	9,456	13,984	11,073	16,398
Pigments	do.	2,643	9,252	1,969	7,423
Cobalt:					
Metal (unwrought, powders, waste and scrap, and mattes and other intermediate metallurgy products)	do.	543	8,880	543	13,963
Metal (wrought and cobalt articles)	do.	481	12,300	323	13,400
Ores and concentrates	do.	49	416	9	231
Oxides and hydroxides	do.	922	6,776	1,102	10,623
Other forms (acetates and chlorides)	do.	542	2,477	822	5,866
Columbium:					
Ferrocolumbium	thousand kilograms	585	5,495	741	6,952
Ores and concentrates	do.	48	337	8	55
Copper:					
Scrap (alloy and unalloyed)	metric tons	324,390	520,141	306,593	446,363
Semimanufactures [bare wire (includes wire rod), bars, cable foil, oxides, hydroxides, pipes, plates, sheets, tubing, and wire (stranded)]	do.	68,519	278,528	77,438	306,873
Sulfate	do.	559	NA	827	2,361
Unmanufactures (ash, anodes, blister, concentrates, matte, ore, precipitates, refined, and unalloyed scrap, copper content)	do.	647,154	1,239,714	679,654	1,215,720
Gold:					
Bullion (refined)	kilograms	140,923	1,719,470	174,377	2,038,850
Doré and precipitates	do.	88,203	413,980	45,536	486,266
Ores and concentrates	do.	328	3,721	10	98
Wastes and scrap	do.	66,943	729,150	64,204	653,748
Indium	do.	NA	NA	NA	NA
Iron ore:					
Ore and agglomerates	thousand metric tons	3,199	124,076	4,045	156,242
Iron and steel:					
Cast iron and steel products	do.	172	315,114	165	338,944
Direct-reduced iron	do.	63	38,103	22	33,845
Fabricated steel products	do.	578	1,580,893	645	1,742,491

See footnotes at end of table.

TABLE 8—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS—Continued					
Iron and steel—Continued:					
Ferroalloys not elsewhere listed:					
Ferrophosphorous	metric tons	5,981	$2,344	2,872	$1,822
Ferrozirconium	do.	88	74	95	138
Ferroalloys (n.e.c.)	do.	3,893	5,229	2,800	4,112
Pig iron	thousand metric tons	14	1,618	15	1,700
Steel mill products	do.	3,904	2,768,712	5,757	3,671,704
Iron and steel scrap [includes mixed rails (new and used) for rerolling and other uses, and ships, boats, and other vessels for scrapping]	do.	11,657	1,657,884	9,514	1,257,388
Lead:					
Ash and residues (lead content)	metric tons	12,765	8,096	11,828	4,106
Ore and concentrate (lead content)	do.	56,600	33,369	87,953	25,159
Scrap	do.	75,507	33,934	93,262	26,574
Unwrought metal and alloys (lead content)	do.	57,226	59,080	94,428	69,982
Wrought metal and alloys (lead content)	do.	6,759	19,923	7,615	20,614
Magnesium:					
Alloys	do.	4,633	16,050	3,233	10,132
Metal	do.	41,882	124,714	42,859	119,848
Powder, sheets, tubing, ribbons, wire, and other forms and other forms	do.	4,352	21,127	8,149	18,046
Waste and scrap	do.	967	2,522	919	2,304
Manganese:					
Ferromanganese (all grades)	short tons	8,302	6,565	16,064	15,414
Metal (alloys, waste, and scrap)	do.	6,773	14,043	5,811	12,658
Ore and concentrates	do.	77,101	9,297	73,074	8,523
Silicomanganese	do.	1,974	1,666	3,167	2,802
Mercury metal	metric tons	311	2,440	786	3,144
Molybdenum (molybdenum content):					
Ferromolybdenum	do.	300	2,372	375	3,058
Ore and concentrates	do.	41,380	169,888	33,424	113,709
Oxides and hydroxides	do.	787	5,095	1,571	9,678
Molybdates (all)	do.	680	3,963	740	3,965
Powder	do.	292	4,565	230	4,907
Unwrought	do.	180	2,453	88	1,204
Wire	do.	338	12,863	360	12,053
Wrought	do.	190	7,595	110	5,570
Nickel (nickel content):					
Unwrought					
Primary [anodes (electroplating), briquets, cathodes, chemicals (catalysts and salts), ferronockel, flakes, oxide sinter, pellets, powder, and shot]	do.	8,873	77,047	9,104	91,359
Secondary (stainless steel and scrap)	do.	37,057	338,770	36,902	334,764
Wrought (bars, foil, pipes, profiles, rods, sheets, strips, tubes, and wire)	do.	465	5,937	354	5,756
Platinum-group metals (iridium, osmium, palladium, platinum, rhodium, ruthenium, and waste and scrap)	kilograms	55,044	415,605	39,624	461,588
Rare-earth metals (rare-earth oxide content):					
Cerium compounds	do.	1,729,771	9,983	1,368,535	8,195
Compounds (inorganic and organic)	do.	2,085,214	18,010	1,793,092	20,954
Ferrocerium and pyrophoric alloys	do.	2,033,217	8,685	2,099,616	9,343

See footnotes at end of table.

TABLE 8—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS—Continued					
Rare-earth metals (rare-earth oxide content)—Continued:					
Metals (includes scandium and yttrium)	kilograms	201,122	$1,249	59,035	$2,683
Ores and concentrates	metric tons	NA	NA	459	NA
Selenium (metal, waste and scrap, selenium content)	kilograms	194,608	1,283	210,495	1,939
Silicon:					
Ferrosilicon	metric tons	50,079	43,993	50,393	43,008
Metal	do.	8,980	92,229	8,246	112,323
Silver:					
Bullion (refined)	kilograms	735,993	119,892	787,474	115,224
Doré and precipitates	do.	13,184	2,353	53,128	8,486
Ores and concentrates	do.	21,861	3,994	299	49
Waste and scrap	do.	1,077,421	159,194	840,229	124,015
Tantalum:					
Ores and concentrates (includes synthetic)	thousand kilograms	14	138	11	248
Unwrought (alloys, metal, powders, and waste and scrap) waste and scrap)	do.	183	29,200	208	27,646
Wrought	do.	60	20,068	77	26,580
Thorium:					
Compounds	kilograms	220	68	2,649	154
Tin:					
Ingots and pigs	metric tons	658	3,344	970	5,455
Tin scrap and other tin-bearing material, except tinplate scrap, (includes bars, rods, profiles, wire, powders, flakes, tubes, and pipes)	do.	106,389	55,921	121,359	88,327
Tinplate and terneplate	do.	145,396	78,687	150,187	89,677
Titanium:					
Metal:					
Scrap	do.	5,487	22,443	4,568	10,706
Sponge	do.	331	2,073	418	2,604
Other unwrought (billet, blooms and sheet bars, ingots, etc.)	do.	5,472	69,235	3,845	47,833
Wrought (bars, rods, etc.)	do.	4,526	148,290	3,300	113,060
Ores and concentrates	do.	18,765	7,398	26,912	10,167
Pigments (dioxides and oxides)	do.	202,288	434,560	189,679	349,516
Tungsten (tungsten content):					
Ammonium paratungstate	do.	356	2,456	770	4,114
Carbide powder	do.	1,074	21,946	839	18,880
Metal and alloy powder	do.	988	18,587	689	13,947
Miscellaneous tungsten-bearing materials [ferrotungsten and ferrosilicon tungsten, unwrought, wire (metal and alloy), wrought, other compounds (other tungstates), and other metal]	do.	795	36,683	822	40,037
Ore and concentrate	do.	139	765	21	165
Vanadium:					
Aluminum-vanadium master alloy	kilograms	381,595	7,468	170,392	4,344
Compounds [pentoxide (includes catalysts), and other (excludes vanadates), vanadium content]	do.	2,437,934	16,166	1,810,150	10,957
Ferrovanadium	do.	334,272	5,480	178,027	2,454

See footnotes at end of table.

TABLE 8—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS—Continued					
Zinc:					
Blocks, pigs, anodes, etc. (unwrought and unwrought alloys)	metric tons	5,804	$11,304	5,477	$8,680
Compounds	do.	8,089	39,182	9,659	42,346
Dust and flakes	do.	8,701	17,039	5,737	8,247
Ore and concentrate	do.	220,446	188,686	381,416	221,948
Oxide	do.	7,141	10,032	6,653	8,756
Waste and scrap (zinc content)	do.	109,316	85,749	96,314	61,706
Wrought zinc and zinc alloys (angles, bars, pipes, plates, rods, strips, etc.)	do.	15,612	18,541	16,536	22,466
Zirconium:					
Ore and concentrates	do.	30,195	21,101	31,333	20,607
Unwrought waste and scrap	do.	188	3,057	238	5,785
Total metals[1]		XX	21,926,000	XX	22,955,000
INDUSTRIAL MINERALS					
Abrasive materials (includes reexports):					
Natural		XX	144,613	XX	158,518
Manufactured		XX	150,860	XX	161,433
Asbestos (includes reexports):					
Manufactured		XX	120,328	XX	116,015
Unmanufactured	metric tons	27,965	7,964	25,636	7,424
Barite: Natural barium sulfate	do.	9,227	1,675	43,296	3,304
Boron:					
Boric acid	thousand metric tons	39	31,679	47	35,457
Sodium borates	do.	585	208,433	554	205,722
Bromine:					
Compounds (contained bromine)	thousand kilograms	14,443	18,166	14,555	21,280
Elemental	do.	2,932	4,008	2,563	7,665
Calcium chloride	metric tons	23,300	6,591	30,568	8,030
Cement: Hydraulic and clinker	thousand short tons	554	38,306	697	45,773
Clays and clay products	thousand metric tons	4,123	584,404	3,997	590,174
Diatomite	do.	144	42,329	152	45,187
Feldspar	do.	24,795	2,167	8,425	1,334
Fluorspar	do.	14,921	1,891	73,943	16,424
Gemstones (includes reexports):					
Diamonds (excludes industrial diamond)	thousand carats	1,215,420	1,432,600	1,839,583	1,382,700
Graphite:					
Artificial (includes artificial, and colloidal or semicolloidal)[3]	metric tons	33,085	31,625	37,662	29,876
Natural (amorphous, crystalline flake, lump or chip, and natural n.e.c.)	do.	11,537	9,481	19,374	11,345
Gypsum:					
Boards	thousand short tons	69	30,959	105	36,943
Crude	do.	129	5,056	74	3,720
Plasters	do.	94	18,381	96	19,872
Other	do.	XX	30,056	XX	25,077
Helium (Grade-A)	million cubic meters	25	33,450	27	36,504
Iodine:					
Crude	thousand kilograms	NA	NA	1,358	15,784
Potassium iodide	do.	NA	NA	105	398

See footnotes at end of table.

TABLE 8—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS—Continued					
Iron oxide pigments:					
Pigment grade	metric tons	9,535	$18,694	20,606	$33,816
Other grade	do.	199,470	111,081	164,084	109,463
Lime	short tons	44,287	4,755	41,975	4,659
Lithium compounds:					
Lithium carbonate	kilograms	9,312,903	30,160	9,564,674	31,273
Lithium hydroxide	do.	3,147,248	12,953	3,078,922	12,998
Lithium metal	do.	111,737	NA	57,373	NA
Magnesium:					
Calcined dolomite	metric tons	10,379	2,213	16,702	3,349
Caustic-calcined magnesia	do.	2,313	1,406	3,640	2,289
Compounds (chlorides, hydroxide and peroxide, and sulfates)	do.	14,162	14,165	8,913	8,022
Dead-burned and fused magnesia	do.	58,610	19,709	66,292	25,038
Magnesite (crude)	do.	8,009	8,060	7,961	5,567
Other magnesia	do.	37,747	16,108	25,149	13,985
Mica:					
Scrap and flake:					
Powder	do.	4,319	2,050	3,420	1,717
Waste	do.	580	646	874	331
Sheet:					
Unworked	do.	148	272	205	309
Worked	do.	612	7,568	411	7,454
Nitrogen compounds (major):					
Anhydrous ammonia	thousand short tons	522	NA	603	NA
Fertilizer materials	do.	13,032	NA	15,177	NA
Industrial chemicals	do.	89	126,658	149	110,131
Perlite (crude)	short tons	e35,000	e956	e32,000	e852
Phosphorus:					
Diammonium and monoammonium phosphates	thousand metric tons	8,493	1,414,219	10,505	1,847,926
Elemental phosphorous	metric tons	17,916	29,620	17,018	30,421
Phosphate rock:					
Ground	thousand metric tons	1,084	38,695	219	13,078
Unground	do.	5,875	215,409	5,530	246,755
Phosphoric acid	do.	555	95,881	440	76,342
Superphosphates	do.	747	100,630	946	125,989
Potash:					
Potassium chloride, all grades	metric tons	445,800	46,500	730,600	NA
Potassium sulfate	do.	243,700	43,300	203,300	NA
Potassium magnesium sulfate	do.	318,200	41,400	306,400	NA
Potassium nitrate	do.	7,841	5,000	15,910	NA
Pumice and pumicite	thousand metric tons	20	483	13	290
Quartz crystal:					
Cultured	thousand kilograms	39	1,745	53	2,620
Natural	do.	NA	NA	NA	NA
Salt	thousand short tons	2,498	32,944	1,959	29,875

See footnotes at end of table.

TABLE 8—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS—Continued					
Sand and gravel:					
Construction:					
Gravel	thousand short tons	NA	NA	700	$6,043
Sand	do.	468	$11,880	439	1,301
Industrial	do.	1,155	83,826	1,637	106,606
Sodium compounds:					
Soda ash	thousand metric tons	2,392	346,693	2,734	409,088
Sodium sulfate	do.	62	6,704	103	11,495
Stone:					
Crushed	thousand short tons	5,100	41,400	2,415	33,003
Dimension		NA	54,019	NA	64,947
Strontium compounds (precipitated carbonate, oxide, hydroxide, and peroxide)	kilograms	2,882,105	2,298	1,800,221	1,765
Sulfur:					
Elemental	thousand metric tons	972	109,327	1,196	119,713
Sulfuric acid (100% H_2SO_4)	metric tons	161,509	11,515	148,872	11,806
Talc (excludes talcum in packages, face, and compact)	thousand metric tons	238	32,909	178	30,050
Vermiculite	thousand short tons	20	NA	11	NA
Total industrial minerals[1]		XX	6,099,000	XX	6,526,000
Total[1]		XX	28,025,000	XX	29,481,000

[r]Estimated. [r]Revised. NA Not available. XX Not applicable.

[1]Data may not add to totals shown because of rounding.

[2]Artificial graphite includes large amounts of materials made from petroleum coke.

TABLE 9

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS					
Aluminum:					
Aluminum oxide (alumina)	thousand metric tons	4,069	$1,268,973	4,592	$1,102,008
Crude and semicrude	metric tons	1,514,147	2,699,773	1,489,600	2,268,296
Manufactures	do.	1,559,503	2,854,340	1,532,886	2,411,269
Antimony:					
Metal	do.	13,940	23,380	13,502	23,841
Ore and concentrate (antimony content)	do.	3,454	4,835	3,381	5,250
Oxides (antimony content)	do.	12,012	19,574	11,950	18,941
Arsenic:					
Acid	do.	21	31	374	427
Metal	do.	796	4,091	1,008	2,899
Sulfides	do.	—	—	(1)	31
Trioxide	do.	26,256	12,570	27,142	14,320
Bauxite:					
Calcined	thousand metric tons	558	37,205	376	25,198
Crude and dried	do.	12,142	NA	11,793	NA
Beryllium:					
Beryl	metric tons	342	418	288	394
Metal and compounds	kilograms	111,185	1,031	118,343	822
Bismuth metals and alloys	do.	1,611,862	11,747	1,411,394	7,876
Cadmium metal	metric tons	1,741	11,904	2,039	7,928
Chromium:					
Chemicals	do.	10,130	24,136	11,987	10,875
Chromite	do.	305,506	22,150	212,139	14,963
Metals and alloys	do.	426,358	292,216	411,602	278,897
Pigments and preparations based chromium	do.	5,652	13,708	4,939	13,453
Cobalt:					
Metal (unwrought, unwrought alloys, waste and scrap, mattes and other intermediate metallurgy products)	do.	6,342	111,106	6,844	165,227
Metal (wrought and cobalt articles)	do.	48	3,729	105	5,503
Oxide and hydroxides	do.	488	8,539	583	12,941
Other forms (sulfates, chlorides, carbonates and acetates)	do.	547	3,227	448	3,482
Columbium:					
Ferrocolumbium	thousand kilograms	2,919	24,685	3,282	27,415
Ores and concentrates	do.	2,251	7,898	2,515	8,445
Oxide	do.	973	15,348	603	10,210
Unwrought (alloys, metals, and powders)	do.	2	149	1	103
Copper:					
Scrap (alloy and unalloyed)	metric tons	134,614	273,753	125,928	216,305
Semimanufactures [bare wire (includes wire rod), bars, cable (stranded), foil, hydroxides, oxides, pipes, plates, tubing, sheets, and wire (stranded)]	do.	87,562	361,477	69,467	294,825

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
		METALS—Continued			
Copper—Continued:					
Unmanufactures (anode, ash, blister, concentrates, matte, ore, precipitates, refined, and scrap [unalloyed], copper content)	metric tons	441,308	$1,030,828	442,027	$962,387
Gallium	kilograms	9,894	3,250	11,271	3,829
Germanium materials	do.	49,789	27,971	26,834	11,999
Gold:					
Bullion (refined)	do.	64,755	795,007	147,491	1,721,576
Doré and precipitates	do.	4,245	50,635	5,597	66,735
Ore and concentrates	do.	5,346	8,355	992	10,874
Wastes and scrap	do.	23,173	206,975	24,668	126,264
Hafnium (unwrought waste and scrap)	metric tons	9	1,662	3	489
Indium (unwrought waste and scrap)	kilograms	30,158	6,555	36,288	7,867
Iron ore:					
Ore and agglomerates	thousand metric tons	18,054	559,525	13,335	436,777
Pellets	do.	9,875	355,470	9,317	338,493
Iron and steel:					
Cast iron and steel products	do.	215	212,769	187	195,644
Direct-reduced iron	do.	385	87,469	423	97,897
Fabricated steel products	do.	2,016	3,054,601	1,709	2,705,856
Ferroalloys not elsewhere listed:					
Ferrophosphorus	metric tons	237	526	6,713	1,835
Ferrotitanium and ferrosilicon-titanium	do.	1,960	9,202	1,166	3,819
Ferrozirconium	do.	—	—	288	483
Ferroalloys (n.e.c.)	do.	2,404	8,351	16,485	24,749
Pig iron	thousand metric tons	347	60,069	434	75,261
Steel mill products	do.	15,575	8,344,593	14,280	9,060,231
Iron and steel scrap (includes used rail for rerolling and other uses)	do.	1,464	196,658	1,166	158,725
Lead:					
Base bullion (lead content)	metric tons	2,713	1,636	419	283
Miscellaneous products (lead content)	do.	515	6,782	1,154	4,133
Ore and concentrates (lead content)	do.	10,668	5,167	12,437	4,466
Pigments and compounds	do.	23,082	33,110	23,946	29,967
Pigs and bars (lead content)	do.	90,638	74,395	116,473	69,351
Reclaimed scrap (includes ash and residues, lead content) dues, lead content)	do.	281	102	117	28
Wrought (all forms, including wire and powders, gross weight)	do.	6,723	9,944	5,792	8,460
Magnesium:					
Waste and scrap	do.	4,075	8,137	4,150	4,653
Metal	do.	16,139	47,025	21,758	52,186
Alloys (magnesium content)	do.	5,344	20,726	4,596	15,903
Powders, sheets, tubing, ribbons, wire, and other forms (magnesium content)	do.	1,197	4,420	1,359	4,866

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
		METALS—Continued			
Manganese:					
Chemicals (manganese dioxide and potassium permanganate)	short tons	9,806	$12,453	23,138	$30,724
Metal	do.	14,279	19,741	17,407	24,509
Ore and concentrates (manganese content)	do.	328,360	80,108	258,504	80,664
Ferromanganese (all grades, manganese content)	do.	656,704	468,658	552,198	378,324
Silicomanganese (manganese content)	do.	163,075	117,847	187,155	130,677
Mercury (metal, mercury-bearing waste and scrap)	metric tons	15	231	56	301
Molybdenum (molybdenum content):					
Ferromolybdenum	do.	871	6,990	953	7,304
Ore and concentrates	do.	478	3,184	161	882
Oxides and hydroxides (gross weight)	do.	643	3,569	948	5,013
Molybdates (all)	do.	63	627	77	772
Powder	do.	71	1,771	28	821
Unwrought	do.	39	2,147	45	1,596
Wire (gross weight)	do.	3	249	2	211
Wrought (gross weight)	do.	61	4,217	53	3,275
Other (inorganic compounds, orange, waste and scrap, and other, gross weight)	do.	1,133	5,268	1,186	6,237
Nickel (nickel content):					
Unwrought					
Primary [briquets, cathodes, chemicals (catalysts and salts), ferronickel, flakes, oxide sinter, pellets, powder, and shot]	do.	131,116	1,177,634	132,445	1,123,536
Secondary (stainless steel scrap and waste and scrap)	do.	142,749	1,255,682	138,657	1,182,174
Wrought (bars, foil, pipes, profiles, rods, sheets, strips, tubes, and wire)	do.	1,035	15,495	1,131	16,880
Platinum-group metals (iridium, osmium, palladium, platinum, rhodium, ruthenium, ores, and waste and scrap)	kilograms	125,354	1,905,830	125,661	1,742,866
Rare-earth metals (rare-earth oxide content):					
Cerium compounds (includes chlorides, hydroxides, nitrates, oxides, oxilate, and sulfates)	do.	359,230	2,040	544,962	4,913
Compounds (includes hydroxides, nitrates, oxides, and others, except chlorides)	do.	4,989,646	37,325	3,693,163	34,079
Chloride mixtures (except cerium chloride)	do.	1,362,951	12,813	3,377,242	8,890
Ferrocerium and other pyrophoric alloys	do.	93,130	1,495	92,997	1,424,071
Monazite	metric tons	440	686	—	—
Oxide mixtures (except cerium oxides)	kilograms	150,728	8,018	892,277	13,138
Rare-earth metals (whether intermixed or alloyed)	do.	198,840	3,050	225,820	3,329
Rhenium:					
Ammonium perrhenate	do.	3,002	2,127	3,513	2,815
Metal	do.	5,888	6,864	10,847	13,316

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS—Continued					
Selenium:					
Selenium dioxide (selenium content)	kilograms	5,108	$67	14,439	$208
Unwrought and waste and scrap (selenium content)	do.	377,785	8,286	333,289	7,815
Silicon:					
Ferrosilicon	metric tons	238,983	134,993	183,214	93,455
Metal	do.	66,383	114,385	43,386	100,373
Silver:					
Bullion (refined)	kilograms	2,697,926	437,380	2,525,133	338,514
Doré and precipitates	do.	48,449	8,741	151,836	25,740
Ore and concentrates	do.	90,202	23,203	21,422	3,659
Waste and scrap	do.	507,649	86,421	1,452,501	153,299
Tantalum:					
Ores and concentrates (includes synthetic)	thousand kilograms	1,067	27,053	1,000	20,609
Unwrought (alloys, metal, powders, and waste and scrap)	do.	96	9,761	137	11,462
Wrought	do.	3	1,028	2	765
Tellurium (unwrought and waste and scrap)	kilograms	34,012	3,928	29,255	3,073
Thallium (unwrought waste and scrap)	do.	450	61	1,013	184
Thorium:					
Compounds	do.	18,598	595	42,609	1,270
Ore and concentrate	metric tons	800	686	—	—
Ore metal (excludes monazite)	kilograms	188,624	33	205,100	31
Tin:					
Compounds	metric tons	426	2,493	245	1,906
Concentrates (tin content)	do.	—	—	1	6
Dross, skimmings, residues, scrap, tin alloys, n.s.p.f.	do.	6,788	35,291	5,855	33,132
Metal (unwrought)	do.	33,810	215,863	29,102	161,725
Tinfoil, powder, flitters, metallics and manufactures, n.s.p.f.	do.	XX	2,086	XX	1,867
Tinplate and terneplate	do.	293,426	199,036	276,326	195,659
Tinplate scrap	do.	8,488	1,782	10,109	2,240
Titanium:					
Concentrates:					
Ilmenite	do.	345,907	22,962	213,886	24,071
Rutile, natural and synthetic	do.	274,605	127,664	127,664	127,664
Titaniferous iron ore	do.	2,818	2,169	27,012	1,593
Titanium slag	do.	373,623	89,450	408,302	105,792
Metal:					
Ingots and billets	do.	162	47	24	1,095
Powder	do.	20	526	34	697
Unwrought	do.	1,093	10,398	612	5,451

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS—Continued					
Titanium—Continued:					
Metal—Continued:					
Waste and scrap	metric tons	3,037	$17,550	2,666	$8,503
Wrought bars, castings, foil, pipes, plates, profiles, rods, sheet, strip, tubes, wire, and other)	do.	1,266	35,746	914	24,014
Other (includes bars, blooms, sheet, slabs, and other unwrought)	do.	193	2,359	141	1,561
Pigments (dioxides and oxides)	do.	147,592	279,602	166,094	285,290
Tungsten (tungsten content):					
Ammonium tungstate	do.	462	3,463	842	6,756
Ferrotungsten	do.	493	2,739	525	3,128
Miscellaneous tungsten-bearing materials (carbide, chlorides, oxides, metal-bearing materials, tungstates, unwrought, waste and scrap, and wrought)	do.	2,620	46,307	6,246	71,114
Ore and concentrates	do.	6,420	31,301	7,837	43,269
Vanadium:					
Ferrovanadium (vanadium content)	kilograms	244,250	3,720	419,573	5,367
Pentoxide (anhydride, vanadium content)	do.	82,627	719	132,904	943
Vanadium-bearing materials [ash and residues, slag, other (includes spent catalyst), pentoxide content]	do.	6,866,041	12,657	2,063,523	5,187
Zinc:					
Blocks, pigs, slabs	metric tons	631,742	991,562	549,137	619,880
Dross, ashes, and fume (zinc content)	do.	6,411	5,942	6,483	4,658
Dust, powder, flakes	do.	8,834	17,724	15,424	26,169
Ore and concentrates (zinc content)	do.	46,684	17,970	45,419	22,110
Sheets, plates, strips, and other forms	do.	929	1,641	539	877
Waste and scrap	do.	31,720	15,101	31,596	14,185
Oxide	do.	49,454	71,998	38,215	43,712
Compounds	do.	11,653	11,451	9,891	9,553
Other (anodes, manufactures, and unwrought alloys)	do.	XX	7,772	XX	22,765
Zirconium:					
Ore and concentrates	do.	26,783	12,407	35,706	13,772
Unwrought waste and scrap	do.	128	880	197	1,347
Totals[2]		XX	31,657,000	XX	32,068,000
INDUSTRIAL MINERALS					
Abrasive materials (natural and artifical)		XX	512,766	XX	480,880
Asbestos fibers	metric tons	41,348	10,772	34,765	8,900
Barite:					
Barium chemicals	do.	28,429	22,165	29,382	22,551
Crude and ground	do.	1,044	46,300	887,205	41,304
Witherite	do.	34	23	18	8
Boron (contained boric oxide):					
Boric acid	thousand metric tons	6	3,921	5	3,784

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS—Continued					
Boron (contained boric oxide)—Continued:					
Colemanite	thousand metric tons	12	$3,310	18	$4,389
Ulexite	do.	29	7,360	16	4,060
Bromine:					
Compounds	thousand kilograms	20,359	64,512	15,880	71,322
Elemental	do.	756	508	146	199
Calcium:					
Metal	kilograms	651,000	3,779	821,457	5,238
Chloride (crude)	metric tons	145,534	21,541	124,094	18,610
Other compounds	do.	57,286	44,871	84,119	45,031
Cement: Hydraulic and clinker	thousand short tons	13,273	533,047	8,701	402,578
Clays and clay products	thousand metric tons	30	11,988	35	13,249
Diatomite	metric tons	625	294	436	162
Feldspar	do.	11,318	723	17,876	1,124
Fluorspar:					
Aluminum fluoride	do.	35,604	40,295	33,326	33,424
Cryolite	do.	7,306	6,775	3,359	3,448
Fluorspar	do.	513,921	65,938	371,407	49,435
Hydrofluoric acid	do.	101,792	109,384	82,370	89,067
Gemstones:					
Coral and similar materials (unworked)	thousand carats	2,792	7,504	2,556	6,746
Diamond	do.	7,528	3,955,222	8,482	3,992,023
Emeralds (cut but unset)	do.	3,720	162,375	3,939	165,508
Pearls (natural, cultured, and imitation)		NA	26,645	NA	23,737
Rubies and sapphires (cut but unset)	thousand carats	5,817	180,375	5,880	152,475
Other precious or semiprecious stones		NA	271,266	NA	294,168
Graphite:					
Natural (amorphous, crystalline flake, lump or chip, and natural n.e.c.)	metric tons	50,213	35,222	33,544	21,662
Electrodes (electric furnace)	do.	38,317	63,499	26,871	45,635
Gypsum:					
Crude	thousand short tons	8,726	61,009	7,633	52,070
Plasters	do.	1	236	11	258
Boards	do.	272	22,786	88	7,842
Other	do.	XX	26,174	XX	27,971
Iodine:					
Crude	thousand kilograms	3,139	43,256	3,503	35,594
Potassium iodide	do.	29	297	52	502
Iron oxide pigments:					
Natural	metric tons	1,956	1,359	3,288	1,624
Synthetic	do.	32,141	35,918	31,437	37,736
Kyanite (andalucite)	do.	17,700	2,942	5,140	933
Lime:					
Hydrated	short tons	29,920	2,147	26,588	1,977
Other lime	do.	143,277	8,245	147,339	9,091

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS—Continued					
Lithium:					
Carbonate	kilograms	4,196,834	$8,381	3,109,83	$7,414
Hydroxide	do.	471	20	20,375	128
Magnesium compounds:					
Calcined dolomite	metric tons	38,441	3,639	27,852	3,370
Caustic-calcined magnesia	do.	83,885	13,957	107,848	15,891
Compounds (chlorides, hydroxide and peroxide, and sulfates)	do.	33,046	9,238	34,384	9,921
Dead-burned and fused magnesia	do.	155,010	32,858	146,530	30,209
Magnesite (crude)	do.	1,957	722	1,956	712
Other magnesia	do.	5,037	8,573	4,109	7,712
Mica:					
Scrap and flake:					
Powder	do.	9,142	5,133	9,725	5,219
Waste	do.	4,034	987	3,630	996
Sheet:					
Unworked	do.	1,615	2,051	1,422	1,608
Worked	do.	1,085	7,431	918	6,835
Nepheline syenite (crushed and ground)	do.	276,000	12,200	289,000	13,069
Nitrogen compounds:					
Anhydrous ammonia	thousand short tons	1,821	178,951	2,184	232,894
Fertilizer materials	do.	7,719	847,304	7,159	822,102
Industrial chemicals	do.	71	65,852	64	59,444
Peat moss (poultry and fertilizer grade)	short tons	598,802	87,533	631,845	96,132
Perlite (crude)	do.	e65,000	e1,775	e60,000	e1,597
Phosphate rock and phosphate materials	thousand metric tons	477	46,365	574	50,620
Potash:					
Potassium chloride	metric tons	6,816,000	520,000	7,348,700	528,500
Potassium nitrate	do.	36,100	10,100	22,300	6,000
Potassium sulfate	do.	51,900	9,500	57,000	10,100
Potassium sodium nitrate mixtures	do.	47,800	5,500	39,000	5,000
Pumice:					
Crude or unmanufactured	do.	266,604	7,858	86,423	10,047
Wholly or partially manufactured	do.	13,704	2,021	2,850	1,382
Quartz crystal (lacas)	thousand kilograms	NA	NA	NA	NA
Salt	thousand short tons	6,580	88,419	6,821	87,380
Sand and gravel:					
Construction	do.	1,742	22,912	1,465	16,638
Industrial	do.	73	3,148	91	932
Sodium compounds:					
Soda ash	metric tons	145,534	20,495	134,312	21,299
Sodium sulfate	do.	161,665	13,155	156,900	13,807
Stone:					
Crushed (chips and fines)	thousand short tons	4,972	35,310	5,728	38,649
Dimension		NA	567,019	NA	462,778

See footnotes at end of table.

TABLE 9—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS

Mineral		1990[r]		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS—Continued					
Strontium:					
Celestite (strontium sulfate)	metric tons	48,724	$4,189	33,204	$2,577
Compounds (carbonate and nitrate)	kilograms	20,162,343	12,982	16,629,319	10,803
Sulfur:					
Elemental	thousand metric tons	2,571	206,450	3,020	241,749
Sulfuric acid (100% H_2SO_4)	metric tons	1,689,618	62,581	1,845,255	57,727
Talc (unmanufactured)	do.	65,099	11,056	66,791	11,925
Vermiculite	thousand short tons	50	NA	42	NA
Total industrial minerals[2]		XX	9,352,000	XX	9,069,000
Total[2]		XX	41,009,000	XX	41,137,000

[e]Estimated. [r]Revised. NA Not available. XX Not applicable.

[1]Less than 1/2 unit.

[2]Data may not add to totals shown because of rounding.

TABLE 10

COMPARISON OF WORLD AND U.S. PRODUCTION OF SELECTED NONFUEL MINERAL COMMODITIES

Mineral		1990			1991		
		World production[1]	U.S. production	U.S. percent of world production	World production[1]	U.S. production	U.S. percent of world production
METALS, MINE BASIS							
Antimony[2]	metric tons	r66,846	W	NA	64,730	W	NA
Arsenic trioxide[3]	do.	r53,976	—	—	47,084	—	—
Bauxite[4]	thousand metric tons	r109,601	W	NA	109,172	W	NA
Beryllium concentrates (gross weight)	metric tons	r7,119	54,548	64	6,607	54,339	66
Bismuth	do.	r3,359	W	NA	3,301	W	NA
Chromite (gross weight)	thousand metric tons	r12,848	—	—	13,237	—	—
Cobalt[2]	metric tons	r35,709	—	—	26,583	—	—
Columbium-tantalum concentrate (gross weight)	do.	r32,103	—	—	33,593	—	—
Copper[2]	thousand metric tons	r8,693	r1,588	18	8,820	1,631	18
Gold[2]	kilograms	r2,127,398	r294,527	14	2,111,522	289,885	14
Iron ore (gross weight)	thousand metric tons	r928,427	56,408	6	897,929	55,516	6
Lead[2]	do.	r3,390	r496	15	3,318	477	14
Manganese ore (gross weight)	thousand short tons	r28,036	—	—	24,666	—	—
Mercury	metric tons	r5,061	W	NA	4,536	W	NA
Molybdenum[2]	do.	r122,232	61,611	r50	112,224	53,364	48
Nickel[2]	thousand metric tons	r937	(5 6)	(6)	923	(56)	1
Platinum-group metals[3]	kilograms	r288,502	e7,740	3	291,678	e7,780	3
Silver[2]	metric tons	r15,122	r2,125	14	14,723	1,848	13
Tin[2]	do.	r218,518	W	NA	196,695	W	NA
Titanium concentrates (gross weight):							
Ilmenite	thousand metric tons	r3,952	W	NA	3,486	W	NA
Rutile	do.	r475	W	NA	450	W	NA
Tungsten[2]	metric tons	r51,918	W	NA	42,960	W	NA
Vanadium[2]	do.	r30,606	W	NA	26,435	W	NA
Zinc[2]	thousand metric tons	r7,320	543	7	7,282	547	8
METALS, SMELTER BASIS							
Aluminum (primary)	do.	r17,977	4,048	23	18,194	4,121	23
Cadmium	metric tons	r20,493	1,678	8	20,673	1,676	8
Cobalt	do.	r25,316	—	—	23,922	—	—
Copper (primary and secondary)[7]	thousand metric tons	r9,087	1,463	16	9,052	1,487	16
Iron, pig	do.	r550,973	r50,028	9	528,485	44,533	8
Lead, refined (primary and secondary)[8]	do.	r5,830	r1,326	r23	5,642	1,229	22
Magnesium (primary)	metric tons	r353,512	139,333	r39	339,269	131,288	39
Nickel[9]	do.	r883,015	3,701	(6)	875,636	7,065	1
Selenium[10]	kilograms	r1,793,633	286,755	16	1,808,551	259,522	14
Steel, raw	thousand metric tons	r770,638	89,726	12	733,673	79,738	11
Tellurium[10]	kilograms	r70,543	W	NA	78,797	W	NA
Tin[11] (primary and secondary)	metric tons	r240,887	W	NA	220,364	W	NA
Zinc (primary and secondary)	thousand metric tons	r7,053	358	5	7,082	377	5
INDUSTRIAL MINERALS							
Asbestos	do.	r3,819	W	NA	3,490	W	NA
Barite	do.	r5,595	12439	8	5,271	12448	8
Boron minerals	do.	r2,966	121,094	r37	2,988	121,240	41
Bromine	metric tons	r416,900	12177,000	r42	401,200	12170,000	42
Cement, hydraulic	thousand short tons	r1,270,970	78,606	6	1,312,302	e77,000	6

See footnotes at end of table.

TABLE 10—Continued

COMPARISON OF WORLD AND U.S. PRODUCTION OF SELECTED NONFUEL MINERAL COMMODITIES

Mineral		1990			1991		
		World production[1]	U.S. production	U.S. percent of world production	World production[1]	U.S. production	U.S. percent of world production
INDUSTRIAL MINERALS—Continued							
Clays:							
Bentonite[3]	thousand metric tons	r9,733	[12]3,474	r36	9,264	• [12]3,432	37
Fuller's earth[10]	do.	r3,480	[12]2,307	66	4,012	• [12]2,740	68
Kaolin[3]	do.	r23,673	[12]9,762	r41	24,748	• [12]9,575	39
Diamond, natural	thousand carats	r101,566	—	—	104,386	—	—
Diatomite	thousand metric tons	r1,629	r [12]631	r39	1,556	610	39
Feldspar	do.	r5,269	630	r12	5,167	580	11
Fluorspar	do.	r5,025	• [5]64	1	4,354	• [5]58	1
Graphite, natural	metric tons	r644,379	—	—	628,894	—	—
Gypsum	thousand short tons	r104,584	16,406	r16	103,544	15,456	15
Iodine, crude	metric tons	r16,114	1,973	12	16,159	1,999	12
Lime[13]	thousand short tons	r148,268	[12]17,481	12	146,426	[12]17,303	12
Magnesite, crude	thousand metric tons	r11,117	W	NA	10,944	W	NA
Mica (including scrap and ground)	metric tons	r210,786	108,845	r52	198,347	102,830	52
Nitrogen: N content of ammonia	thousand short tons	r107,561	r13,806	13	103,308	13,991	14
Peat[14]	do.	r196,612	763	([6])	185,389	697	([6])
Perlite	do.	r2,017	[12]639	r32	1,998	[12]567	28
Phosphate rock (gross weight)	thousand metric tons	r154,356	46,343	30	146,859	48,096	33
Potash (K_2O equivalent)	do.	r27,685	1,713	6	25,548	1,749	7
Pumice[10]	do.	r10,739	[12]443	4	10,802	[12]401	4
Salt[13]	thousand short tons	r200,989	[12]40,738	20	202,450	[12]39,620	20
Sand, industrial (silica)	do.	r129,468	[12]28,406	r22	121,715	[12]25,600	21
Sodium compounds, n.e.s. (natural and manufactured):							
Soda ash	thousand metric tons	r32,273	9,156	28	31,344	9,005	29
Sulfate	do.	r4,870	[12]665	r14	4,837	[12]696	14
Strontium[10]	metric tons	r233,527	—	—	240,356	—	—
Sulfur, all forms	thousand metric tons	r58,154	11,560	20	55,592	10,816	19
Talc and pyrophyllite[15]	do.	r9,084	1,267	r14	8,932	1,037	12
Vermiculite[10]	short tons	r638,462	• [12]230,000	36	576,108	[12]185,000	32

rEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Those commodities for which U.S. data are withheld to avoid disclosing company proprietary data, the world total excludes U.S. output and the U.S. percent of world production cannot be reported.

[2]Content of ore and concentrate.

[3]World total does not include an estimate for China.

[4]U.S. figures represent dried bauxite equivalent of crude ore; to the extent possible, individual country figures that are included in the world total are also on the dried bauxite eqiuivalent basis, but for some countries available data are insufficient to permit this adjustment.

[5]Shipments.

[6]Less than 1/2 unit.

[7]Primary and secondary blister and anode copper, including electrowon refined copper that is not included as blister or anode.

[8]Includes bullion.

[9]Refined nickel plus nickel content of ferronickel, nickel oxide, and other nickel salts.

[10]World total does not include estimates for output in the U.S.S.R. or China.

[11]Includes tin content of alloys made directly from ore.

[12]Quantity sold or used by producers.

[13]Data for the United States include Puerto Rico.

[14]Data for the United States exclude proprietary amounts of fuel peat.

[15]The figure for the United States for 1991 excludes proprietary pyrophyllite production.

THE MINERAL INDUSTRY OF ALABAMA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Geological Survey of Alabama for collecting information on all nonfuel minerals.

By Doss H. White, Jr.,[1] and Lewis S. Dean[2]

The value of nonfuel mineral production in Alabama in 1991 was $539.9 million, a decrease of $20.7 million, a result of the nationwide recession that was felt throughout the State's economy. The 3.7% decline in mineral sales was due primarily to a slowdown in construction, which had a major impact in the construction minerals mined instate. Production and sales of crushed stone and sand and gravel fell significantly below the value reported in 1990. Despite the recession, Alabama moved from 21st to 20th place nationally in mineral value.

Mineral industry developments in 1991 were primarily in the metals manufacturing sector. Reynolds Metals Co., Sheffield, celebrated 50 years of operation in Alabama. During the November celebration, the company dedicated a $121 million expansion that included a new casting facility and sheet rolling operation. Gulf States Steel Corp., Gadsden, completed the first full year of operation of its new multimillion-dollar continuous caster.[3] The Foundry of the Shoals Inc., Florence, replaced two coke-fired furnaces with electric furnaces.

Robinson Iron, an Alabama foundry noted for its restoration work on many of the country's prestigious landmarks, supplied a large portion of the ironwork used in restoring the historic Raffles Hotel in Singapore.

In the fuels sector, Mobil Exploration and Producing U.S. Inc. developed a dewatering system for drilling fluids that allowed the fluid to be recovered and recycled. The Nation's first compressed air energy storage powerplant began operations in May in south Alabama.

Despite the economic downturn, mineral imports through the Port of Mobile remained strong. The mineral

TABLE 1
NONFUEL MINERAL PRODUCTION IN ALABAMA[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Cement:							
Masonry	thousand short tons	252	$13,852	262	$15,462	e238	e$14,042
Portland	do.	3,169	130,590	3,585	165,344	e3,937	e181,102
Clays[2]	metric tons	1,878,070	18,537	2,049,776	27,747	2,124,380	22,103
Lime	thousand short tons	1,481	70,361	1,526	70,816	1,510	75,506
Sand and gravel:							
Construction	do.	e10,400	e36,500	14,103	50,243	e12,700	e45,700
Industrial	do.	805	8,092	878	9,075	531	6,133
Stone:							
Crushed and broken[3]	do.	31,737	167,332	e36,100	e202,400	27,145	161,843
Dimension	short tons	W	W	W	W	9,552	2,449
Combined value of bauxite, clays [bentonite, kaolin (1990-91)], gemstones, salt, stone [crushed dolomite and granite (1991), crushed granite (1989-90)], talc and pyrophyllite, zircon concentrates, (1989), and values indicated by symbol W		XX	15,489	XX	r19,493	XX	31,037
Total		XX	460,753	XX	r560,580	XX	539,915

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data; values included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" data.
[3]Excludes certain stones; kind and value included with "Combined value" data.

industry accounted for 10% of the exports. The Bulk Materials Handling Plant shipped 1.8 million short tons of various bulk cargo. The plant handled 1.4 million tons of iron ore, the leading commodity. Ilmenite tonnage increased 14% to 223,000 short tons. Traditional mineral commodities such as gypsum, copper, slag, and manganese were joined by bentonite, calcined bauxite, and ferrosilicon. The ferrosilicon was shipped to the State of Washington by rail and to Pennsylvania and West Virginia by truck.[4] U.S. Pipe and Foundry Co., Birmingham, a subsidiary of Walter Industries, exported iron pipe, fittings, and accessories to Oman.[5]

EMPLOYMENT

Alabama's mineral industry, both nonfuels and fuels, employed 7,743 persons in fiscal year 1991 (October 1 to September 30). The nonfuel sector employed 1,777 and the fuels sector, excluding coalbed methane and petroleum/natural gas development and production, totaled 7,743. In nonfuels, crushed stone employment (including stone for lime manufacture) accounted for 49% and clay and sand and gravel an additional 41%. The coal industry employed 4,406 workers in underground mines and 1,760 miners in surface operations.[6]

REGULATORY ISSUES

Interstate Lead Co. (ILCO), Leeds, a secondary lead producer, filed for chapter 11 protection in July. The filing was due to the expenditures necessary to comply with Federal, State, and local air and water pollution laws. ILCO had approximately $12 million in assets and about the same in liabilities at the time of the filing. The company has an annual capacity of 40,000 to 45,000 short tons of lead per year.[7]

In September, the Alabama Department of Environmental Management denied ICI Americas Inc. a permit for deep well injection of wastes. The company hoped to discharge saltwater and agricultural chemicals into a disposal well drilled 4,600 feet beneath its Cold Creek Plant north of Mobile.[8]

EXPLORATION ACTIVITY

Gold exploration continued in Alabama during 1991 with the drilling of prospects in the Devils Backbone district of Tallapoosa County and in the Arbacoochee district of Cleburne County.

LEGISLATION AND GOVERNMENT PROGRAMS

The 1991 session of the Alabama Legislature passed no bills that would impact the mineral industry. The State's head of the Department of Conservation and Natural Resources went on record that the State needed a law taxing "mined" sulfur (sulfur recovered from petroleum and natural gas processing). A bill was introduced that would place a 5-dollar-per-long-ton tax on sulfur production. The bill, opposed by the Alabama Petroleum Council, did not pass.[9]

The Geological Survey of Alabama, Tuscaloosa, continued or completed several programs related to the State's mineral resources. Reports were published on industrial mineral resource sites and processing facilities in West Alabama, on the status of the State's mineral industry during 1991, and on the structural geology of the Hightower reentrant in Cleburne County. The program of county mineral resource assessment continued with the publication of mineral resource maps of Blount and Russell Counties. Several county mineral studies were also under way. Energy and water resource programs continued to collect data and samples for analysis of resource quality and use. A report on the regional analysis of the Black Creek-Cobb coalbed-methane target interval in the Warrior basin was also published.

The State Lands Division of the Alabama Department of Conservation and Natural Resources generated more than $10 million in receipts from its land-based asset management program. The division oversees oil and gas exploration and development, sand and gravel operations, and coal mining, among other activities, on State lands.[10]

The School of Mines and Energy Development (SOMED), University of Alabama, helped fund or support a graduate research fellowship program, faculty research grants, and college and cooperative research. Five faculty research grants totaling $90,000 were supported by SOMED during the 1991-92 academic year. SOMED also provided approximately $1 million in support of research activities in energy, mineral, economic and environmental research, and academic programs at the University of Alabama. Approximately $286,000 was provided to the different schools at the University for cooperative projects with Federal and State agencies and the private sector.[11]

Personnel at the U.S. Bureau of Mines Intermountain Field Operations Center (IFOC), Denver, CO, reviewed environmental assessments for projects in Mobile, Pickens, and Sumter Counties. The reviews were to ensure that the projects would have no adverse impact on mineral resources or existing mineral operations. In October, IFOC personnel completed a minerals environmental document, "Preliminary Mineral Resource Impact Study for Proposed Birmingham Northern Beltline, Jefferson County, Alabama." The document described the mineral resources and past and existing mining operations in the highway corridors under consideration.

The U.S. Bureau of Mines Tuscaloosa Research Center (TURC), Tuscaloosa, was involved in studies into mineral recovery and environmental enhancement. Mineral recovery studies included dielectric heating properties of minerals, improved recovery of mineral values during the flotation sequence, chemical and physical mechanisms of solid-liquid separation techniques, improved flotation kinetics, very fine slurry mineral recovery, acid/alcohol leaching of phosphate ores, and processing of advanced ceramics. In the environmental field, TURC personnel examined mineral processing wastewater treatment, Carolina gold waste, phosphate waste treatment,

elimination of soil contamination at mining/mineral processing sites, and stabilization of mining and processing wastes. TURC personnel published 8 reports of investigations, presented 46 papers, and published 44 papers in nongovernment publications.[12]

FUELS

In fiscal year 1991 (October 1990 to September 1991), Alabama coal production totaled 27.5 million short tons, a decrease of 2.6% from the 28.2 million tons mined in 1990. Underground mines accounted for 16.8 million tons and surface mines for 10.7 million. Tuscaloosa County was the leading producer (34%), followed by Walker (26%) and Jefferson (25%). The State's coke industry converted 3.4 million tons of coal into 2.4 million tons of coke.

Bulk coal exports through the Port of Mobile McDuffie Terminal totaled 8.3 million tons in fiscal year 91. Coal shipped through the McDuffie facility was mined in Alabama, the Appalachians, the Illinois Basin, and the Powder River Basin in Wyoming. A total of 125 colliers were loaded for export to Africa, Brazil, Ireland, Japan, Morocco, Taiwan, Turkey, and the United Kingdom. Late in the year, the 119,819 tons of coal loaded aboard the Magandang Ilog set a record for the largest export coal cargo loaded in port.[13]

A 5-day wildcat strike cost Jim Walter Resources $8.2 million. Approximately 2,300 miners walked off the job at four Walter Resources mines in Tuscaloosa and Jefferson Counties to protest a health plan change.[14]

Despite a 2-year congressional extension of the tax credit, drilling permits for new coalbed methane wells plummeted to one-tenth of the level of 1990. The decline was due to a drop in natural gas prices. In the mid-1980's, coalbed methane was valued at $3.86 per thousand cubic feet (Mcf). This included selling price and tax credit. In 1991, the selling price was about $1.50 per Mcf. Even with the tax credit, the selling price in 1991 was less than the selling price alone for the mid-1980's.[15]

During the year, more than 10,000 permits to drill for oil and natural gas were issued by the State. A significant increase in exploratory drilling has occurred in the past few years.[16]

State Oil and Gas Board records indicated that Alabama's oil and condensate production totaled 8,823,096 barrels and 9,814,182 barrels, respectively. Natural gas output totaled 225,311,165 Mcf.

Work was completed on a plant that would convert solid waste to ethanol at the Tennessee Valley Authority's National Fertilizer and Environmental Research Center at Muscle Shoals. Researchers hoped that the project would demonstrate the feasibility of producing a liquid fuel for vehicles while reducing the need for landfills for solid wastes.[17]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Table 1 notes the performance of seven mineral commodities produced in Alabama. Production and sales increased for portland cement, lime value increased but sales declined, and both output and value fell for the other five commodities.

Of the seven mineral commodities whose tonnage and sales are withheld, output and value rose for bentonite, gemstones, kaolin, and talc; bauxite output was up but value declined; and production and tonnage fell for salt and dimension stone.

Cement.—Portland cement accounted for almost 36% of Alabama's mineral value and was the leading mineral commodity, valuewise, produced in the State. This was the first year that cement sales were higher than crushed stone. The State moved from seventh to sixth place ranking in production among the 39 portland cement-producing States and moved from fifth to second in tonnage among the 33 masonry-producing States.

In 1991, portland cement production totaled 3.6 million metric tons valued at $181 million. This was an increase of 320,000 metric tons and almost $16 million. Portland cement was the only major commodity whose output and value exceeded that of the previous year, and this was the fourth consecutive year that production increased.

The State's portland cement industry produced cement at five plants in Birmingham, Demopolis, Mobile, and the Montevallo area. All five produced clinker, which was ground into cement using the dry-process method.

Masonry cement output, 216,000 metric tons, was valued at $14 million. This was a decline of 22,000 metric tons in production and $1.4 million in value. Output was from three plants in Greystone, Roberta, and Theodore.

Clays.—The State ranked second in total clay production and ninth in clay value among the 37 clay-producing States. The State's producers mined common clay and/or shale, bauxite, bentonite, fire clay, and kaolin.

Bauxite.—Alabama and Georgia were the only States with bauxite production. Harbison-Walker Refractories Div. of Dresser Industries Inc. and Mullite Co. of America mined the high-alumina clay in Barbour and Henry Counties. Most of the clay was calcined and sold to the refractory industry. Output declined for the third consecutive year, but value increased about 17%.

A third firm, Carbo Ceramics in Eufaula, purchased bauxite for proppant manufacture. Proppants, small spheres, were used by the petroleum industry to "prop" rock fractures open in the producing zones of petroleum wells to increase production.

Bentonite.—Southern, or nonswelling, bentonite was mined by American Colloid Co. from a pit in Lowndes County southwest of Montgomery. The State ranked fifth in output and value among the 11 States with bentonite production. Much of the production was sold for

TABLE 2
ALABAMA: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1990		1991	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Paper and pulp	413,085	$19,857	403,571	$19,417
Soil stabilization	W	W	25,296	1,379
Steel, basic oxygen	W	W	446,733	21,488
Sugar refining	W	W	14,963	768
Water purification	237,517	7,395	256,334	13,387
Other[1]	875,412	43,564	362,955	19,067
Total	1,526,014	70,816	1,509,852	75,506

W Withheld to avoid disclosing company proprietary data.
[1]Includes acid water neutralization (1990), alklies, aluminum and bauxite, basic oxygen steel, citric acid, electric steel (1990), food (animal or human), incinerator gas scrubber, ladle desulfurization (1990), mason's lime, oil-well drilling, open-hearth steel (1990), other chemical and industrial, other construction, petrochemicals, petroleum refining, precipitated calcium carbonate, sewage treatment, and tanning (1990).

foundry sand usage. Other sales were for use in common brick, roofing tile, refractories, and asphalt emulsions.

In October, American Colloid signed a contract with Rust Engineering Co., Ross, OH, to supply 138 short tons of "Bentogrout." The material will be used as a radon containment cap for K 65 Silos 1 and 2 at the U.S. Department of Energy's Fernald Environmental Management Project in Fernald, OH. The silos were constructed in the 1950's to hold waste generated during pitch blend processing.

Common Clay and/or Shale.—roduction was reported by 16 firms operating 16 pits. Output totaled 2 million metric tons valued at $18.6 million; nationally, the State ranked fifth in tonnage and first in value among the 43 clay/shale-producing States. Principal sales were by or to the brick (common and face) (43%), concrete block (output withheld), and cement (28%) industries. Other sales/uses were to or by the lightweight aggregate, pottery, quarry tile, and structural concrete producers.

Fire Clay.—Production was reported by four companies operating five mines in Calhoun, Shelby, and St. Clair Counties. (A fifth producer was active in Walker County.) Seven States produced fire clay, and Alabama's fire clay industry ranked third behind Missouri and Ohio in tonnage and second behind Missouri in value. Production totaled 80,778 metric tons valued at almost $3.5 million. This was a decrease from the 96,237 metric tons valued at almost $4 million reported in 1990. Principal markets were the refractory and firebrick industries.

Kaolin.—Two firms produced kaolin from two mines in Barbour and Henry Counties. Production and value increased substantially. Sales were to customers producing refractory grogs, abrasives, and face brick.

Lime.—The sales value of lime products ranked second among the mineral commodities produced in the State. Lime sales accounted for approximately 14% of the State's total mineral value, and Alabama ranked fifth among the 32 lime-producing States in 1991. Output declined 14,000 metric tons; however, sales increased by almost $5 million. Four companies in Shelby County, south of Birmingham, produced both quicklime and hydrated lime from locally mined limestones. Sales and/or uses are summarized in the lime table.

Salt.—The State moved to 8th from 10th position among the 14 salt-producing States in the United States. Output and value declined slightly from those reported in 1990, but were higher than those in 1989. The Olin Corp. operated a solution mining facility and chemical complex at the site of the McIntosh salt dome in Washington County. Water pumped into the dome through surface wells dissolved the salt, and brine was recovered through other wells. Brine was used to produce chlorine, caustic soda, compressed hydrogen, and salt. Sales were to the pulp and paper, water purification, and sewage treatment industries.

In September, the Nation's first "air energy" storage plant was dedicated at McIntosh. Earlier, Olin Corp. completed the solution mining of part of the McIntosh dome for Alabama Electric Cooperative (AEC) of Andalusia. A $65 million, on-site powerplant pumped compressed air into the cavity; the air was recovered through a turbine and motor generator to produce electricity. The facility provided 110 megawatts of power to AEC customers in south Alabama and the Florida Panhandle during periods of high demand. During low demand periods, the plant purchased energy from a nearby powerplant to compress air back into the cavity.

Sand and Gravel.—Sales of sand and gravel, both construction and industrial, accounted for almost 10% of the State's mineral value. Alabama ranked 21st among the 50 sand and gravel-producing States. Production of both types totaled 12,000 metric tons valued at $51.8 million.

Sand and gravel mining/dredging along portions of the Alabama River were in danger of being banned as the Federal Government considered a U.S. Fish and Wildlife Service recommendation to name the Alabama sturgeon to the Federal endangered species list. If the fish is placed on the endangered list, the Alabama Power Co. would be required to increase waterflow through its dams along the Coosa River.

Construction.—The production of construction sand and gravel is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This report contains

TABLE 3

ALABAMA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch): Riprap and jetty stone[2]	980	4,345	$4.43
Coarse aggregate, graded:			
Concrete aggregate, coarse	2,929	11,235	3.84
Bituminous aggregate, coarse	2,683	13,820	5.15
Bituminous surface-treatment aggregate	643	2,563	3.99
Railroad ballast	W	W	3.90
Fine aggregate (-3/8 inch):			
Stone sand, concrete	493	2,335	4.74
Stone sand, bituminous mix or seal	1,122	4,475	3.99
Screening, undesignated	240	921	3.84
Coarse and fine aggregate:			
Graded road base or subbase	3,097	12,156	3.93
Unpaved road surfacing	183	749	4.09
Terrazzo and exposed aggregate	W	W	33.06
Crusher run or fill or waste	2,636	10,646	4.04
Other construction materials[3]	371	1,909	5.15
Agricultural: Agricultural limestone[4]	1,126	4,929	4.38
Chemical and metallurgical:			
Cement manufacture	2,120	5,610	2.65
Lime manufacture	3,542	13,599	3.84
Flux stone	W	W	4.12
Chemical stone	W	W	2.29
Special: Other fillers or extenders[5]	1,035	57,699	55.75
Other miscellaneous uses[6]	203	837	4.12
Unspecified:[7]			
Actual	3,415	12,212	3.58
Estimated	328	1,802	5.49
Total[8]	27,145	161,843	5.96

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes limestone, marble, and sandstone, excludes a minor amount of dolomite and granite withheld to avoid disclosing company proprietary data.
[2]Includes macadam.
[3]Includes withheld amounts for coarse aggregate, graded, and coarse and fine aggregates.
[4]Includes other agricultural uses.
[5]Includes asphalt fillers or extenders, mine dusting or acid water treatment, and whiting or whiting substitute.
[6]Includes withheld amounts for chemical and metallurgical.
[7]Includes production reported without a breakdown by use and estimates for nonrespondents.
[8]Data may not add to totals shown because of independent rounding.

estimates for 1989 and 1991 and actual data for 1990.

Sales of construction sand and gravel were estimated at $45.7 million, a decline from the $50.2 million reported by the sand and gravel industry in 1990. Tonnage declined from 12.8 million metric tons in 1990 to 11.5 million metric tons in 1991. Despite the decrease, sand and gravel value ranked third behind cement and lime in Alabama's 1991 mineral sales. Nationally, the State ranked 21st among the 50 States in construction sand and gravel sales, an increase of 1 position over the 1990 ranking.

In the last year that a complete industry survey was undertaken, reports were received from 57 sand and gravel companies operating 79 mines, 42 stationary, and 15 portable plants. Six counties had production in excess of 1 million metric tons; the five leading counties were Elmore, Macon, Mobile, Montgomery, and Escambia. These five accounted for about 50% of the State's total production. Principal sand and gravel sales were for concrete aggregate (76%), road base/cover (11%), and asphaltic concrete (8%). End uses for 43% of the tonnage were unspecified.

Industrial.—Alabama ranked 18th among the 37 States with industrial sand and gravel production. Output and value, 482,000 metric tons with a $6.1 million value, declined from the 796,000 metric tons, $9.1 million reported in 1990.

The industry consisted of six companies operating mines in seven counties. Bullock, Tuscaloosa, and Macon were the three leading counties, accounting for more than 80% of the production. Sales were to the foundry and filter industries and for sand blasting traction applications.

Stone.—The production of stone is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Crushed.—Alabama ranked 17th among the 49 crushed stone-producing States. Crushed stone accounted for 30% of the State's total mineral value and was the second leading commodity, valuewise, mined in the State. Production, 24.6 million metric tons (excluding dolomite, granite, and sandstone) valued at $162 million, fell 1.2 million metric tons and $5.5 million below the production and value data reported by industry in 1989.

Production was reported by 22 companies operating 45 quarries in 19 counties. In descending order of tonnage, limestone, marble, dolomite, granite, and sandstone were quarried. Limestone accounted for about 91% of the tonnage; marble about 5%; and dolomite, granite, and sandstone about 4%. Stone companies and county

TABLE 4

ALABAMA: CRUSHED STONE [1]SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[2]	W	W	W	W	—	—
Coarse aggregates, graded[3]	2,618	11,627	3,772	16,519	—	—
Fine aggregates (-3/8 inch)[4]	W	W	W	W	—	—
Coarse and fine aggregates[5]	2,959	10,523	2,978	13,712	—	—
Other construction materials	1,717	6,501	1,333	6,272	—	—
Agricultural[6]	101	596	1,025	4,333	—	—
Chemical and metallurgical[7]	—	—	5,865	20,046	—	—
Special[8]	—	—	1,035	57,699	—	—
Unspecified:[9]						
Actual	875	3,267	1,282	6,343	1,257	2,603
Estimated	45	162	283	1,640	—	—
Total[10]	8,314	32,676	17,573	126,564	1,257	2,603

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Excludes dolomite and granite; withheld to avoid disclosing company proprietary data.
[2]Includes macadam, riprap and jetty stone.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand (concrete), stone sand (bituminous mix or seal), screening (undesignated).
[5]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run (select material or fill).
[6]Includes agricultural limestone and other agricultural uses.
[7]Includes cement manufacture, lime manufacture flux stone, and chemical stone for alkali works.
[8]Includes mine dusting or acid water treatment, asphalt fillers or extenders, whiting or whiting substitute, and other fillers or extenders.
[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[10]Data may not add to totals shown because of independent rounding.

TABLE 5

ALABAMA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991[1]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	42	27,843	$96,991	$3.48	37	25,512	$100,647	$3.95
Dolomite	4	2,278	9,674	4.25	—	—	—	—
Marble	5	W	W	37.52	3	1,596	60,973	38.20
Granite	1	W	W	4.93	—	—	—	—
Sandstone	—	—	—	—	1	38	222	5.84
Total[2]	XX	31,737	106,665	3.36	XX	27,145	161,843	5.96

XX Not applicable. W Withheld to avoid disclosing company proprietary data; included with "Total."
[1]Excludes dolomite and granite; withheld to avoid disclosing company proprietary data.
[2]Data may not add to totals shown because of independent rounding.

highway departments also mined a significant tonnage of chert in north Alabama, which is not covered in the U.S. Bureau of Mines stone canvass.

Nine counties reported production in excess of 1 million tons. The three leaders, which accounted for almost 60% of the tonnage, in descending order of output were, Shelby, Jefferson in the Birmingham metropolitan area, and Madison in the Huntsville metropolitan area.

The five principal crushed stone uses as reported by the stone companies were (1) graded road base, (2) lime manufacture, (3) bituminous aggregate, (4) concrete aggregate, and (5) fill. These five end uses accounted for 14.6 million metric tons or almost 60% of the total output.

Moulton Limestone in northern Alabama was purchased by the Rogers Group Inc. With the sale, the company's

name was changed to Rogers Group Moulton Quarry.

Dimension.—Three companies reported dimension stone production from three quarries in 1991. In descending order of tonnage, limestone was produced by Alabama Limestone Co. in Franklin County, sandstone was produced in Blount County by Lamb Stone Co., and Dixie Marble Inc. produced marble in Talladega County. Production was reported, in descending tonnage, as cut/veneer stone, rough blocks, sawed stone/blocks, and flagging-dressed stone. Output, 8.7 million metric tons, was almost 2 million metric tons below the estimated production for 1990. Value declined about $600,000 below the 1990 estimate.

Sulfur (Recovered).—Four companies, one less than in 1990, recovered sulfur at plants in Escambia, Mobile, Tuscaloosa, and Washington Counties. Both output and value declined, reflecting declining production of petroleum and natural gas.

Talc.—The State ranked sixth out of the nine talc-producing States. Cyprus Minerals Co. operated a talc mine and mill near Alpine, the only active talc operation in the Southeastern United States. Talc from Montana and Australia were also ground at the Alabama mill. Principal markets were the cosmetic and pharmaceutical industries.

Other Industrial Minerals.—A number of raw mineral commodities, in addition to those listed on table 1, were shipped into the State and either used as parts of a manufacturing process or manufactured into higher value products.

Fused aluminum oxide and aluminum-zirconium oxide were produced by the Norton Co. at a plant in Huntsville. Output from the Madison County facility was for abrasive use.

Fluorspar was shipped into the State by International Minerals and Chemicals Co., Florence, in Lauderdale County. The mineral was used in the manufacture of fluosilicic acid.

Hydrous ammonia plants were operated by the Tennessee Valley Authority, Muscle Shoals, and USS Agri-Chemicals Inc., Cherokee. Both facilities were on the Tennessee River in northwestern Alabama.

Magnesium minerals from Greece, Mexico, and Turkey were imported by Muscle Shoals Minerals, Barton, in Colbert County, for the production of fused magnesium oxide used in heating elements.

Mica produced by Junaluska Mica Co. from mines in Cherokee County, NC, was shipped to Tuscaloosa, Alabama. The material was used in the manufacture of asphalt roofing.

Armand Products Co. completed a new potassium carbonate facility at the Occidental Chemical Co. plant in Muscle Shoals. Potassium carbonate was used to make television tubes.

Perlite was expanded at W. R. Grace and Co. and Armstrong World Industries at plants in Irondale, Jefferson County. The crude mineral was obtained from mines in the Western United States.

Vermiculite was expanded by W. R. Grace at its Irondale plant. The crude material was obtained from South Carolina mines.

Zirconium ore and concentrates were purchased from the Republic of South Africa and Florida by Muscle Shoals Minerals. The material was processed into fused zirconium oxide.

Other mineral shipments included diabase from North Carolina to a Phenix City plant for insulation manufacture, iodine used by a Mobile firm, synthetic iron oxide pigments and regenerator oxides produced by Gulf States Steel Inc. in Gadsden, and synthetic mullite produced by Harbison-Walker at its Eufaula operation. Tungsten was used in weapons manufacture by Martin Technology at its Huntsville plant, and zeolite catalysts were produced by Union Carbide Corp. at a plant near Mobile.

Metals

The State's metal industry consisted of one extractive tantalum operation and aluminum, ferroalloy, and iron and steel manufacturers. The only secondary lead smelter in the State closed during the year.

Aluminum.—Reynolds Metals Co. operated the company's largest aluminum fabricating facility at Listerhill in Colbert County. Scrap aluminum was melted into 15-ton, 26-inch-thick ingots and rolled into coils of sheet. The sheet was used for cans, siding, and appliance manufacture.

In 1991, Reynolds celebrated 50 years of operation in Alabama by dedicating a $121 million expansion in November. The company has spent more than $400 million in recent years at the North Alabama facility to upgrade the cold- and hot-rolling mills and coating lines.

Ferroalloys.—The State maintained its third place ranking among the 14 States reporting ferroalloy production. Production in 1991 totaled 93,000 metric tons valued at $84 million. This was a 4,000-metric-ton, $9 million decline from the production and value, respectively, reported in 1991.

Iron and Steel.—Six companies operated steel mills in Birmingham, Gadsden, and Tuscaloosa. Gulf States Steel Co., Gadsden, and USX Corp., Birmingham, operated integrated steel mills. Minimills were operated by Birmingham Steel Corp., Commercial Metals Co., and SMI Steel Inc. in the Birmingham area. Tuscaloosa Steel Corp., Tuscaloosa, operated a plate mill.

In October, USX's pipe mill in Fairfield laid off 100 employees because of a lack of orders. The depressed state of the drilling sector of the oil and gas industry was cited as the reason for the downturn in orders. At yearend, the company was negotiating the development of contracts for design and construction of coal injection facilities for the Fairfield Works.

In December, the Fairfield Works began casting double-strand slabs from a single mold at its continuous casting operation. Prior to introducing the new

casting technology, larger width slabs had to be slit to produce narrower widths.

Commercial Metals Co. completed installation of a new, four-strand continuous caster at its Birmingham mill. A new melt shop, scheduled for 1993, will raise the company's output to about 500,000 tons per year of angles, flats, channels, and flange beams.

U.S. District Court ruled in favor of Gulf States Steel Corp. in an environmental suit. The court ruled that LTV Corp., Dallas, the previous owner of the Gulf State facility, was libel for $31.1 million in environmental equipment costs to bring the Gadsden mill into compliance with emission regulations. A LTV spokesperson said that the company would appeal.

In March, British Steel PIC completed its acquisition of Tuscaloosa Steel Corp. Later in the year, Tuscaloosa Steel announced a two-phase, $7.5 million expansion. Phase 1, which will include a 40,000-square-foot storage area and new cutting equipment, was scheduled for completion in 1992. Phase 2, the installation of new metal shears, would begin then.

The 103-year-old Foundry of the Shoals Inc., Florence, converted from coke-fired to electric furnaces for melting gray iron. The 89-year-old A & B Foundry, Birmingham, closed in May. The closing, blamed on the recession, affected 170 jobs.

Lead.—During the year, Sanders Lead Co., Troy, was fined for hazardous waste and air pollution violations. Interstate Lead Co., Leeds, filed a chapter 11 petition for reorganization in U.S. Bankruptcy Court. The cost of air and water pollution equipment that the company was required to install to meet environmental standards was cited as the reason for the action.

Silicon Metal.—Simetco Inc. restarted a 20-kilowatt furnace at its Montgomery plant. The furnace had been idle since 1989 when low prices created by foreign imports forced many domestic silicon metal companies to decrease output.

Tantalum.—O'Dell Construction Co.'s subsidiary, Coosa Mining Ltd., operated the only tantalum mine and mill in the United States. The operation, near Rockford in Coosa County, mined a tantalum-bearing pegmatite and employed wet gravity methods to recover a tantalum concentrate that was sold to the U.S. Government. Mica was recovered as a byproduct and sold to a Georgia firm.

Other Metals.—Ilmenite, a titanium mineral, was imported from Australia by Kerr McGee Chemical Corp. for feedstock for its synthetic rutile plant near Mobile. After processing, the synthetic material was shipped to a company plant in Hamilton, MS, for use in the manufacture of titanium dioxide pigments.

Manganese and chromite were imported by Prince Manufacturing Co., Phenix City. The minerals were sold for use as a coloring agent in brick.

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[1]State Mineral Officer, U.S. Bureau of Mines, Tuscaloosa, AL. He has 31 years of mineral-related industry and government experience and has monitored the mineral activities in Alabama since 1989. Assistance in the preparation of the chapter was given by Maylene E. Hubbard, editorial assistant.

[2]Geologist, Mineral Resources Division, Geological Survey of Alabama.

[3]Birmingham Post-Herald. Steel Firm Feeling Recession's Pinch. Jan. 24, 1991.

[4]Port of Mobile. Bulk Materials Handling Plant. V. 65, No. 2, Feb. 1992, pp. 12-13.

[5]Port of Mobile. New CEO of Walter Industries Pays Visit to Port. V. 64, No. 11, Nov. 1991, p. 9.

[6]Alabama Department of Industrial Relations, Office of Safety and Inspection. Annual Statistical Report. Pp. 2-3.

[7]American Metals Market. ILCO Files for Chapter 11 Protection. V. 99, No. 143, July 29, 1991.

[8]Birmingham Post Herald. ADEM Moves To Ban Disposal of Toxic Wastes in Deep Wells. Sept. 19, 1991.

[9]The Tuscaloosa News. State Conservation Chief Urges Sulfur Mining Tax. May 15, 1991.

[10]Alabama Department of Conservation and Natural Resources, State Lands Division. Annual Report. Fiscal Year 1991, pp. 35-36.

[11]Alexander, C. Asst. Academic Vice President, School of Mines and Energy Development, University of Alabama. Private communication, 1991; available upon request from Doss H. White, Jr., BuMines, Tuscaloosa, AL.

[12]Tuscaloosa Research Center. Research Program, Fiscal Year 1991.

[13]Port of Mobile. McDuffie Terminal. V. 65, No. 2, Feb. 1991, p. 10.

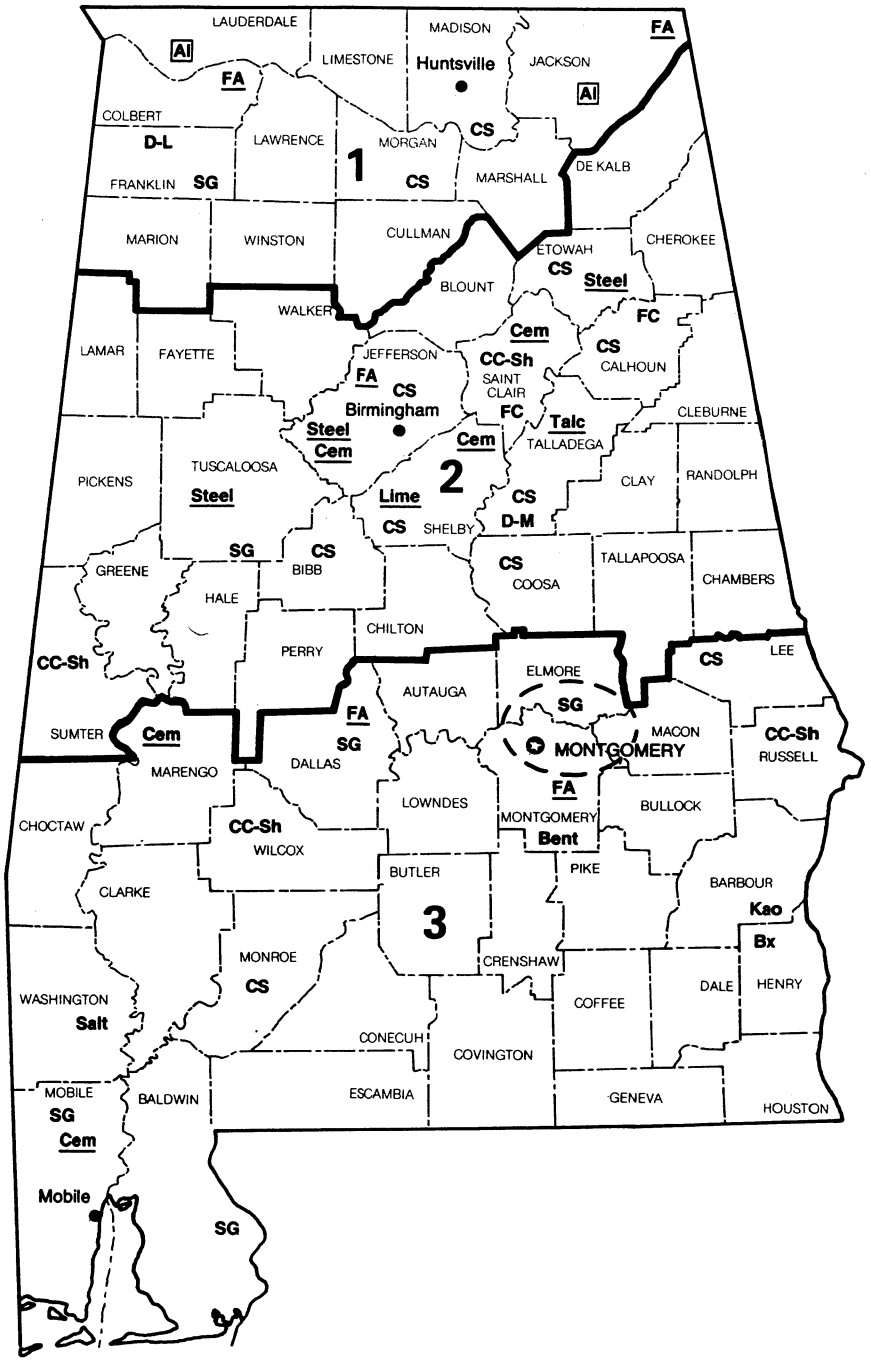
[14]Business Alabama Monthly. Wildcat Strike Costs Jim Walter $8.2 Million. Nov. 1991, p. 43.

[15]———. Boom With a Catch. V. 7, No. 3, Mar. 1992, pp. 25-27.

[16]Alabama Petroleum Council. Council Report. Aug. 1991, p. 2.

[17]———. Council Report. Mar. 1991, p. 2.

ALABAMA



LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Al	Aluminum plant
Bent	Bentonite
Bx	Bauxite
CC-Sh	Common Clay & Shale
Cem	Cement plant
CS	Crushed Stone
D-L	Dimension Limestone
D-M	Dimension Marble
FA	Ferroalloys plant
FC	Fire Clay
Kao	Kaolin
Lime	Lime plant
Salt	Salt
SG	Sand and Gravel
Steel	Iron and Steel plant
Talc	Talc plant

Concentration of mineral operations

Principal Mineral-Producing Localities

TABLE 6
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum (smelters):			
Reynolds Metals Co.	Reynolds Metals Bldg. Richmond, VA 23218	Smelter	Colbert.
Bauxite:			
Harbison-Walker Refractories Co. Inc.,[1] a division of Dresser Industries Inc.	Dale Rd. Route 1, Box 58 Eufaula, AL 36027	Mine and plant	Barbour and Henry.
Mullite Co. of America	901 East 8th Ave. King of Prussia, PA 19406	Mines and plant	Do.
Cement:			
Allied Products Co.[2]	Box 36130 Birmingham, AL 35236	Quarry and plants	Jefferson and Shelby.
Blue Circle Inc.[3]	Box 182 Calera, AL 35040	Quarry and plant	Shelby.
Citadel Cement Corp.	2959 Paces Ferry Rd., Suite 7 Atlanta, GA 30339	do.	Marengo.
Ideal Basic Industries Inc.	950 17th St. Box 8789 Denver, CO 80201	Quarry and plants	Mobile.
Lehigh Portland Cement Co.	Box 1882 718 Hamilton Mall Allentown, PA 18105	Quarry and plant	Jefferson.
National Cement Co. Inc.[4]	Box 7348 Mountain Brook Station Birmingham, AL 35223	do.	St. Clair.
Clays:			
Bickerstaff Clay Products Co. Inc.	Box 1178 Columbus, GA 31902	Mines and plant	Jefferson and Russell.
Blue Circle Inc.	Box 182 Calera, AL 35040	Mine and plant	Shelby.
Jenkins Brick Co.	Box 91 Montgomery, AL 37101	Mines and plant	Elmore and Montgomery.
Livlite Corp.	Drawer V Livingston, AL 35470	Mine and plant	Sumter.
Ferroalloys:			
Interlake Inc., Globe Metallurgical Div.	Box 348 Selma, AL 36701	Electric furnace	Dallas.
International Minerals & Chemical Corp.	Garner Rd. Bridgeport, AL 35740	do.	Jackson.
Ohio Ferro-Alloys Corp.	Box 68 Montgomery, AL 36057	do.	Montgomery.
Reynolds Metals Co.	Box 191 Sheffield, AL 35660	do.	Colbert.
Lime:			
Allied Products Co.	Box 268 Alabaster, AL 35007	Quarry and plant	Shelby.
Dravo Lime Co.[4]	One Gateway Center Seventh Floor Pittsburgh, PA 15222	do.	Do.
Salt:			
Olin Corp.	Box 28 McIntosh, AL 36553	Brine wells and chemical plant	Washington.

See footnotes at end of table.

TABLE 6—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Holland & Woodward Co. Inc.	Box 19147 Decatur, AL 35601	Mine and plants	Franklin.
R & S Materials Inc.	Box 3547 Montgomery, AL 36109	do.	Elmore and Montgomery.
S & S Materials	Box 640 Panama City, FL 32401	Mine	Dallas.
Superior Products Inc.	Box 171 Jemison, AL 35085	Mine and plants	Chilton.
Stone:			
Allied Products Co.	Box 628 Alabaster, AL 35007	Quarries and plants	Shelby.
Blue Circle Inc.	Box 182 Calera, AL 35040	Quarry and plant	Do.
Dravo Lime Co.	One Gateway Center Seventh Floor Pittsburgh, PA 15222	do.	Colbert, Lee, Shelby.
National Cement Co. Inc.	Box 7348 Mountain Brook Station Birmingham, AL 35223	do.	St. Clair.
Vulcan Materials Co.	Box 7324-A Birmingham, AL 35253	do.	Calhoun, Colbert, Etowah, Franklin, Jackson, Jefferson, Madison, Morgan, Talladega, Shelby.
Talc:			
Cyprus Industrial Minerals Co.	Alpine, AL 35014	do.	Talladega.

[1]Also kaolin and synthetic mullite.
[2]Also lime and stone.
[3]Also clays and stone.
[4]Also stone and sand and gravel.

THE MINERAL INDUSTRY OF ALASKA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Division of Geological and Geophysical Surveys, Alaska Department of Natural Resources, for collecting information on all nonfuel minerals.

By R. J. Minarik,[1] T. K. Bundtzen,[2] R. C. Swainbank,[3]
J. E. Wood,[4] and A. H. Clough[5]

Nonfuel mineral production for Alaska in 1991 was valued at $494.1 million, a decrease of more than 14% from that of 1990, according to the U.S. Bureau of Mines. Although the quantity of zinc increased, a drop in the production value of the metal accounted for the bulk of the decrease in the State's total nonfuel mineral production value.

Zinc continued to be the leading mineral commodity produced in terms of value, followed by, in decreasing order of production, lead, construction sand and gravel, gold, and silver. The aggregate value of the metallic minerals—gold, lead, silver, tin, and zinc—dropped almost 18% from that reported in 1990. Although the value of metallic minerals decreased in 1991, it still accounted for almost 85% of the State's total mineral production value.

Alaska ranked 21st nationally for total mineral production value compared with 18th in 1990. The State was the Nation's sole producer of tin, ranked first in the production of zinc and placer gold, second in lead, and third in silver. Nationally, Cominco Alaska Inc.'s Red Dog Mine ranked 1st in zinc production, 4th in lead, and 12th in silver. Kennecott's Greens Creek Mine ranked 1st in the Nation for silver production, 3d in zinc, and 10th in lead.

TRENDS AND DEVELOPMENTS

The bulk of Alaska's total mineral production value came from the Greens Creek and Red Dog Mines. Gold output from placer mines stabilized, but fewer mines operated due to low bullion prices, exhaustion of resources, and increasing regulatory requirements. Placer mining continued as predominantly a small-business industry that provided many jobs for rural Alaska.

Industrial mineral production continued to be dominated by construction materials—portland cement, construction sand and gravel, and crushed stone. Production of these materials has remained stable the past several years, a result of large highway construction and repair efforts near Anchorage and Fairbanks and infrastructure development in the Alaska Peninsula region, especially development in support of onshore processing facilities servicing Alaska's large commercial fishing fleet.

Expenditure for mineral exploration and development was estimated by the State to be $65.5 million, compared with $77.6 million in 1990. Total drill footage reported in 1991 decreased 47% from

TABLE 1
NONFUEL MINERAL PRODUCTION IN ALASKA[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gemstones		NA	W	NA	W	NA	$5
Gold[2]	kilograms	5,756	$70,800	3,232	$40,200	3,196	37,331
Sand and gravel (construction)	thousand short tons	e17,000	e48,500	15,100	41,800	e14,000	e39,200
Stone (crushed)	do.	2,900	20,300	e2,700	e19,800	[3]1,085	[3]4,688
Combined value of cement (portland), lead, silver, stone [crushed sandstone (1991)], tin, zinc, and values indicated by symbol W		XX	73,752	XX	r474,781	XX	412,840
Total		XX	213,352	XX	r576,581	XX	494,064

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Recoverable content of ores, etc.
[3]Excludes certain stones; kind and value included with "Combined value" data.

that of 1990. Most of the reduction was caused by a shift in emphasis from advanced exploration to acquiring permits and continuing development at the Kensington, Alaska-Juneau, and Fort Knox deposits and the Greens Creek Mine. Twenty-four companies reported significant drilling programs in 1991, with some having programs in more than one region.

EMPLOYMENT

Nonfuel mineral employment was estimated at 3,531 by the State, an increase of almost 2% from the 3,470 estimated in 1990. Employment declines in exploration and in the mining of base metals, lode gold, jade, soapstone, and tin were offset by job increases in mineral development, peat production, placer mining, and the production of construction sand and gravel. Coal production accounted for 115 jobs in 1991, unchanged from 1990.

Mechanized placer mining employed 1,240 persons; lode gold and silver, 235; base metals, 415; recreational mining, 320; construction sand and gravel, 685; stone, 165; peat, 45; tin, jade, and soapstone, 25; exploration, 268; and development, 133. Most employees at base metal, lode gold and silver, and coal mining operations worked all year. Other types of operations were mostly seasonal and operated from 3 to 6 months of the year. Exploration and development employees are calculated by the State as working 260 days per year.

REGULATORY ISSUES

Senate bill 544 (Ch. 92, SLA 90) became effective on October 15. This legislation replaced the reclamation section of Senate bill 129 (Ch. 101, SLA 89) enacted in May 1989. The act requires reclamation for all mining operations on Federal, State, and private lands in Alaska, including sand and gravel and other materials, beginning on October 15, 1991. Reclamation for land used in a mining operation from that point forward is mandatory and must be guaranteed with a reclamation bond with a maximum amount of $750 per acre. There is a small mine exemption to the bonding requirement for mines disturbing less than 50,000 cubic yards annually at one location or having annual disturbance of less than 5 acres. Reclamation at all mines must be performed annually, or as soon as a disturbed area is no longer needed for the mining operation. The Department of Natural Resources was empowered to establish and manage a statewide bonding pool available to mines operating on lands of all classifications in Alaska. This statewide bonding pool is managed by the Alaska Division of Mining and is being used by a majority of the mines needing reclamation bonding to satisfy the mandatory bonding requirements.

Also, 1991 was the first full year in which new State regulations regarding rents and royalties were in effect. Senate bill 129 requires that the holder of any mining claim, leasehold location, or mining lease on State land must pay annual rental in advance to retain equity in the property. The rental for each year shall be credited against the production royalty for that year. Production royalty is paid annually on that year's net profits of the mining operation. Also, the holder may pay $100 per claim before the end of the labor year instead of performing the labor requirement. Failure to pay rent or royalty is considered abandonment of the claim.

EXPLORATION ACTIVITIES

According to the State, grassroots mineral exploration continued at a relatively healthy rate although general exploration has declined from the near record-breaking levels established in 1990. Part of the reason was that a number of properties once regarded as exploration projects have moved to advanced exploration or development stages, including Echo Bay Alaska Inc.'s Alaska-Juneau and Kensington projects and AMAX Gold Inc.'s Fort Knox project.

The number of active State and Federal mining claims continued a decline that began in 1989. Active claims totaled 57,666 in 1991, compared with 62,528 in 1990, 67,528 in 1989, and 75,542 in 1988. Part of the decline can be attributed to modifications in State regulations on the maintenance of claims and increased exploration on Native corporation lands that require no claim staking. Of the 57,666 active claims in 1991, 30,622 were State claims and 27,044 were Federal. During 1991, assessment work continued on 52,976 claims, and 3,391 new State and 1,299 new Federal claims were staked. The State collected $0.50 per acre annual fee, with a typical claim bill being $20 for a 16-ha (40-acre) claim.

A number of projects were in advanced exploration or development stages. Echo Bay continued to explore and develop the historic Alaska-Juneau (A-J) Mine, the State's largest past producer of lode gold. Work included acquiring permits, a final draft Environmental Impact Statement (EIS), and metallurgical testing. Echo Bay provided a $111,980 grant to the Mineral Industry Research Laboratory at the University of Alaska for work on milling and gold recovery. Echo Bay purchased the remaining 15% of the A-J unit from Watts, Griffis and McQuatt Inc. (WGM). The purchase included the nearby historic Treadwell deposit across the Gastineau Channel on Douglas Island.

In an effort to increase the reserve base, drilling and underground development continued at the Kensington gold mine, a joint venture of Echo Bay and Coeur Alaska, with Echo Bay as the operator. The property is sited about 80 kilometers north of Juneau. In addition, the Horrible ore body was explored. Although intersected by the main haulage drift, Horrible is not considered part of the main Kensington vein system. A number of environmental and permitting issues were addressed, and the U. S. Forest Service released a draft EIS in June. Because the property is within the borough limits, the City and Borough of Juneau continued involvement in the mine's development.

Fairbanks Gold Ltd. drilled at its Fort Knox gold deposit sited on Alaska State lands about 24 kilometers northeast of Fairbanks. Work included bulk sampling

and condemnation drilling to ascertain where to locate mine infrastructure for the proposed large-scale open pit mine. AMAX Gold announced its intentions to purchase all assets of Fairbanks Gold by stock transfer. Estimating production in late 1994 or early 1995, AMAX Gold planned to continue necessary development, permitting, and environmental work.

In the northern region, exploration continued in the Noatak lead-zinc province, in the Ambler mineral belt, and in historic placer mining areas. NANA Regional Corp. used geochemical surveys and site-specific geological mapping to explore for gold, lead, silver, and zinc in the Ambler district and in the Candle-Inmachuk districts of the Seward Peninsula. Those searching for placer gold included Dodies Dream Association along the south fork of the Koyukuk River within the Alyeska pipeline corridor and Robert Pelky on Ironside Bar and on the south fork of the Koyukuk River near Wiseman. Chandalar Development evaluated hard-rock potential for gold and silver at the former Mikado Mine, and Paradise Valley Inc. completed a crosscut looking for gold, lead, silver, and zinc in the Flat Creek drainage east of Wild Lake in the central Brooks Range.

In the western region, exploration declined on the Seward Peninsula and the lower Koyukuk and middle Yukon River basins, a result of the cessation of large placer and lode gold exploratory projects in the Nome district and reduced hard-rock gold exploration north of McGrath.

Kennecott Exploration, in partnership with Bering Straits Native Corp. (BSNC) and Hawley Resource Group, conducted geological mapping, geochemical sampling, and hard-rock drilling of the Aurora Creek stratiform zinc deposit in the Sinuk River drainage. The partnership also explored the Gold Hill gold system north of Nome. BSNC independently completed staking and mapping activities in the Bluff and Mount Distin gold and base metal mineralized areas. Aspen Exploration applied for permits to test mine a gold deposit at the Sophie Gulch-Rock Creek mineral zone.

North Pacific Mining Co., the mining unit of Cook Inlet Regional Corp., continued exploration efforts to confirm and expand reserves at the Illinois Creek prospect southwest of the Kaiyuh Hills in the Yukon River basin. Illinois Creek is the largest of several polymetallic, gold-bearing gossans in the area. Work included drilling, trenching, and the acquisition of mine permits.

To ensure proper placement of its airstrip and surface facilities, Central Alaska Gold Co. did condemnation drilling and geotechnical drilling at a gold and copper deposit at Nixon Fork. Others working in the western region included Flat Creek Mining Co., which explored for placer paystreaks and lode gold on Timber and Flat Creek in the Ruby-Poorman district; on the Seward Peninsula, Allen Vezey, along with Stevens Exploration and Management Corp., drilled for placer gold and mapped sand and gravel resources in the Solomon district; Tolstoi Mining Co. looked for placer gold and platinum on Boob Creek and in tributaries on Mount Hurst west of McGrath; and the U.S. Minerals Management Service issued offshore exploration permits to U.S. Deep Ocean Inc. to search for gold in Norton Sound near Nome.

In the Innoko-Tolstoi district, Innoko River Enterprises prospected for gold on its Native allotment at Cripple Landing north of McGrath. Alamin Mining Co. conducted production tests and a drill program at its Bear Creek claims. Mineral values were found on both Cripple and Bear Creeks, which are part of the drainage system for the mineralized Cripple Mountains.

In the eastern interior region on Ester Dome near Fairbanks, Citigold Alaska Inc., as operator for La Teko Resources Ltd.'s Ryan Lode hardrock gold project, drilled and confirmed reserves in the main northeast-trending vein structure and in the newly discovered subparallel Curlew/Iving Lode, southwest of the Ryan Lode. This was the largest drill project reported in Alaska in 1991. At the same time, Citigold contracted Inco Exploration and Technical Services Inc. to neutralize spent cyanide leach pads and impoundment waters from previous operations.

Also on Ester Dome, American Copper and Nickel Co. (ACNC) continued to evaluate the Grant Mine vein system in a joint venture with Silverado Mines U.S. Inc. The company defined and drilled selected targets, including the O'Dea vein structure and in the Ethel pit area east of the Ryan Lode property. ACNC also explored on State claims at Eagle Creek, a plutonic-hosted gold prospect north of Fairbanks.

AMAX Gold explored west of Pedro Dome north of Fairbanks and at the Liberty Belle copper-bismuth-gold deposit east of Healy. The joint venture of Tri-Valley Corp. and TsNIGRI (Central Research Institute of Geological Prospecting for Base and Precious Metals) of Moscow, Russia, explored in the Richardson district east of Fairbanks; work included detailed geological mapping and intensive soil, stream sediment, and rock geochemical surveys. Central Alaska Gold, in partnership with Caithness Gold Mining, conducted site-specific and regional reconnaissance. BHP-Utah conducted geochemical and geological mapping studies on bulk minable gold and polymetallic massive sulfide deposits in the Circle district. On leases from Fairbanks Exploration Inc., Freegold Recovery evaluated lode gold and silver potential in the Cleary Summit-Pedro Dome area in the Fairbanks district. Montague Gold entered into an agreement with ASA Inc., which has an agreement with Doyon Ltd. to explore land owned by the Interior Native regional corporation. Lodestar Exploration researched the Taurus copper-gold-molybdenum porphyry system in the Tanacross Quadrangle near the Alaskan Highway. Grateful Dog Mining examined the mineral potential of the Treasure Creek drainage and the old Love Site military installation.

Placer mining firms conducting exploration in the area included D'Log Industries in the Bonnifield district; in the Chena River drainage, Herning Exploration and Mining on Palmer Creek; in the Circle district, Greenhorn Mining on Ketchum Creek and Rainbow Mining

on Flat Creek; Jensen Mining on Sears Creek in the Delta district; in the Fairbanks district, Alder Creek Mines on Fairbank Creek, Polar Mining on lower Goldstream Creek, and Sweepstakes Mining on Kokomo and Grouse Creeks; in the Fortymile district, 45-Pup Mining; Polar Mining on Hinkley Gulch in the Richardson district; and Windy Hill Mining on Little Boulder and Silverbow Creeks in the Tofty district.

Drift mining potential of deeply buried gold placer deposits was examined in the Fairbanks district, including work by RCL Mining on lower Dome Creek and ACE General Contractors Inc. in lower Goldstream valley near Fox.

In the south-central region, Howard Keck, as lessee, and the firm Hunt, Ware and Proffett, as manager, drilled and conducted detailed geological and geochemical mapping of the Johnson River polymetallic deposit west of Anchorage in the southern Alaska Range. A joint venture of Cathedral Gold, Pacific Sentinel, and North Pacific Mining Co. (NPMC) searched for copper-gold targets on the west side of Cook Inlet. NPMC independently explored Chugach Alaska Corp. lands on the Kenai Peninsula, employing various surface sampling surveys. NPMC also evaluated its Toklat massive sulfide prospect in the Talkeetna Mountains.

Placer Dome U.S. Inc. leased ground from Cominco Alaska Exploration Inc. and drilled the newly discovered Deadman Mountain property, a high-grade gold-arsenic-antimony-silver deposit south of the Denali Highway near the Valdez Creek Mine. Ahtna Minerals Co. initiated a minerals exploration program on Ahtna lands in the Copper River valley. Chugach Alaska continued reconnaissance exploration in the Katalla, Port Graham, and English Bay areas. Gold Tech Resources Inc. and KDT Exploration and Mining Co. looked for both lode and placer deposits of platinum and gold in the Valdez Creek and Pass Creek areas north of the Denali Highway. WGM continued exploration of the former Cliff Mine, a gold-quartz deposit on Valdez Arm west of Valdez. Work done by WGM included dewatering of underground workings and the sampling of old stopes. The Polaris Group, an Alaska-based venture-capital fund, purchased shares of Nova Gold Resources, owner of the Cliff Mine.

A number of companies and individuals explored historic placer mining camps for placer potential. Cambior Alaska Inc. conducted drill programs in the Valdez Creek fan-delta area downstream from the operating Valdez Creek Mine, and in Windy Creek drainage south of Valdez Creek valley. Randy Elliot mapped, prospected, and reported overburden removal at McCarthy, while John Whitney prospected in the old Sunrise district of the Kenai Peninsula. Crow Creek Mining Co. conducted dredging and mapping surveys on its placer prospects in the Girdwood area near Anchorage, and Caprock Corp. completed exploratory drilling and started pit design on a property leased from the Rowallan Mine Partnership near the confluence of White and Valdez Creeks upstream from the Valdez Creek Mine. Also, Arnold and Sally Echola prospected on Gold Creek in the Nelchina district; in the Cache Creek district, Lake Creek Placers continued evaluating gold-platinum placer deposits in conglomerate reefs at Lake Creek west of Talkeetna, and TC Mining explored on Cache Creek itself. Finnbear Mining Co. assessed hard-rock and placer gold-platinum potential of the Finnbear claims in the Kahitna drainage southeast of Rainy Pass.

In the southwestern region, Cominco Alaska explored its Pebble property, a copper-gold-molybdenum porphyry deposit west of Newhalen and north of Lake Iliamna. Work included definition drilling, permitting, and the initiation of prefeasibility studies. Central Alaska Gold and Placer Dome drilled a new discovery on lands owned by Doyon Ltd. on Vinasale Mountain south of McGrath. Calista Corp. searched in the Donlin Creek area north of Crooked Creek on the Kuskokwim River and at the Stuyahok placer camp in the Marshall district of the lower Yukon River drainage.

Others in the region included Battle Mountain Exploration, which mapped and sampled in the Iditarod Quadrangle; Jualin Creek Mining Co., which explored for placer and lode gold in the Jualin Creek drainage; Paul Sayer, who proved up reserves of placer gold and scheelite in Little and Ester Creeks in the historic Ophir district; Misco-Walsh Mining Co. explored the Golden Horn property, a gold-tungsten-silver deposit, and Flat Creek Placers bulk sampled in the upper Flat Creek area in the Iditarod district, including tailing sites left over from pre-1920 dredging activities of the Yukon Gold Co.; Howard Bowman received patents on mining claims on Portage Creek along the shore of Lake Clark; and R.A. Hanson Co. did extensive testing on clay-rich pay zones, including the construction of flotation cells, at its placer platinum properties in the Goodnews district.

In the southeastern region, Hyak Mining conducted assessment work at the Enterprise Mine north of Limestone Inlet, southeast of Juneau. The company also did reconnaissance activities at the East Point prospect, south of Freshwater Bay, on northeastern Chichagof Island. After Hecla Mining Co. dropped its option, Hyak and AJT Mining continued exploration on the Red Diamond prospect on southern Douglas Island above Nevada Creek. Ivanhoe Partners explored the Ivanhoe prospect, north of Juneau.

Red Dodson explored at Bokan Mountain, a former producer of uranium and thorium in southern Prince of Wales Island. Also on Prince of Wales Island, Cominco Alaska Exploration conducted geophysical prospecting on the Big Harbor property, a base metal deposit north of Trocadero Bay, southeast of Craig, and Guy Comer explored at the Lucky Nell Mine, a vein gold deposit near Hollis. Cominco Alaska also worked near the Alaska-British Columbia border, west of Haines. The area contains numerous Kuroko-like massive sulfide and barite deposits along with gold skarns.

U.S. Borax sold the mineral rights to the Quartz Hill molybdenum deposit east of Ketchikan to Cominco Ltd. Borax had obtained Federal patents on core claims that cover the property, but molybdenum

prices and tailings disposal are critical to its development. Salisbury and Associates explored and assessed the PEEJ Claim Group near Point Couverden west of Juneau. In search of base metal and precious-metal deposits, Salisbury continued as operator for ACNC in the Dolomi district on Prince of Wales Island. In the Wrangell area, Kennecott Exploration searched for massive sulfide deposits. Alaska-Dano Mines did surface exploration for base and precious metals near Funter Bay on Admiralty Island, west of Juneau. Work included field mapping and surface geochemical sampling.

Prospectors Roger Eichman, Floyd Branson, and Dale Henkins worked claims at the Dream prospect in the Chilkat Range south of Haines and at the Peterson Mine on the mainland north of Juneau. Northeast of Juneau, Henkins and Eichman sampled at the Gold Fork property, a vein gold deposit on Carlson Creek. Placer Dome drilled then dropped its option on the Jualin gold property held by Hyak Mining northwest of Juneau.

Ashgrove Cement West Inc. explored and conducted prefeasibility studies on its Oswego limestone claims. The claims are at View Cove on east-central Dall Island, west of Prince of Wales Island. Ashgrove would use the Oswego limestone in the production of portland cement.

LEGISLATION AND GOVERNMENT PROGRAMS

Work progressed on resolution of the 1985 Weiss vs. State of Alaska lawsuit and the many complex issues surrounding the Alaska Mental Health Lands Trust. The Alaska Division of Lands, the lead Department of Natural Resources agency, attempted to satisfy provisions of the court order that demanded resolution and reconstitution of the Trust lands. The problem is that the State has sold or otherwise disposed of 55% of the original 1 million acre territorial land grant enacted in 1956 and confirmed by the 1959 Alaska Statehood Act, which was dissolved by the 1978 Alaska Legislature. The Governor of Alaska's preferred option, referred to as chapter 66 settlement, would reconstitute the remaining Trust lands and add new lands pledged as security that are judged to be of value equal to the original Trust lands sold or relinquished by the State. Another solution would be to reestablish the remaining Trust lands and supplement them with other net State income.

At the request of the Alaska Legislature, the Department of Community and Regional Affairs (DCRA) studied in-place taxation of natural resources. DCRA recommended that in-place natural resources be permanently exempted from municipal taxation. The legislature unanimously adopted the recommendation by the passage of Senate bill 330, which provides for the permanent exemption.

The Institute of Mining Technology of the University of Alaska Southeast, at Juneau, received an allotment of $148,000 from the U.S. Bureau of Mines. The school has received a total of $2.76 million since inception of the Mineral Institute Program in 1978.

Usibelli Coal Mine Inc., with five other private and public organizations, participated in the ongoing Healy Clean Coal Project (HCCP). The goal of the project is to build a modern mine-mouth powerplant using state-of-the-art technologies designed to reduce sulfur, nitrogen, and particulate matter emissions. Of the $194 million cost, about 50% was to be supplied through a U.S. Department of Energy grant.

FUELS

Usibelli Coal produced the bulk of Alaska's coal in 1991. About one-half of the coal mined at the company's Healy coalfield was used at six powerplants in interior Alaska; the other one-half was exported through the Port of Seward to the Korean Electric Power Co. in Honam, Republic of Korea. Usibelli mines primarily from two pits, the Poker Flats pit that accounted for about 84% of the production, and the Gold Run pit. The mines are sited on lands leased from the State of Alaska. The coal is classified as subbituminous-C with extremely low sulfur, but moderate to high ash and high moisture.

Arctic Slope Consulting Group (ASCG), operator for Arctic Slope Regional Corp., mined bituminous coal at its Aluaq Mine in the Deadfall syncline area of northwest Alaska. Most of it was used for heating in local north slope villages, an ongoing effort to offset demand for expensive petroleum-based products in remote areas. In 1991, the Alaskan Legislature awarded $2 million to Arctic Slope Regional Corp. to continue the project's exploration and feasibility studies. ASCG continued exploration in the area, concentrating its efforts near Cape Beaufort.

In the Matanuska Valley, Hobbs Industries drilled, trenched, excavated, and completed landside remediation studies at the Evan Jones coal mine near Sutton. After bulk sampling at the Castle Mountain Mine near Chickaloon, the company delayed further development, a result of a Mental Health Lands dispute. Other coal properties in various stages of development included the Wishbone Hill bituminous coal deposit northeast of Palmer in the Matanuska Valley, where Idemitsu Alaska Inc. conducted reserve evaluation drilling, engineering design, and environmental studies; and in the Beluga coalfields northwest of Cook Inlet, where D & R Ventures Inc. did development and permitting work at the Diamond Chuitna Mine, a joint project of BHW Group and the Diamond Shamrock Chuitna Coal Joint Venture.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Gold.—Although the quantity of gold production reported, in response to the U.S. Bureau of Mines survey, remained essentially unchanged at 3,196 kilograms, value decreased 7% to $37.3 million. The average price for gold in 1991 was $11.68 per gram, compared with $12.44 in 1990. Three lode properties and 10 placer operators responded to the

Bureau's survey. Gold production reported to the Bureau was 42% of the State's estimated production.

The State estimated 1991 gold production at 7,585 kilograms, an increase of more than 5% from that reported in 1990. The bulk of the increase was attributable to the resumption of full-scale operations at the Valdez Creek Mine by Cambior Alaska. The production value of gold was $88.3 million, a slight drop from that reported by the State in 1990. About 85% of the gold was produced by an estimated 202 placer mines and the balance from 2 lode mines. State production estimates for 1991 "are based on data compiled from 177 DGGS questionnaires returned by companies, individuals, Native corporations, and government agencies; phone conversations with 19 sand, gravel, peat, and stone quarry operators; regional summaries provided by the U.S. Forest Service (USFS) and Alaska Department of Transportation and Public Facilities (DOPTF); and bullion sale volume estimates from selected precious metal refiners."[6]

In 1991, the 10 largest gold producers in Alaska recovered 4,380 kilograms or 57% of the State's total production. These producers were Alaska Gold Co., Alaska Placer Development Inc., Cambior Alaska Inc., GHD Resources Partners Ltd., Kennecott Greens Creek Mining Co., NYAC Mining Co., Polar Mining Inc., Rosander Mining Co., Sphinx Mining Inc., and Thurman Oil and Mining.

For the second consecutive year, Chandalar Development Corp. was the northern region's largest gold producer. The company mined ground on Tobin Creek east of the Trans-Alaska pipeline corridor, using a dry-land jig recovery plant. Paradise Valley Inc. extracted gold from an opencut mining operation on Flat Creek, east of Wild Lake in the Central Brooks Range; recreational mining for tourists also was offered by Paradise Valley. Large nuggets were found using a metal detector at Inside-Out Mining Co.'s property, an underground drift operation on Nolan Creek north of Wiseman.

Operators reported working in the Koyukuk-Nolan district were Glenn Bouton on the Middle Fork of the Koyukuk River; Mascot Mining Inc. on Vermont Creek; Bill Nordeen on Emma Creek; Light Mining on Nolan and Acme Creeks; and Tricon Mining on Archibald Creek. Others reported working in the north region included Don Knutson and Mary McKinstry on Smith Creek in the Nolan-Wiseman area; Mitch Fleming on Myrtle Creek in the Wiseman area; and Mike Shupe on Boulder Creek in the Chandalar district.

The western region had a drop in estimated gold production. The shutdown of Westgold Ltd.'s BIMA offshore dredge and the closure of Anvil and Windfall Mining Companies' opencut mines were the primary reasons for the decline. In the Nome district, Alaska Gold Co. operated two onshore floating bucketline stacker dredges. Dredge No. 5 worked on the Third Beach (Monroeville Beachline) deposit at its intersection with Dry Creek, about 3 miles northwest of town. Dredge No. 6 continued digging westerly along Submarine Beach, about 3 miles west of the Nome airport. GHD Resources' Kiwalik Flats operation, near the village of Buckland, was Seward Peninsula's largest opencut placer mine. GHD installed a jig plant to improve recovery and to determine the efficiency of conventional sluice-box operations of previous years.

Also in the Candle district, Au Mining Inc. and Clara Bea Inc. operated an opencut, front-end-loader-fed operation near the Candle townsite. Several miles upstream of Candle Creek, Alan Olson and Victor Layer reworked previous gravels, and nearby, the Rheinhart-Berg partnership mined Mud Creek.

In the Inmachuk River drainage south of Deering, Jack Hoogendorn drift mined gravels underneath Pliocene basalt lava flows. In the Kougarok district, N.B. Tweet and Sons operated a floating dredge on Henry Creek, Dick Creek Mining produced from a small opencut placer on Dick Creek, and Cheryl Jong mined on Washington Creek.

Other Seward Peninsula placer mines included the following: in the Koyuk district, Edwin Hatch on Sweepstake Creek, D.B. Parent's, Dozette, and Gardner operations on Bear Creek, and Swanson Mining on Dime Creek; in the Nome district, Homer Hoogendorn on Buster Creek and the Global Resources American Creek Dredge on Cripple Creek; Ed Schwoyer on Bluestone River in the Port Clarence district; and Dave Gerke in the Solomon district.

In the Yukon River basin, Taiga Mining Co. Inc. leased and operated Alaska Gold's Hogatza Dredge on Bear Creek in the Middle Koyukuk River drainage. Taiga reactivated the bucketline stacker dredge in 1989 and was working mineralized areas left by previous operators. South of the Yukon River, Flat Creek Mining Co. mined on Federal claims on Flat Creek. Operators in the Ruby-Poorman district include 7.5 Ounce Mining on Trail Creek; Short Gulch Mining on Ophir Creek; Sphinx Mining on Monument Creek; Swift Creek Mining Co. on Swift Creek; Tilleson Mining and Reclamation on California Creek; Miscovich Mining Co. on Poorman Creek; and Green Mining and Exploration on Long Creek.

Others active in the western region include Rosander Mining Co. on Colorado Creek, a northerly drainage of the Cripple Mountains; Bob and Manzie Magnuson mined at Madison Creek northwest of the old mining town of Ophir; near the Madison Creek operation, Doug Sherrer recovered gold and platinum in production tests at Boob Creek; and Yukon Mining Co. was active on Golden and Illinois Creek near Tanana.

The eastern interior region was the leading gold-producing area in Alaska. In the Fairbanks mining district, Polar Mining operated two large placer mines on lower Goldstream Creek north of Ester Dome, and Fish Creek. Both mines operated year-round, although activities in the winter months included only drilling, blasting, and overburden removal. On Fairbanks Creek, Thurman Oil and Mining operated a large opencut placer mine; Cook's Mining worked 4 1/2

months downstream from the old hard-rock McCarty Mine and also stripped overburden on Deep Creek for future production; and Alder Creek Mines prepared a section of bedrock to evaluate the worth of old dredge tailings.

On patented claims controlled by Alaska Gold, Al Hopen worked two placer mines, one on Cleary Creek near the Cleary Hill Mine mill and on Little Eldorado Creek. Other opencut placer operators in the Fairbanks area included Andy Miscovich Sr. on Chatham Creek; on Dome Creek, Andy Miscovich Jr. and Layne Gardner; on Ester Creek, Jerry Hassel, John McLain, and Carson Holt; Lucky Seven Mining on Fish Creek; Jack Neubauer in Fox Gulch; Goldstream Exploration on Gilmore Creek; T. J. Mining on Homestake Creek; Herning Exploration and Mining on Palmer Creek in the upper Chena River drainage; Don Stein on Twin Creek; and Vince Monzulla on Virginia Creek.

Drift mining and development of deep frozen placers in the Fairbanks district included Roberts Mining at its Dome Creek property; on lower Dome Creek, RCL Mining removed ice and muck and conducted test runs of drift gravels from reactivated workings; Don Read on Vault Creek; EVECO-ACE Construction on Goldstream Creek near the U.S. Corps of Engineer's Fox permafrost tunnel; and Voytilla Mining Ventures.

Active placer claims in the Circle district dropped by one-third from those of 1990. Operators included Vern Stepp on Bottom Dollar Creek; George Seuffert on Butte Creek; Ed Gelvin on Crooked Creek; John Sipes and Magic Circle Inc. on Deadwood Creek; on Harrison Creek, Mike Dugger and Charles Cleveland; Steve Olsen on Eagle Creek; on Faith Creek, Sam Koppenberg; on Ketchum Creek, Greenhorn Mining and Fred Wilkenson; Ed Lapp and Earl Beistline on Mastodon Creek; Paul and Co., Mack Rite, and Harold Dunham on Porcupine Creek; and on Portage Creek, Bob Cacy, Eddra Ziegler, and John Cole.

In the Rampart and Eureka-Manley areas, Shoreham Resources Ltd. operated an opencut placer mine on the Sullivan Bench in the historical Tofty-Hot Springs district west of Manley Hot Springs. In addition to gold, Shoreham recovered silver and tin as cassiterite. Others working in the area included Don Delima and Jeff Knaebel on American Creek; Rick Swenson on Doric Creek; Thurman Oil and Mining on Eureka Creek; on Hoosier Creek, Lucas Mining; Eleven Pup Mining and Steve Losonsky on Hunter Creek; on Little Boulder Creek, J. L. Wood; Munsell Mining on Little Minook Creek; Ed Salter and Associates on Joe Bush Creek; on North Fork Creek, Kelly Mining; and Williams Mining on Ruby Creek.

Alaska Placer Development Inc. operated one of the State's largest placers on the Livengood Bench just north of the old townsite of Livengood. The company hydraulically stripped muck overburden and mined and sluiced a gravel paystreak overlying a rough limestone bedrock. Also in the Livengood district, Heflinger Mining and Equipment mined a small opencut on Livengood Creek.

The Fortymile district had an estimated 24 placer mines, including Harold Nevers on American Creek; Forest Hayden on Baby Creek; Ham Mining Co., Alice Bayless, John Burns, and Kachemak Mining on Chicken Creek; G. A. Hanks and Sons on Lost Chicken Creek; Fortyfive Pup Mining, using a newly constructed trommel, on Fortyfive Pup Creek; on Ingle Creek, Leo Regner; Brandt Goodall on Mosquito Creek; on Myers Creek, Dennis Eich and Angess Purdy; Robert Roberts on Skookum Creek; and Fred Heflinger and Boundry VIA Co. on Walker Fork.

Alaska Unlimited Inc.'s property on Gold King Creek was the largest placer mine in the Bonnifield and Delta districts. Also in the districts were Jensen Mining and Construction on McCumber Creek south of Delta Junction; Tom Faa on upper Moose Creek; Jim Roland on Lower Moose Creek; and Jackson Mining Co. on Totatlanika River.

The south-central region had a significant increase in gold production, a result of the resumption of full-scale mining by Cambior Alaska at the Valdez Creek Mine late 1990. Sited approximately 88 kilometers east of Cantwell, the mine has been Alaska's largest placer mine for 6 of the past 7 years. With a stripping ratio of 15:1, overburden was removed to expose several superimposed ancestral channels of Valdez Creek. A stream diversion project that channeled water around the open pit operations, required by the Alaska Department of Fish and Game, was completed. According to the State, development drilling at Valdez Creek accounted for 80% of Alaska's total reported placer drilling.

Others mining in the area included Hoffmann Mining on the middle fork of the Chistochina River; Mrak Placer Mining in the Willow Creek drainage near Hatcher Pass; Randy Elliott on patented claims at Dan Creek within the Wrangell-St. Elias National Park Preserve; Lake Creek Placers, recovering both platinum and gold from the Gold Sand Bar Group on Lake Creek in the Cache Creek; Martin Herzog, also in Cache Creek; Girdwood Mining Co. along Crow Creek near Girdwood; and Outsider Mining Co. in Canyon Creek south of Anchorage.

In the southwestern region, NYAC Mining Co. mined at the headwaters of Bear Creek in the historic NYAC mining district south of Aniak. In the Innoko district, Magnuson Mining Co. worked stream and bench placer deposits in Ganes Creek Canyon. Nearby, Anderson and Son Mining leased and mined land owned by Doyon Ltd. in Yankee Creek. Also, Little Creek Mining continued to operate on Little Creek, and Larry Wilmarth and partners mined on Julian Creek in the George River.

In the Iditarod district, Micro-Walsh Mining Co. continued production testing and processing at its Golden Horn deposit. The mine produces a complex gold-silver-tungsten-antimony-mercury concentrate. Flat Creek Placers Inc. recovered gold from dredge tailings in Flat Creek; Dick Wilmarth worked on lower Chicken Creek near its confluence with Bonanza Creek; and Alvin Agoff mined in Prince Creek on the south side of Chicken Mountain. Dave Penz mined on Buster Creek, a tributary to Kako Creek in the old Marshall district of the

lower Yukon River. Ernie Chase operated on the Stuyahok River in the eastern-most part of the district.

In the southeastern region, Kennecott Greens Creek Mining Co. produced gold at its Greens Creek zinc-silver mine on Admiralty Island, about 29 kilometers west of Juneau. Other gold production in the area included that from the Big Nugget Mine in the Porcupine mining district near Haines, and Jerry Fabrizo produced on Porcupine Creek, also near Haines.

Platinum-Group Metals.—No production of platinum-group metals was reported to the U.S. Bureau of Mines, although several placer operators recovered small amounts of platinum and platinum-group metals as a byproduct of their gold production. The State estimated production at 465 grams.

Silver.—Alaska was the Nation's third-ranked silver-producing State. Kennecott's Greens Creek zinc-silver mine was the State's leading silver-producing mine and the Nation's top ranked silver mine for the third consecutive year.

At Cominco's Red Dog zinc mine, silver in concentrate form was produced as a byproduct from smelter feeds. Production declined because of the complex nature of the ore mineralization and the resulting metallurgical problems.

Tin.—Recent reported tin production has been concentrated in the Ruby-Poorman district in the western region and the Tofty-Hot Springs district in the eastern interior region. The only significant production reported in 1991 was by Shoreham Resources, which recovered tin as cassiterite at its Cache Creek gold placer mine.

Zinc and Lead.—Alaska was the Nation's top-ranked zinc-producing State, producing more than double Tennessee's production, the Nation's second-ranked State. Alaska ranked second in the Nation for lead production.

Cominco Alaska's Red Dog Mine was the State's and the Nation's largest zinc producer. The mine also produced lead and silver. Red Dog is a massive sulfide deposit about 145 kilometers north of Kotzebue in the DeLong Mountains of the northwestern Brooks Range. The opencut mine is owned by NANA Regional Corp. Inc. and leased to Cominco, which owns and operates the mining and processing facilities. Ore was milled near the mine, then the lead, zinc, and bulk (ISF) lead-zinc concentrates were trucked to the port site near Kivalina on the Chukchi Sea, approximately 84 kilometers from the main camp. During the short open-water season of about 100 days, the concentrates were barged from shallow port-site waters to oceangoing ore carriers, which then delivered concentrates to customers in Europe, the Far East, and to trains bound for Cominco's refining facility in Trail, British Columbia.

Kennecott Greens Creek Mining's Greens Creek Mine was the State's second largest zinc producer and ranked third in the Nation for zinc production; the mine also produced gold, lead, and silver. The company employed 238 year-round workers. The U.S. Forest Service prepared an environmental assessment to identify waste disposal issues and locate additional storage and disposal sites. Additional waste rock disposal sites were required because of the nearly quadrupling of the original reserves and because much of the originally designated sites were being used for the disposal of unstable marine clays excavated during mill construction. Stability problems were solved by the excavation and drilling of a series of horizontal dewatering wells. Kennecott submitted a modified plan of operation to the Forest Service and began to make major mill improvements and upgrades, including the addition of tower mills and column flotation cells in an effort to improve grinding capabilities. The improvements were designed to improve concentrate quality and were not expected to change annual mill production. Kennecott and consultant On-Line Exploration mapped and sampled on the Mansfield Peninsula, northwest of the mine.

Industrial Minerals

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1990 and estimates for 1989 and 1991. Estimated sand and gravel production dropped more than 7% in quantity and 6% in value from that reported in 1990.

Construction sand and gravel was produced on the North Slope, along the Rail Belt, in the southeastern Panhandle, and in various bush locations. In the northern region, ARCO Alaska produced gravel to service its production and site facilities at Prudhoe Bay and Kuparuk operations. In addition to its river flood-plain reserves, ARCO recycled reclaimed gravel and washed drill cuttings for use in pad construction. BP Exploration also produced gravel for construction and maintenance purposes. Sand and gravel was mined and utilized a number of ways at the Red Dog Mine north of Kotzebue. In the Nome area, gravel was provided to three Alaska Department of Transportation and Public Facilities (DOTPF) projects, including Bering Straits Native Corp.-supplied gravel for a 16-kilometer section of the Nome to Council road project.

In the Fairbanks area, Earthmovers Inc. operated three gravel pits that provided sand and gravel for various DOTPF construction projects. For similar uses, H & H Contractors mined pit run sand and pea gravels and some tailings. Fairbanks Sand and Gravel Inc., owned by Sealaska Corp., mined pit run sand and gravel with a floating clamshell dredge and used the product for road fill, landscaping, and manufacture of concrete blocks at its south Fairbanks plant.

Others reporting sand and gravel production in the eastern interior region included ACE General Contractors, from dredge tailings in the Fox area near Fairbanks; Great Northwest Inc. from the

TABLE 2

ALASKA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch): Riprap and jetty stone[2]	405	921	$2.27
Coarse aggregate, graded[3]	45	96	2.13
Fine aggregate (-3/8 inch)[4]	23	75	3.26
Coarse and fine aggregate:			
Graded road base or subbase	264	1,064	4.03
Unpaved road surfacing	49	131	2.67
Crusher run or fill or waste	147	1,658	11.28
Other construction materials	5	20	4.00
Unspecified:[5]			
Actual	2	19	9.50
Estimated	144	703	4.88
Total[6]	1,085	4,688	4.32

[1]Includes granite, limestone, miscellaneous stone, slate, and volcanic cinder and scoria, excludes a minor amount of sandstone withheld to avoid disclosing company proprietary data.
[2]Includes filter stone and other coarse aggregate.
[3]Includes concrete aggregate, coarse, and bituminous aggregate, coarse.
[4]Includes stone sand, concrete, and stone sand, bituminous mix or seal.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.
[6]Data may not add to totals shown because of independent rounding.

College Road mine site, on ground leased from the University of Alaska in Fairbanks; Jerry Hassel of R.B. Gravel Co., along with gold at its Goldstream Valley property; Popo Agee Inc. at Dry Creek on the George Parks Highway, suppling gravel to local Healy markets. Also on the Parks Highway, Caswell Creek Aggregate mined at Mile 85; Delta Concrete Production Inc. mined, washed, and screened gravel from the Delta River; Alyeska Pipeline Service Co. mined along the Trans-Alaska Pipeline right-of-way north of Fairbanks and south of the Yukon River; and DOTPF extracted gravel from a number of BLM, ADL (State of Alaska), and other unspecified sites.

In the south-central region, the Alaska Railroad, DOTPF, and 11 companies reported sand and gravel production. The Alaska Railroad hauled gravel from the Palmer-Wasilla area to Anchorage markets. Uses included the rebuilding of portions of the Seward and Glenn Highways and the construction of additional port facilities. DOTPF produced sand and gravel used in the construction of the Cordova Road. Companies also reporting sand and gravel production included Jackson Construction, which mined, washed, and screened gravel from pits in the Kenai-Soldotna area; Rock Products Inc. mined at its Wasilla area material sites; on State of Alaska leases, SAFAR Construction extracted gravel from its Portage River valley pit near Girdwood; Herman Brothers Construction Co. mined in Palmer; AAA Valley Gravel Inc. mined at its property on Trunk Road near Palmer; Spring Creek Sand and Gravel depleted its Chugiak pit; and K's Concrete Service and Luke's Mining Co. operated at their sites near Homer.

In the southwestern region, production from Calista Corp. property was used primarily for airport construction; Bristol Bay Native Corp. and village corporation partners mined gravel for airport and road maintenance in and north of Dillingham; and DOTPF processed and used sand and gravel for road maintenance in the Dillingham area and for airport repairs at McGrath.

In the Alaska Peninsula region, the demand for sand and gravel used for construction in the fish processing industry was increasing; also, small villages throughout the Koniag area produced pit-run sand and gravel for various community needs. Bristol Bay Native Corp. and Choggiung Ltd. provided sand and gravel for State capital improvement projects throughout the Bristol Bay area, with the largest demand in King Salmon and Neilman.

In the southeastern region, a large part of construction sand and gravel production went for contractors working on Tongass National Forest road and log transfer sites. At the Acme pit, Hildre Sand and Gravel mined pit-run sand and gravel that was sold to Juneau Ready Mix for processing and product upgrade. Other producers included Red Samm Construction Co. on private lands throughout the Panhandle; Ron Thomas from a State lease at the head of Portland Canal; and Bruce Morley with pit-run gravel from the Ludwig pit on the Douglas Highway for various on-site projects.

Stone (Crushed).—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990. No production of dimension stone was reported in Alaska in 1990.

Although on a much smaller scale, crushed stone was produced in areas similar to those for construction sand and gravel, including on the North Slope, along the Rail Belt, in the southeastern Panhandle, and in various bush locations.

DOTPF produced crushed stone for use in the reconstruction of the Cordova Road in the south-central region, and crushed stone in the form of riprap for road maintenance in the Dillingham area and for airport repairs at McGrath in the southwestern region.

In the Alaska Peninsula region, riprap-grade stone was used for construction in the fish processing industry; stone also was used for road maintenance near villages and for logging roads. Koniag Inc. produced pit-run rock from Women's Bay and Afognak Island. The Women's

Bay rock pit was leased to Brechan Inc. and consists of graywacke rock used primarily for local driveway and roadbed subgrade. The Afognak Native Corp. and Koncor Ltd. used similar pit-run rock for logging roads and log transfer sites on the coast. Many small villages throughout the Koniag area used graywacke for various community needs. Westwood Foods was completing its Unalaska fish processing facility and used basalt rock for harbor armoring to protect the facility from storms. Similar work was completed on St. Paul Island.

In the southeastern region, the bulk of the crushed stone production went to contractors working on Tongass National Forest road and log transfer sites. Other producers included the City of Thorne Bay, which mined shot rock at the South Thorne Bay and Deep Creek subdivision sites; various contractors from pits throughout the Ketchikan Gateway Borough; and the Wrangel and Petersburg offices of the U.S. Forest Service, which mined pit-run rock for road construction in the Stikine area of the Tongass National Forest.

Other Industrial Minerals.—Alaska Basic Industries manufactured gray portland cement at its plant in Anchorage using domestic clinker and gypsum received at the Port of Anchorage by marine transportation. This was the only cement plant in Alaska.

NANA Regional Corp. mined jade from its Ambler River deposits in the Jade Mountains of upper Kobuk River area. NANA extracted large boulders of jade that were then slabbed with diamond saws and made into salable products by its Kotzebue operational subsidiary, Jade Mountain Products Inc.

In Fairbanks, peat was produced by Great Northwest Inc. at its College Road mine site, on bogs leased from the University of Alaska. In the Matanuska-Valley-Anchorage area, peat producers included A & A Services, The Dirt Co., and Landscape Supply Corp. The bulk of Alaska's peat production was used for horticultural purposes.

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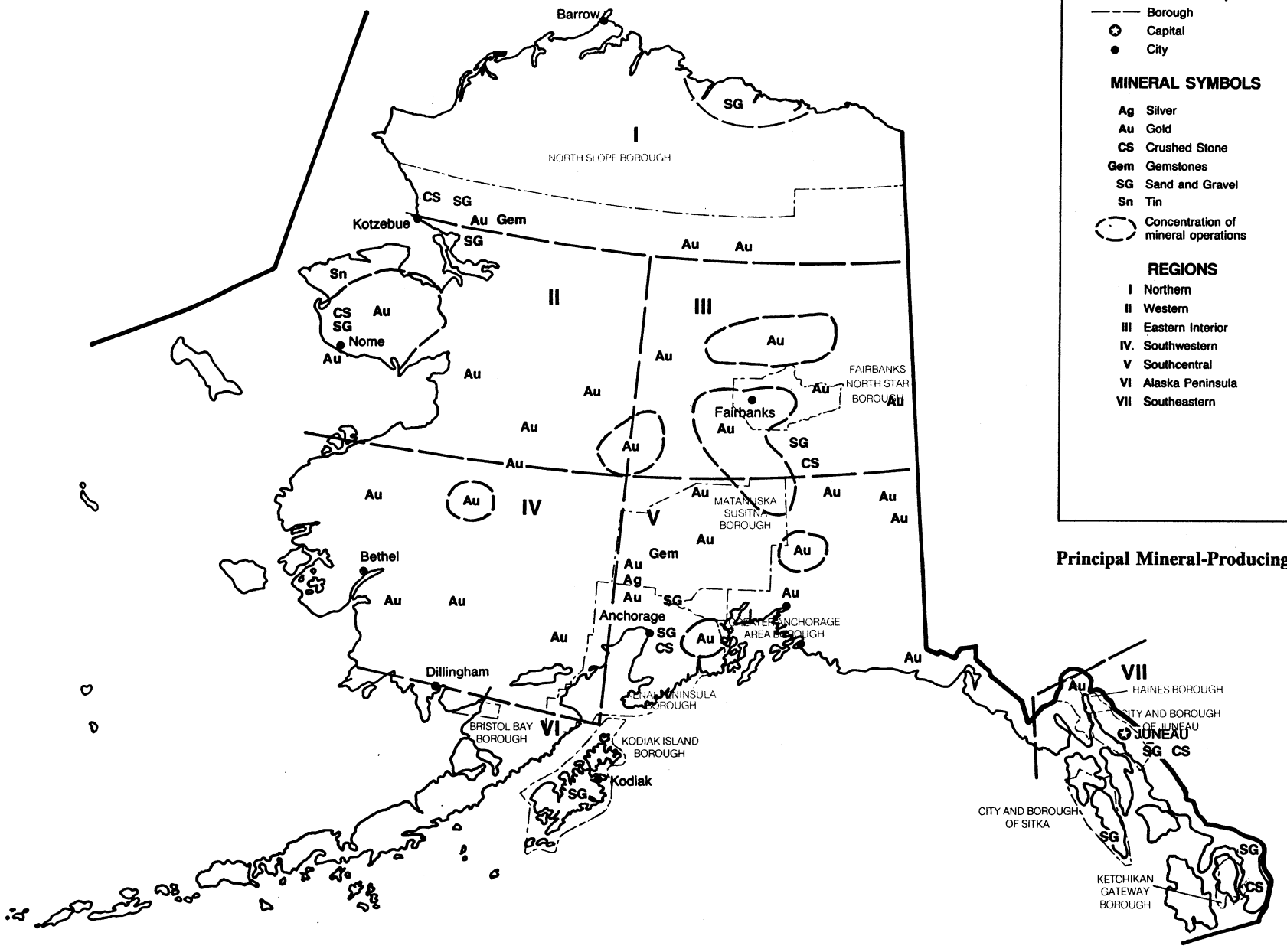
[5]Mineral Development Specialist, Alaska Division of Economic Development, Juneau, AK.

[6]Bundtzen, T. K., R. C. Swainbank, J. E. Wood, and A. H. Clough. Alaska's Mineral Industry 1991. Div. of Geol. and Geophys. Surv. Spec. Rep. 46, 1991, 89 pp.

ALASKA



Principal Mineral-Producing Localities

TABLE 3
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	Region
Cement:			
Alaska Basic Industries	1040 O'Malley St. Anchorage, Ak 99501	Grind and blend	Cook Inlet-Susitna.
Gold:			
Alaska Gold Co.	Box 640 Nome, AK 99762	Placer-dredge	Seward Peninsula.
Cambior Alaska Inc.	Box 110 Cantwell, AK 99729	Placer	Southcentral.
Kennecott Greens Creek Mining Co.	300 Vintage Blvd. Suite 200 Juneau, AK 99801	Lode-under ground	Southeastern.
Polar Mining Co.	4545 Woodriver Dr. Fairbanks, AK 99709	Placer	Yukon River.
Gemstone (jade):			
NANA Regional Corp.	Box 49 Kotzebue, AK 99752	Quarry	Northern.
Stone:			
Aleutian Construction Co.	3909 Arctic Blvd. Anchorage, AK 99501	do.	Aleutian Islands.
KRM Inc.	Box 8100 Ketchikan, AK 99901	do.	Southeastern.
City of Petersburg	Box 329 Petersburg, AK 99833	do.	Do.
South Coast Inc.	Box 8620 Ketchikan, AK 99901	Quarries	Seward Peninsula.
U.S. Bureau of Indian Affairs	Box 3-8000 Juneau, AK 99801	do.	Southeastern.
Tin			
Shoreham Resources Ltd.	Box 10499 Fairbanks, AK 99710	Placer	Eastern Interior.
Zinc, silver, lead:			
Kennecott Greens Creek Mining Co.	3000 Vintage Blvd. Suite 200 Juneau, AK 99801	Lode-underground mine	Southeastern.
Cominco Alaska Inc.	Box 1230 Kotzebue, AK 99752	Lode-open pit	Northern.

THE MINERAL INDUSTRY OF ARIZONA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Arizona Department of Mines and Mineral Resources for collecting information on all nonfuel minerals.

By Jean A. Dupree[1] and Leroy E. Kissinger[2]

As it has since 1988, Arizona led U.S. nonfuel mineral production, a distinction the State owed primarily to its copper mining industry. Valued at $2.83 billion, total State nonfuel mineral output fell 8% below that of 1990. Arizona also remained the leading copper-producing State in the Nation. Arizona's copper output was worth $2.47 billion and equated to 63% of the Nation's total copper value and 87% of Arizona's total nonfuel mineral value. Accompanying Arizona's 1991 copper production were the usual coterie of significant byproducts: gold, lead, molybdenum, rhenium, silver, and sulfuric acid. At $2.51 billion, base-metal and precious-metal production furnished 89% of Arizona's nonfuel mineral value and 30% of the Nation's nonferrous metal value. In addition, Arizona continued to supply important quantities of gemstones, crude gypsum, lime, perlite, and pumice.

TRENDS AND DEVELOPMENTS

Facing ore depletion at San Manuel in 1997, Magma Copper Co. reached an unprecedented new labor agreement in October with seven unions representing its San Manuel and Pinto Valley operations. The new 15-year contract called for problem-solving bargaining and binding arbitration if parties are unable to agree to labor contract terms by July 1997. In essence, the contract eliminated the possibility of a strike or lockout for nearly 8 years. Battling the clock, Magma continued to probe the feasibility of deeper development of the lower K (Kalamazoo) ore body. An essential ingredient of the ongoing study was to demonstrate, by the end of 1992, that operating costs could be lowered from $5.40 to $4 per short ton with a participative labor force and a new mine plan. Assisting in the Kalamazoo feasibility study were the mine division employees, whose productivity increases were rewarded with proportional increases in gainsharing payouts.

ASARCO Incorpoarted proposed a swap of one of three of Arizona's

TABLE 1
NONFUEL MINERAL PRODUCTION IN ARIZONA[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	188,211	$2,506	140,162	$2,318	228,411	$3,830
Copper[2]	do.	898,466	2,593,734	978,767	2,657,649	1,024,066	2,468,255
Gemstones		NA	2,821	NA	2,098	NA	3,173
Gold[2]	kilograms	2,768	34,047	5,000	62,191	2,068	24,159
Iron oxide pigments (crude)	metric tons	W	W	W	W	18	22
Sand and gravel (construction)	thousand short tons	e33,900	e133,900	27,915	92,166	e22,500	e79,400
Silver[2]	metric tons	171	30,186	173	26,836	148	19,212
Stone (crushed)	thousand short tons	6,649	28,552	e5,300	e13,500	7,060	32,842
Combined value of cement, diatomite (1989-90), gypsum (crude), iron ore (usable, 1991), lead (1989, 1991), lime, molybdenum, perlite, pumice (1990-91), pyrites, salt, sand and gravel (industrial), stone (dimension), tin (1989), and values indicated by symbol W		XX	220,594	XX	r207,591	XX	198,230
Total		XX	3,046,340	XX	r3,064,349	XX	2,829,123

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Recoverable content of ores, etc.

wooded swamps for washes it needed for tailings disposal at the Ray Mine. Under the proposal, Cooks Lake and PZ Ranch, near Winkelman, would be donated to the Nature Conservancy for development of their riparian environment. The land parcel incorporated 69 acres of wetlands and 256 acres of farmlands and ranchlands along the San Pedro River.

Asarco faced an onslaught of articles in Tucson and Phoenix newspapers attempting to link arsenic emissions from the Hayden smelter to an alleged higher-than-average incidence of lung cancer in the central Arizona Copper Basin. Two Arizona Department of Health Services studies and a University of Pittsburgh study of the Hayden smelter could not, however, demonstrate such a linkage. The University of Pittsburgh study concluded that the cancer rate in the Hayden area, in fact, was below what should be expected. Because too few lung cancer deaths had occurred, one State health department study could not conclude that an elevated cancer rate existed at Hayden. Asarco, however, agreed in May to fund an additional study by the State health services department and continued to analyze ways to reduce stack and fugitive emissions.

After encountering fierce public opposition, Newmont Exploration Ltd. dropped its effort to obtain an exploration permit to drill 36 claims in the Cave Creek area of southeastern Arizona. The company abandoned its permit request in support of a U.S. Forest Service plan to designate 90,000 acres of the Coronado Forest as a National Recreation Area. Public furor over the threat of mineral exploration triggered the unsuccessful introduction of legislation in the U.S. House of Representatives (H.R. bill 2790) to withdraw 13,100 acres of land in the Cave Creek drainage in the Chiracahua Mountains from mining or mineral leasing.

On January 13, demolition of the smokestacks at Phelps Dodge's Douglas Reduction Works signaled the end of a facility that had been one of the State's most important smelters for more than 80 years. Douglas had been idled since January 1987 because of new, and more restrictive, air quality standards. The smelter originally was built to handle ores from mines at Bisbee, AZ, and Nacozari, Sonora, Mexico.

EMPLOYMENT

An average of 14,881 people was employed in Arizona's mining sector during 1991; total employment in the Arizona copper industry alone was 12,369, up 10% from the 1990 average of 11,200. According to the Arizona Mining Association, combined indirect and direct benefits of the copper industry to the State economy were more than 58,000 jobs and $5.6 billion. Total income earned in the State mining sector was $565 million; about 76% of that amount, or $430 million, came from the copper producers.[3] Average weekly earnings of all workers (including management) in the mining sector was $709; an average employee in copper mining and processing earned $719.[4]

REGULATORY ISSUES

A 1987 law that allowed private sand and gravel operations to own and mine Arizona riverbeds and streambeds was declared unconstitutional in September by the Arizona Court of Appeals. The decision may prove to be a heavy financial blow to the State's sand and gravel industry, forcing hundreds of operations to relinquish thousands of acres they had claimed under the law. The court ruled that the law violated the State constitution's gift clause provisions, which prohibit the gift of public assets to private concerns. The Arizona Land Department announced it would appeal the ruling to the State Supreme Court.

Under a settlement announced in January, the Salt River Project was fined $113,500 by the Environmental Protection Agency (EPA) and must investigate possible contamination at its Navajo Generating Station near Page. The fine, roughly one-quarter of the amount originally proposed by EPA, was for alleged hazardous waste violations.

The EPA proceeded with its investigation of ground water contamination in an area near an operating explosives and fertilizer plant at St. David in Cochise County. Owned and operated by the Apache Powder Co. since 1922, St. David sold most of its explosives to the mining industry.

The Arizona Department of Environmental Quality examined remedial action alternatives for the Eagle Picher mill site in Sahuarita. The site was used between 1943 and 1952 by Eagle Picher Mining and Smelting Co. as a lead and zinc ore-processing site. Soils at the site contain heavy metals in concentrations that exceed federally acceptable levels. AMAX Inc. and Anaconda Minerals Co.-ARCO Corp. will be responsible for remediation.

EXPLORATION ACTIVITIES[5]

According to the Arizona Department of Mines and Mineral Resources, interest in Arizona copper properties was higher in 1991 than at any time since the start of the 1970's gold boom. Leachable copper properties were particularly "hot." Exploration dollars, however, were mainly funneled into evaluation of known deposits as opposed to the generation of new targets. In comparison to copper activity, gold exploration in the State was more sluggish in 1991, although it was widespread.

Phelps Dodge Corp. continued evaluating the Lone Star and Dos Pobres copper deposits near Safford. Lone Star contained 1.5 billion metric tons (1.6 billion short tons) of leachable material at 0.38% copper. Dos Pobres contained 209 million metric tons (230 million short tons) of sulfide mineralization grading 0.89% copper and 136 million metric tons (150 million short tons) of leachable material grading 0.48% copper. Drilling during 1991 identified a leachable resource at Dos Pobres suitable for development. Phelps Dodge also completed bulk sampling and metallurgical testing for its Cochise property near Bisbee and began evaluating results. The company estimated that Cochise contained 190 million metric tons (210 million short tons) of leachable ore grading 0.40%

copper that could be mined for about a decade.

A. F. Budge Mining Co. continued drilling the Korn Kob copper skarn deposit in Pima County. Revised reserves for the property were 16.3 million metric tons (18 million short tons) of 0.4% acid-soluble material. In spite of the reserve estimate and the identification of two additional targets, the company returned the property to Keystone Minerals.

Arimetco International Inc. (Arizona Metal Co.) weighed the idea of using an existing shaft on its Van Dyke property in Gila County as an extraction well for in situ copper recovery. The Van Dyke oxide ore body, underneath the town of Miami, contained an estimated 91 million metric tons (100 million short tons) of 0.51% copper. Arimetco reopened and began rehabilitating the shaft, hoping to inject solutions into old workings using wells drilled underground and to use the drifts and the shaft to convey pregnant solutions to the surface.

With its 1991 purchase of Westmont Mining Inc., Cambior USA acquired control of the Carlota claims in Gila County. The area, which would be mined as three closely spaced pits, had drill-indicated reserves of 49 million metric tons (54 million short tons) containing 0.45% copper.

Oneida Resources Inc.'s work on the Mexican Hat gold property in southeastern Cochise County was canceled pending an improvement in the price of gold. Oneida and Placer Dome U.S. Inc. had agreed in April for Oneida to do between 20,000 and 40,000 feet of reverse circulation drilling. An engineering study by Placer Dome showed a reserve of 5.2 million metric tons (5.7 million short tons) at a grade of 0.8 gram gold per metric ton (0.027 ounce per short ton). Infill drilling could raise the total near-surface geologic resource to 93,000 kilograms (300,000 ounces).

Newmont Gold Co. continued exploration at Apache Peak in the Coronado Forest north of Tucson and expanded its land parcel by 20 acres to a total of 925 acres.

According to its Form 10-K, Fischer-Watt Gold Co. Inc. drilled 10 holes (2,740 feet) on the Secret Pass property during 1991. Also in 1991, Silver Talon Mines Ltd. entered into an arrangement with Santa Fe Mining to acquire an 80% interest in the Secret Pass project.

Cyprus Minerals Co., seeking millfeed to replace the waning reserves at its Copperstone Mine, acquired and drilled the BVO property in Yuma County.

Bema Gold Corp. took over Norgold Resources and, thereby, the Yarnell Mine in Yavapai County. Bema began permitting the Yarnell gold deposit that contained estimated reserves of 6.9 million metric tons (7.6 million short tons) grading 1.0 gram gold per metric ton (0.036 troy ounce per short ton). Bema planned to begin production in 1992 and to develop Yarnell as an open pit heap-leach operation producing 1,000 kilograms (32,000 troy ounces) per year.

According to the company's Form 10-K, Magma Gold, Ltd. conducted a 1991 feasibility study of the Tiger Mine, near the company's San Manuel operations. Magma Gold at this time decided not to pursue development of Tiger, which contains an estimated gold resource of 2.7 million metric tons (3 million short tons) grading 1.41 grams per metric ton (0.05 ounce per short ton).

Silver Glance Resources Inc. continued investigating the silver-fluorite-lead reserves on its property in the Silver District north of Yuma. Fluorite deposits were of increasing interest as hydrofluorocarbons gained greater acceptance as alternatives to chlorofluorocarbons.

LEGISLATION AND GOVERNMENT PROGRAMS

During the 1st regular session and four special sessions of Arizona's 1991 40th Legislature, a total of 1,039 bills was introduced, of which 347 passed. Among bills signed by the Governor during the first regular session was House bill 2011, which levied a $2.12-per-acre-foot fee for ground water used for beneficial use (including mining). Also enacted was Senate bill 1176, which extended funding for the Governor's task force on environmental education and reset reporting dates of the committee. Senate bill 1055 was signed into law and limited transfers of ground water between basins. Under the new law, water can only be taken from retired irrigated lands.

Two environmental bills failed, including Senate bill 1192, which would have established an office of public advocate for the environment funded by fees collected by the Department of Environmental Quality. Senate bill 1109, which also died, would have amended State statute to increase protection of existing wetlands.

The Arizona Department of Mines and Mineral Resources released several publications of interest to the minerals industry. Among them was D39, "Directory of Active Mines in Arizona with Map;" OFR91-6, "Industrial Minerals in Arizona's Cultured Marble Industry;" OFR91-8, "Pumice and Pumicite in Arizona;" C33, "County Agencies Concerned with Mining & Mineral Resources in Arizona;" C34, "State Agencies Concerned with Mining & Mineral Resources in Arizona;" and C37, "Arizona Mining Update—1991."

The Arizona Geological Survey released several reports that were of interest to those investigating mineral resources: Down-to-Earth Series 1, "Energy Resources of Arizona," and OFR 91-4, "A Preliminary List of References on the Geology of Arizona." In addition, the agency republished several contributed reports, including CM-91-A, "Geologic Map and Cross Sections of the Washington Camp-Duquesne Mining District, Patagonia Mountains, Santa Cruz County, Arizona;" CR-91-A, "Geologic Maps of the Underground Workings of the Black Rock and Sally Uranium Mines, Navajo County, Arizona;" and CR-91-B, "Geology and Production History of the Bluestone No. 1 Uranium-Vanadium Mine, Garnet Ridge, Apache County, Arizona, with Notes on the U.S. Atomic Energy Commission's Drilling Project."

The U.S. Bureau of Mines continued its assessment of known mineral

occurrences in Coconino, Coronado, and Kaibab National Forests. Work also continued on a regional mineral resource appraisal of detachment fault terrane in west-central Arizona. In addition, an inventory was made of the mineral resource impacts of proposed construction at the Phoenix Sky Harbor International Airport.

Technology for in situ leaching of copper from rubblized ore in developed, underground mines has been available for some time. In partnership with Asarco and Freeport McMoRan, the Bureau evaluated technologies of in situ leach copper mining at an undeveloped target, the Santa Cruz deposit near Casa Grande. Researchers were attempting to find a means to predict solution movement through the deposit, an understanding that could improve the efficiency of well patterns and pumping strategies for metals recovery. During a tracer test of a pilot well pattern, solutions remained inside the well field, a finding that eased environmental concerns regarding the effects of escaping solutions. The Bureau also tested fluid flow technology and thereby improved models for simulating and predicting fluid flow through leaching zones accessed by underground mine workings.

In its continuing support of the Arizona Mining and Mineral Resources Research Institute, the U.S. Bureau of Mines contributed $148,000 during 1991. The Institute, at the University of Arizona in Tucson, was administered by a faculty member of the Department of Materials Science and Engineering.

FUELS

During 1991, the State produced coal, uranium, and minor amounts of oil and natural gas. According to U.S. Department of Energy statistics, Arizona contributed 1.3% of the Nation's coal production. The State remained 16th in the Nation in coal production and reported a record high 13.2 million short tons. Peabody Coal Co. mined bituminous coal from two surface mines in Navaho County in northern Arizona.[6] Of all U.S. surface coal mines, Peabody's Kayenta Mine was 17th in the Nation with 7.8 million short tons, and the Black Mesa Mine ranked 27th with 5.1 million short tons of production.[7]

Andalex Resources Inc. received permission for a new coal loading facility at Williams, in northern Arizona, that would give the Utah coalmining company access to the Santa Fe Pacific rail line. Andalex planned to develop the facility for unloading coal from trucks and onto railcars for shipment.

U.S. uranium producers were severely hurt by a glut of imports, primarily from the former U.S.S.R. and China. Low prices forced Energy Fuels Nuclear Co. to suspend all U.S. uranium operations at the beginning of 1991; as a result, the company closed the Kanab North Mine, which had produced about 1 kiloton (2.3 million pounds) of uranium since 1987. A total of 56 workers was laid off in January, leaving 43 employees to perform routine maintenance.

The Ninth U.S. Circuit Court of Appeals rejected an appeal by the Havasupai Tribe to halt development of Energy Fuels Nuclear's Canyon uranium mine. By a 3-to-0 ruling, the court denied the tribe's claim of a right of access to a site of religious significance. The court also rejected the argument that the U.S. Forest Service, in approving the mine plan, failed to adequately consider potential impacts to the tribe's underground water source.

According to the U.S Energy Information Administration, Arizona produced 111,000 barrels of crude oil during the year[8] and 1,225 million cubic feet of marketed natural gas.[9]

REVIEW BY NONFUEL MINERAL COMMODITIES[10]

Metals

Copper.—Arizona continued to lead the country in copper production, a rank it has held for more than 80 years. Production of the red metal reported to the U.S. Bureau of Mines from 20 Arizona mines was about 1.02 million metric tons (2.25 billion pounds), about 5% higher than 1990 production. Combined State copper mine output contributed 63% of total domestic production. Seven of the country's 10 largest copper mines were in Arizona.[11] Of Arizona's 15 counties, 9 produced copper in 1991. Leading the county list were (in decreasing order of production) Greenlee, Pinal, Pima, and Gila Counties.

The average producer copper price deteriorated further from 1990's price of $1.23 to $1.09 per pound; average 1991 Comex price was $1.05. During May, for the first time in 15 months, the Comex price slipped below $1. By yearend, the Comex price had fallen to $0.98 per pound, a drop of 13% compared with the close of 1990.

Four major companies and as many junior firms produced copper in Arizona during 1991. The four majors were: Phelps Dodge Corp., headquartered in Phoenix and having operations in Greenlee and Cochise Counties; Cyprus Minerals Co., with operations in Gila, Mohave, Pima, Pinal, and Yavapai Counties; Magma Copper Co., headquartered in Tucson and having operations in Gila and Pinal Counties; and Asarco, with operations in Pinal and Pima Counties. Smaller firms with copper production included Arimetco International, South Atlantic Ventures Ltd., Queenstake Resources Corp., and A. F. Budge Mining Co.

Phelps Dodge Corp. was, by far, Arizona's leading copper producer. Phelps Dodge operated the Morenci Mine (Greenlee County) and Copper Queen Mine (Cochise County).

In 1991, Morenci continued to be the Nation's largest copper producer and the second largest copper mine in the world. The Morenci facility included the Morenci and Metcalf open pits, two concentrators, and a solvent extraction-electrowinning (SX-EW) plant. Phelps Dodge owned 85% undivided interest in the Morenci operation; the remaining interest was held by Sumitomo Mining Co. Ltd. and Sumitomo Corp. According to Phelps Dodge's 1991 annual report, the company recovered a record 310,400 metric tons (342,200 short tons) of

copper from Morenci, about 35% of which was recovered at the SX-EW plant. Construction continued on the $112 million Northwest Extension project, which will eventually add 63,500 metric tons (70,000 short tons) of SX-EW production per year at Morenci. If the project is completed in mid-1992, as the company anticipated, the Morenci SX-EW plant would be the largest in the world. Phelps Dodge continued evaluating the Coronado deposit in Morenci, which contains 160 million metric tons (180 million short tons) of sulfide material grading 0.71% copper and 270 million metric tons (300 million short tons) of leachable ore at a grade of 0.29% copper.

Phelps Dodge also produced a small amount of cement copper from the Copper Queen operation at Bisbee in Cochise County. Copper Queen consisted of a precipitation operation at the mined-out Lavender Pit.

Cyprus Minerals Co. placed second of Arizona's copper companies in terms of 1991 mine production. Cyprus Minerals Co.'s operations during 1991 included the open pit Sierrita/Twin Buttes complex, an open pit mine at Bagdad, an open pit mine at Miami (formerly called Inspiration), an in situ leach operation at Casa Grande, and an open pit copper mine at Mineral Park. Approximately 70% of the company's copper concentrate was processed internally. When the Miami smelter achieves full capacity in 1993, the company plans to treat all its domestic production at its own facilities.

Cyprus treated the neighboring Sierrita and Twin Buttes Mines, about 20 miles south of Tucson in Pima County, as a consolidated operation. According to U.S. Bureau of Mines data, Sierrita, considered alone, had the 3d largest copper production in the State and the 6th highest in the United States; by itself, Twin Buttes ranked 9th in Arizona and 14th in the United States during 1991. Sierrita proper included an open pit mine, an 86,000-metric-ton-per-day concentrator, molybdenum plant, two roasters, and an oxide-ore dump-leaching system and SX-EW plant. Ore from the Twin Buttes open pit was conveyed to Sierrita; Twin Buttes oxide ore, however, was processed on-site, utilizing agitated leach for processing at the Twin Buttes SX-EW plant. Ore from both properties was processed at the Sierrita concentrator into copper and molybdenum concentrates. According to Cyprus' 1991 Form 10-K, combined output of the two mines in 1991 was 125,000 metric tons (275.5 million pounds).

Cyprus' Bagdad, ranking fifth in 1991 among the State's copper mines and eighth in the United States, produced copper with significant molybdenum and silver byproducts. The Bagdad operation in Yavapai County included an open pit mine, a 68,000-metric-ton-per-day concentrator, and an oxide dump-leaching system and SX-EW plant. According to Cyprus' 1991 Form 10-K, the mine yielded 99,400 metric tons (219.2 million pounds) of copper during 1991.

Cyprus' Miami operation in Gila County consisted of an open pit mine that produced acid-soluble ore for heap leaching, an associated SX-EW plant, a smelter, a refinery, and a rod mill. Miami's 1991 output of 57,600 metric tons (127 million pounds) of copper cathode from the SX-EW operations was near capacity. During November, molten copper matte and slag ruptured an electric furnace wall at the Miami smelter, an event that triggered a shutdown for the remainder of the year. The incident moved ahead of schedule a $106 million smelter expansion and modernization program originally planned for early 1992. Heading the list of proposed improvements was the company's turn to ISASMELT technology, an act that would pioneer the use of such technology in the United States. Cyprus anticipated that ISASMELT technology would reduce Miami's energy costs by weaning the company away from its present electric furnace. The process would allow Cyprus to burn sulfur contained in pelletized concentrate to produce much of the smelting heat, thereby cutting down on energy consumption. The electric furnace would continue to be used for separating matte and slag. Cyprus expected the new furnace to enhance environmental compliance, increase smelting capacity by 50%, reduce copper production costs by $0.05 per pound, and make the company self-sufficient in smelting. According to the company's Form 10-K, Cyprus' rod mill at Miami produced 114,000 metric tons (252 million pounds) of copper rod in 1991, operating at about 93% capacity and primarily fed by Cyprus' cathode.

Cyprus' Casa Grande operation in Pinal County consisted of an underground mine and two on-site roasters with combined annual capacity of roasting 136,000 metric tons (150,000 short tons) of copper concentrate. The Casa Grande facility roasted copper concentrates from other Cyprus operations and processed solutions at its SX-EW plant from leaching roasted calcines and underground in situ leaching of oxide ore. During 1991, Cyprus evaluated the feasibility of copper production from the Casa Grande deposit via open pit mining and heap leaching.

At Cyprus' Mineral Park Mine in Mohave County, the company leached dumps and operated a precipitate plant. Mineral Park produced 1,680 metric tons (3.7 million pounds) of copper in 1991, according to Cyprus' 1991 Form 10-K.

Magma Copper Co. operated the underground and open pit San Manuel Mine, the open pit Pinto Valley deposit, a leach operation at Miami, and the underground Superior Mine. Magma had Arizona's third largest copper production for 1991.

San Manuel's 1991 output was second among Arizona's copper mines and third in the Nation. According to the company's 1991 Form 10-K, San Manuel in Pinal County produced 143,000 metric tons (315.9 million pounds) of copper, of which 100,000 metric tons (220.3 million pounds) came from the underground operation. San Manuel's electrowon production, including material from its in situ leach segment and its open pit heap-leach operation, was 41,600 metric tons (91.7 million pounds), about 29% of San Manuel's total copper production. Production from the upper Kalamazoo, which began in 1990, reached a production rate of 10,000 metric tons

(11,000 short tons) per day in December 1991.

During the year, Magma achieved a precedent-setting labor agreement, one that eliminated the possibility of strikes for nearly 8 years. The new contract also linked employee productivity increases to gainsharing dividends, a stratagem Magma hoped would lower production costs and make development of the lower Kalamazoo ore body feasible before San Manuel ore runs out, as it is expected to do, in 1997.

Pinto Valley ranked sixth in the State and ninth in the United States in copper production. According to Magma's 10-K form, electrolytic (refined) cathode copper output from the Pinto Valley open pit mine in Gila County amounted to 65,900 metric tons (145.2 million pounds) during 1991; 6,890 metric tons (15.2 million pounds) of electrowon cathode copper was produced from the Pinto Valley dump-leaching operation.

Output from Magma's leach operations at Miami in Gila County was 8,750 metric tons (19.3 million pounds). Materials leached at Miami included the block-caved underground workings and concentrator tailings.

According to Magma's 1991 Form 10-K, output from Magma's Superior property in Pinal County was 11,000 metric tons (24.4 million pounds) of cathode copper. During November, a stubborn fire at Superior was put out after burning for about 10 days. The fire, which curtailed production through December, was detected only after miners complained of headaches and tests indicated elevated carbon monoxide levels. Company officials speculated that spontaneous combustion had ignited mine timber.

Effective January 1, 1992, Magma will merge its smelting-refining and marketing-sales divisions to create Magma Metals Co., a new wholly owned subsidiary. According to Magma's annual report, its Outokumpu flash furnace was the largest capacity single furnace in the world, and its San Manuel smelting and refining complex was the lowest cost facility in the United States. The smelter's rated annual production capacity of 0.9 million metric tons (1.0 million short tons) of copper concentrate amounted to about 25% of U.S. production. According to Southwestern Paydirt, San Manuel smelted a record 1.05 million metric tons (1.16 million short tons) of concentrate in 1991, 60% of which was furnished by Magma's own production. Magma evaluated expansion of its smelting and refining complex to take advantage of the worldwide shortage of smelter capacity. According to its annual report, Magma's total electrowon cathode production from its leach operations increased to 59,000 metric tons (130 million pounds) in 1991.

Asarco mined copper at its open pit Mission complex, at the open pit Ray Mine, and at Silver Bell.

In production terms, Ray was Arizona's fourth largest copper mine and seventh-ranked nationally. According to its annual report, Asarco obtained 106,400 metric tons (117,300 short tons) of contained metal from the Ray Mine in 1991. Asarco began a $194 million expansion program at its Ray Mine in Pinal County in 1989, one that included constructing a new tailings storage area, an ore concentrator next to the mine, and an in-pit crusher and conveyor system to deliver ore to the new mill. Until yearend, permitting snags delayed installation of the concentrator. Mill startup was anticipated for the second quarter of 1992. By 1993, the expansion was expected to add 300 new jobs and to boost Ray's annual output 58% to 165,000 metric tons (182,000 short tons). Coupled with completed improvements at Mission, the Ray expansion was expected to make Asarco self-sufficient in supplying concentrate for its Hayden and El Paso smelters. During late 1990, the company consolidated administration of the Ray operations with those of the Hayden smelter. Asarco's Ray smelter was essentially a stone's throw from its Hayden smelter, idle since Kennecott shut it down during the mid-1980's.

In October, Asarco completed its $100 million expansion at the Mission complex (including the original Mission, Pima, San Xavier, and Palo Verde pits in Pima County). The company anticipated that the project would improve annual copper output by one-third, from 82,000 metric tons (90,000 short tons) to 112,500 metric tons (124,000 short tons). The State's 7th and the Nation's 10th largest copper producer, Mission produced 80,300 metric tons (88,500 short tons) of contained copper in concentrates, according to Asarco's annual report.

During late 1991, Asarco began permitting for a new $54 million SX-EW plant at the Silver Bell Mine in Pima County. According to Asarco, when the plant is completed in 1994, it will have an annual production capacity of 16,300 metric tons (18,000 short tons) of cathode copper. Silver Bell produced 3,600 metric tons (4,000 short tons) of cement copper during 1991, according to Asarco's annual report.

Arimetco International continued mining the Johnson open pit in Cochise County about 60 miles east of Tucson. According to Engineering and Mining Journal, Johnson produced 2,700 metric tons (5.9 million pounds) of copper and supplied Arimetco with 60% of its 1991 production before the company finished expansion at the Yerington Mine in Nevada. About 13.6 million metric tons (15 million short tons) of ore, left on leach pads by the mine's previous owner (Cyprus Minerals Co.), was used as feedstock for Arimetco's SX-EW facility until mid-1991. In July, mining began in the Burro Pit and was expected to continue until the end of 1993. As the Burro Pit is exhausted, the company planned to relocate mining activities to the nearby Copper Chief ore body, which has ore reserves of about 8.7 million metric tons (9.6 million short tons) at 0.42% copper.

Planning and permitting for Arimetco's Emerald Isle Mine in Mohave County began midyear 1991. The property was returned to Arimetco from Holcorp Mining Ltd. after an attempted sale in 1990. Construction of a 7,300-metric-ton-per-day (8,000-short-ton-per-day) SX-EW plant began in September; startup was anticipated for spring 1992. Arimetco planned to use a combination of solutions from heap leaching and in situ

leaching of the bottom of the pit to feed the facility.

Production began in Pima County at the Oracle Ridge Mine, owned 70% by South Atlantic Ventures Ltd. and 30% by Continental Materials Co. The new underground mine, about 15 miles north of Tucson and near San Manuel, had sporadic development since Continental purchased the mine in 1968. The new concentrator began milling ore on February 28, and the company shipped its first copper concentrates to Asarco's Hayden smelter in early March.

The Bureau of Land Management, Safford District Office, held public hearings for AZCO Mining Inc.'s proposed Sanchez Mine in Graham County. According to AZCO, when the mine functioned at capacity, it would employ 210 people and would produce 22,700 metric tons (25,000 short tons) of copper cathode annually. If developed, the mine would be Arizona's first major new open pit copper mine in at least 18 years. Sanchez lies along a trend that includes Phelps Dodge Corp.'s Lone Star and Dos Pobres deposits.

Gold.—Gold data for Arizona were severely understated this year because data were reported late to the Bureau; complete production totals will be available only in the 1992 revised table 1 data. Reported output of Arizona's 10 gold-producing operations was 2,068 kilograms (66,490 troy ounces). Arizona's largest primary gold mine, Cyprus Minerals Co.'s Copperstone, led State production, followed by two copper mines: Phelps Dodge Corp.'s Morenci operation (Greenlee County) and Magma Copper Co.'s San Manuel Mine (Pinal County). Listed in decreasing order of production, Pinto Valley (Gila County), Superior (Pinal County), Ray (Pinal County), Mission (Pima County), and Oracle Ridge (Pinal County) mines also recovered gold as a byproduct of copper mining. Republic Goldfields Inc.'s Congress Mine (Yavapai County) produced gold and byproduct silver. A. F. Budge Ltd.'s Vulture Mine (Maricopa County) and Queenstake Resources Corp.'s Golden Prince Mine (Cochise County) produced gold and byproduct silver and copper. Average gold price in 1991 was $363.29 per troy ounce.

Arizona's largest gold mine, Copperstone (La Paz County), processed 3,480 kilograms (112,000 troy ounces) during the year according to Cyprus Minerals Co.'s Form 10-K. Production increased 5% over the 3,313 kilograms (106,500 troy ounces) reported for 1990. Cyprus expected the mine's remaining 1.9 million metric tons (2.1 million short tons) of reserves, grading 2.4 grams gold per metric ton (0.071 troy ounce per short ton), to be exhausted in 1993. The mine was an open pit operation that utilized milling, heap leaching, and carbon-in-pulp recovery; operation of the heap-leach facility began in 1991.

According to U.S. Bureau of Mines statistics, Queenstake Resources recovered gold from its underground Gold Prince Mine in Cochise County. Its product was sold to Phelps Dodge's New Mexico Hidalgo smelter as silica flux.

A. F. Budge (Mining) Ltd. reported gold production only for the Vulture Mine (Maricopa County) for 1991.

Magma Gold Ltd. acquired the McCabe Mine from Stan West Mining Corp. and began shipping gold ore. According to Magma's Form 10-K, McCabe, a small underground mine in Yavapai County near Humboldt, produced 121 kilograms (3,900 troy ounces) of gold and 523 kilograms (16,800 ounces) of silver during 1991 from concentrate shipped to the San Manuel smelter. The 3-year mining plan for the operation indicated the property contained about 270,000 metric tons (300,000 short tons) of material at 10 grams per metric ton (0.3 troy ounce per short ton).[12]

In March, Fischer-Watt Gold and Mining, Drilling, and Milling Inc. entered into a 50-50 joint-venture agreement to put the Mystic Mine near Sun City in Maricopa County into production. In 1991, Fischer-Watt began mining and milling ore at Mystic, which contained a small but high-grade gold resource of 45,000 metric tons (50,000 short tons) at 17 grams per metric ton (0.5 troy ounce per short ton).

Malartic Hygrade Gold Mines Ltd. changed its name to Republic Goldfields Inc. The company's underground Congress Mine in Yavapai County completed its first full year of production.

Wounded Bull Resources N.L. also changed its interesting name to the more prosaic Pima Mining N.L. Pima entered into an agreement with Westmont Minerals for the Newsboy property (Maricopa County) near Wickenburg, one that gave Pima a 100% interest. Newsboy contained proven and probable resources of 5.2 million metric tons (5.7 million short tons) in two deposits averaging 1.4 grams gold per metric ton (0.04 ounce per short ton). The company hoped to begin production in 1992.

DRX Inc. and Western States Minerals Corp. formed a joint venture to develop the Commonwealth property near Pearce in southwestern Cochise County. Under the terms of the agreement, Western States would earn a 60% interest in the property.

Molybdenum.—Of eight States, Arizona was the second largest producer of molybdenum in the United States, trailing only Colorado. All State output, which increased in 1991, was a byproduct of copper production. In 1991, molybdenite concentrates were recovered at six mines: Morenci, San Manuel, Sierrita, Twin Buttes, Bagdad, and Pinto Valley.

According to its 1991 Form 10-K, Cyprus produced 16,400 metric tons (18,000 short tons) of molybdenum at its Arizona mines. Cyprus operated two roasters at Sierrita in Pima County to process three-fourths of the company's molybdenum concentrate production from Sierrita/Twin Buttes, Bagdad, and its Thompson Creek molybdenum mine in Idaho. Sierrita led the State in molybdenum production. According to the company's 1991 Form 10-K, combined molybdenum output from Sierrita/Twin Buttes properties was 7,800 metric tons (17.2 million pounds). Cyprus Bagdad produced 5,310 metric tons (11.7 million pounds) of molybdenum during the year, according to the company's 10-K form.

According to its Form 10-K, Magma Copper Co.'s combined sales of molybdenum disulfide from San Manuel and Pinto Valley amounted to 2,400 metric tons (5.4 million pounds).

Silver.—Arizona maintained its fifth place among the Nation's 16 silver-producing States. Production dropped, however, to 148 metric tons (4,760 troy ounces) from the 173 metric tons (5,560 troy ounces) produced during 1990. Arizona's 1991 output supplied 8% of the U.S. total. Of the 12 Arizona mines that produced silver, only 4 (listed in decreasing order of production) —Republic Goldfields' Congress, A. F. Budge's Vulture Mine, Cyprus' Copperstone, and Queenstake's Golden Prince—were not copper mines. Asarco's Mission complex (Pima County), Cyprus's Bagdad Mine (Yavapai County), Phelps Dodge's Morenci (Greenlee County), Asarco's Ray Mine (Pinal County), and Magma's San Manuel Mine (Pinal County) were, in decreasing order, the State's largest silver producers. The same mines also continued to rank among the country's top 25 silver mines for 1991.[13] Combined output from these five primary copper mines contributed 79% of Arizona's total silver production. Average producer price for silver during the year was $4.04 per troy ounce.

Other Metals.—Arizona continued to have the Nation's only output of rhenium during 1991, all of which was recovered by scrubbers at Cyprus' Sierrita molybdenum roaster. Rhenium, which occurred as a trace element associated with molybdenum, was recovered as pelletized ammonium perrhenate.

Minor quantities of byproduct lead were also recovered by Asarco from its Mission ores.

Industrial Minerals

Cement.—Output of both portland and masonry cement is estimated for 1991. According to the estimated data, Arizona ranked 17th of 38 States that reported portland cement production. Compared with that reported for 1990, production appears to have fallen 9%. Output of masonry cement continued a downward trend begun in 1987 and dropped an estimated 26%. Arizona ranked 17th among 33 States that manufactured masonry cement, according to Bureau estimates.

Arizona Portland Cement Co. continued operating its cement plant at Rillito north of Tucson. Phoenix Cement operated its plant at Clarkdale in Yavapai County.

Ashland Oil Inc.'s APAC Construction Group signed a letter of intent to sell 19 operating properties, which primarily included aggregate reserves in Arizona, to a subsidiary of Onoda Cement Co. Ltd.

Clays.—The State produced common clay and bentonite, 228,400 metric tons total. In total 1991 clay production, Arizona ranked 30th of 44 States. Arizona's reported clay output jumped about 63% above that reported in 1990, the gains posted by the common clay producers; reported bentonite production actually declined slightly.

Arizona was 29th of 43 States that reported 1991 common clay production to the Bureau. Listed in decreasing order of importance, Yavapai, Pima, Maricopa, and Pinal Counties produced common clay during 1991. Clinton-Campbell Contracting, Phoenix Cement Co., Pantano, and Magma Copper Co. produced common clay, which was used to manufacture portland cement, brick, structural tile, and as asphalt emulsifier. According to the State Department of Mines and Mineral Resources, clay was also mined by Building Products Co. and by GSA Resources.

Clays from Pantano Wash in Pima County supplied almost one-half the clay mined in Arizona, according to the Arizona Department of Mines and Mineral Resources. The Pantano material has been called the only high-alumina clay in the State suitable for making high-quality face brick. Pantano clays supplied "fire clay" of mixed kaolinite-illite clay minerals usable as a skeleton former and self-fluxing glass former in structural clay products. It was also the dominant coloring agent in the bricks and tile in which it was used. Clinton-Campbell Contracting Inc., which operated the Phoenix Brick Yard, produced structural clay products (bricks). The company mined clay filler at Tolleson in Maricopa County and blended it with Pantano Wash material that was hauled to Phoenix from 140 miles away. The Pantano clay deposit also was one of the alumina sources for Arizona Portland Cement's Rillito plant.

Building Products operated two clay mines and a slate mine that collectively supplied its sewer pipe factory in Phoenix. In Yavapai County, GSA mined hectorite that was processed into thickeners for pharmaceuticals and cosmetics. The company also mined a saponite clay, which was shipped out of State for use as viscosifiers for detergents and as a drainage aid for treating pulp for fine white paper produced from recycled paper fibers.

Of 11 bentonite-producing States, Arizona was seventh, although State production dropped for the year. Low-swelling calcium bentonite was utilized as an oil and grease absorbent and for ceramic products, and the nonswelling variety was used to make dessicants. Low-swelling (calcium) bentonite was mined by Engelhard Corp. in Apache County and by McKusick Mosaic Co. in Gila County. According to the Arizona Department of Mines and Mineral Resources, Engelhard shipped its product east for processing into oil refinery catalysts and as a clarifier for oils. McKusick utilized its material to make ceramic tile. Nonswelling (calcium) bentonite was produced near Sanders in Apache County by United Dessicants of United Catalyst Inc. Raw clay was shipped to the company's plant near Belen, NM, for processing into moisture-absorbing dessicants.

Gemstones.—In 1991, each of the 50 States produced at least $1,000 worth of gem materials. Ten, however, accounted for 95% of the U.S. total 1991 output of natural gemstones. Of these 10, Arizona

was fifth, dropping from third place. Arizona had the most varied output of natural gemstones, including agate, amethyst, antlerite, azurite, chrysocolla, fire agate, garnet, jade, malachite, obsidian (Apache tears), onyx, peridot, petrified wood, precious opal, shattuckite, smithsonite, and turquoise. Arizona's turquoise, peridot, petrified wood, and azurite-malachite production had the highest value in the United States; value of the State's turquoise and peridot output was the highest in the world. Additionally, four manufacturers produced synthetic or simulated gems valued at approximately $100,000.[14]

Gypsum.—The State ranked 11th of 20 States that reported 1991 crude gypsum production. Output fell about 18%. Gypsum mined in Arizona was used to make wallboard and portland cement and was also used as a soil amendment in agriculture and horticulture. Four companies operated five mines with reported crude gypsum production: National Gypsum Co. (Pinal County), Superior Companies (Pinal and Yavapai Counties), Western Gypsum Co. (Mohave County), and Pinal Gypsum Co. (Pinal County). According to the Arizona Department of Mines and Mineral Resources, Western Organics also produced gypsum at its mine in La Paz County. National Gypsum was by far the State's largest producer.

The State was last of the 28 States that have calcined gypsum output. Emerging from bankruptcy (declared in October 1990), National Gypsum mined gypsum at Winkelman and operated a calcining facility and wallboard plant in the Phoenix area.

Lime.—Production of lime remained virtually identical to that reported for 1990, and Arizona kept its ninth place of 32 States that reported lime production. Lime was produced commercially only by Chemstar Inc. at two plants: one at Nelson (Mohave County), where the company produced quicklime and hydrated lime; and the second at Douglas (Cochise County), where the company sold only quicklime. Magma Copper produced a relatively small tonnage of hydrated lime for its own use at the company's San Manuel division in Pinal County.

The Chemical Lime Group, parent company of Chemstar, formed a joint venture with Mexico's Sonocal S.A. to assist the Mexican company in operating and improving its high-calcium lime plant in Naco, Sonora. As quoted in Rock Products, Chemical Lime had no plans to ship American lime into Mexico, but the company left open the possibility of some shipments of Mexican lime into the southwestern United States, particularly to the copper industry.

Perlite.—Of the six States that produced perlite, Arizona continued to be second only to New Mexico in perlite production. State 1991 production recovered almost to 1989 levels, increasing 11%; in contrast, value fell about 24%. Harborlite Corp. and the Nord Perlite Co. continued operating surface mines near Superior, Pinal County. Using perlite shipped from other States, Therm-O-Rock Industries Inc. in Maricopa County expanded perlite for fillers and for horticultural uses.

Pumice.—Arizona was fifth of six States with reported 1991 pumice production. From its mine near Flagstaff in Coconino County, Arizona Tufflite Inc. produced material for stonewashing and horticulture, and, according to the Arizona Department of Mines and Mineral Resources, also for use as lightweight aggregate. According to the State Department of Mines and Mineral Resources, Chem-Stone mined a smaller quantity of pumice and processed it with purchased material to make stonewashing, stone dying, and stone bleaching materials for the laundry finishing industry.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. As a result, this chapter contains estimates for 1991 and 1989 and actual data for 1990. According to Bureau estimates, Arizona's construction sand and gravel production decreased about 14% during the year.

A gravel mine at Woodruff Butte inadvertently destroyed several Hopi shrines, among which was a historical boundary marker sacred to the tribe. The mine owner halted operations and contemplated the options, one of which was to persuade the Hopi Tribe to buy the property.

Industrial.—Arizona's production of industrial sand and gravel dropped 5% for 1991. The State tied with Montana for 31st place of 37 producing States. Production continued at Arizona Silica Sand Co.'s Houck Mine in Apache County and at Silica Mines Inc.'s mine near Oracle in Pinal County.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1991 and 1989 and estimated data for 1990.

Crushed.—Crushed stone production in Arizona for 1991 improved over both 1990 and 1989 output, 6% higher than the 1989 output reported to the Bureau. Of the State's 28 producers, the leading 5 were, in decreasing order of production: Chemical Lime Co., Phoenix Cement Co., Arizona Portland Cement Co., the U.S. Bureau of Reclamation, and Arizona Quality Granite Co. Top producing counties were Yavapai, Pima, and Maricopa. Most crushed stone produced in Arizona was limestone and was used in the manufacture of cement and lime. Arizona, however, also produced significant amounts of crushed granite, volcanic cinder, sandstone, marble, quartzite, and traprock. A total of 37 crushed stone quarries operated during the year.

Pfizer Specialty Minerals drilled and tested the Santa Rita limestone deposit, about 35 miles southeast of Tucson.

TABLE 2
ARIZONA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Riprap and jetty stone	179	810	$4.53
Coarse aggregate, graded:			
Bituminous surface-treatment aggregate[2]	86	555	6.45
Fine aggregate (-3/8 inch):			
Stone sand, bituminous mix or seal[3]	93	632	6.80
Coarse and fine aggregate:			
Graded road base or subbase	299	907	3.03
Unpaved road surfacing	22	48	2.18
Terrazzo and exposed aggregate	W	W	9.50
Other coarse and fine aggregate	82	360	4.30
Other construction materials[4]	28	266	9.50
Chemical and metallurgical: Cement manufacture	2,017	9,825	4.87
Other miscellaneous uses[5]	1,540	5,469	3.55
Unspecified:[6]			
Actual	422	1,860	4.41
Estimated	2,293	12,109	5.28
Total[7]	7,060	32,842	4.65

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes granite, limestone, marble, miscellaneous stone, quartzite, sandstone, traprock, and volcanic cinder and scoria.
[2]Includes concrete aggregate, coarse, and bituminous aggregate, coarse.
[3]Includes stone sand, concrete, and screening undesignated.
[4]Includes withheld amounts for coarse and fine aggregates, and roofing granules.
[5]Includes poultry grit and mineral food, lime manufacture, and sulfur oxide removal.
[6]Includes production reported without a breakdown by use and estimates for nonrespondents.
[7]Data may not add to totals shown because of independent rounding.

Subsequently, the company acquired the deposit and the Calcium Products mill from Calcium Products of Arizona. According to the Arizona Department of Mines and Mineral Resources, Pfizer began a multimillion dollar improvement and expansion project, including installation of additional roller mill capacity. Historically, Calcium Products has produced fine-ground functional fillers for wallboard joint compound. Pfizer planned to add other fine-sized filler products for use as sealants, plastics, stuccoes, and grouts. It was anticipated that the company will also produce larger size materials for livestock feed supplement.

During 1991, Georgia Marble Co. acquired the Andrada Marble Co. and the Andrada quarry in Pima County near Tucson. According to the Arizona Department of Mines and Mineral Resources, Georgia Marble began constructing a new processing plant at the quarry and developing new quarry sites. The company planned to have the new plant finished by early 1992. In addition to Andrada's historic emphasis on sized marble products for landscaping, pool plaster, and livestock feed supplement, Georgia Marble planned to focus on production of fine-ground calcium carbonate for functional fillers in manufactured products when its new plant is completed.

Dimension.—Only American Sandstone (a subsidiary of Blaser Corp.) in Coconino County reported dimension stone production in Arizona for 1991. The company produced sandstone that it dressed for flagstone. Arizona was 25th of 34 States in dimension stone production. According to the State Department of Mines and Mineral Resources, eight other companies quarried dimension stone in Arizona: Anasazi Co., Halquist Stone Co. Inc. (Apache Stone Division), Drake Stone Products, Dunbar Stone Co., Harley Gray Stone Co., Hudman Stone, Outland Resources Inc., and Western States Stone Co. The companies quarried sandstone, marble, quartzite, and schist in Coconino, La Paz, Maricopa, and Yavapai Counties. Products included facia, tiles, blocks, and shaped stone.

Other Industrial Minerals.—In mid-1991, Arimetco began negotiations with the University of Arizona to acquire the Whitecliffs diatomite deposit in Pinal County near Tucson. The mine ceased production during the middle of 1990, when it was operated by Whitecliffs Industries.

A small amount of specular hematite mined for pigment was produced by Swansea Minerals Inc. from tailings at the Swansea Mine in La Paz County.

Morton International Inc. mined salt at its solar operation in Glendale in Maricopa County. Production increased in 1991 by 29%. Morton reported in its annual report that the company responded to increased environmental concerns by lining the solar evaporation ponds with protective linings. A new laser system also was installed to enable uniform harvesting and an improvement in salt quality. Arizona was 12th of 14 States that produced salt.

According to the Arizona Department of Mines and Mineral Resources, Minerals Research and Recovery Inc. of Tucson recovered and processed copper smelter slag for roofing granules, abrasives, filtration media, nuclear shielding, and ship ballast from the slag pile of Phelps Dodge's now idle New Cornelia smelter at Ajo in Pima County.

Ironite processed and blended tailings from the defunct Iron King Mine's zinc-copper beneficiation mill to make soil supplements. The company's processing plant is in Humbolt, Yavapai County.

Arizona continued to be the country's largest producer of byproduct sulfuric acid, all of which was generated at the

TABLE 3

ARIZONA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	—	—	—	—	179	$811
Coarse aggregates, graded[2]	—	—	W	W	W	W
Fine aggregates (-3/8 inch)[3]	—	—	—	—	93	632
Coarse and fine aggregates[4]	W	W	W	W	332	1,098
Other construction materials	—	—	—	—	W	W
Agricultural[5]	—	—	—	—	W	W
Chemical and metallurgical[6]	W	W	W	W	1,011	3,787
Other miscellaneous uses	2,516	$11,048	128	$930	86	567
Unspecified:[7]						
Actual	—	—	—	—	423	1,860
Estimated	228	1,112	20	94	2,045	10,903
Total	2,744	12,160	148	1,024	4,169	[8]19,657

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[1]Includes riprap and jetty stone.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), and bituminous surface treatment aggregate.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[4]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, roofing granules, and other coarse and fine aggregates.
[5]Includes poultry grit and mineral food.
[6]Includes cement manufacture, lime manufacture, and sulfur oxide removal.
[7]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[8]Data do not add to total shown because of independent rounding.

TABLE 4

ARIZONA: CRUSHED STONE SOLD OR USED BY PRODUCERS, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	11	3,969	$17,622	$4.44	10	4,166	$18,635	$4.47
Marble	3	W	W	18.35	3	W	W	4.99
Granite	8	2,022	8,324	4.12	14	2,144	10,192	4.75
Traprock	—	—	—	—	3	73	W	W
Sandstone and quartzite	1	W	W	8.96	3	334	2,002	5.99
Volcanic cinder	8	531	1,234	2.32	2	26	52	2.00
Miscellaneous stone	—	—	—	—	2	W	W	4.44
Total[1]	XX	6,649	28,552	4.29	XX	7,060	32,842	4.65

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

State's copper smelters and roasters. Most such acid was used by the copper industry for leaching ore.

Therm-O-Rock Industries and W. R. Grace and Co. exfoliated vermiculite at their plants in Maricopa County. The State ranked 10th of 19 producing States during 1991. Both companies sold material used mainly for horticulture and in the manufacture of concrete; a limited amount was sold for fireproofing material and for making insulation and plaster.

GSA Resources and UOP produced the zeolite chabazite from the Bowie deposit that straddles the Cochise-Graham County line. UOP processes the zeolite into specialty molecular sieve products at the company's plant in Mobile, AL. The company's product sales exceeded the combined sales of the seven other U.S. zeolite producers.

Apache Nitrogen Products Inc. in Cochise County began permitting for refurbishing and modernizing a nitric acid plant shut down 10 years ago. When the modernized addition to the existing 500,000-short-ton-per-year St. David

plant comes on-line, it was expected to increase the facility's consumption of anhydrous ammonia to 75,000 short tons. The St. David facility supplied ammonium-based explosives to regional mines as well as urea and ammonium nitrate liquid fertilizer for the agricultural industry.

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[1]State mineral specialist, U.S. Bureau of Mines, Denver, CO. She has 13 years of government and industry experience. The author gratefully acknowledges the assistance of Pat Latour, editorial assistant, in the preparation of this chapter.

[2]Director, AZ Dep. Mines and Miner. Resour., Phoenix, AZ.

[3]Leaming, G. F. The Copper Industry's Impact on the Arizona Economy 1991. WEAC. Mar. 1992. Available from the AZ Mining Association.

[4]Niemuth, N. J. The Primary Copper Industry of Arizona in 1991. AZ Dep. Mines and Miner. Resour., SR-18, 58 pp.

[5]Much of the information in this section came from Niemuth, N. J., Exploration 1991—Arizona. Min. Eng.—Annual Review 1991. May 1992.

[6]Coal Production. Energy Information Administration. Oct. 1992.

[7]Facts About Coal—1992. National Coal Association.

[8]Petroleum Supply Annual 1991, v. 1. Energy Information Administration. June 1992.

[9]Natural Gas Annual 1991. Energy Information Administration. Oct. 1992.

[10]Except where noted, all mine production data cited in this section have been quoted from company 1991 annual or form 10-K reports.

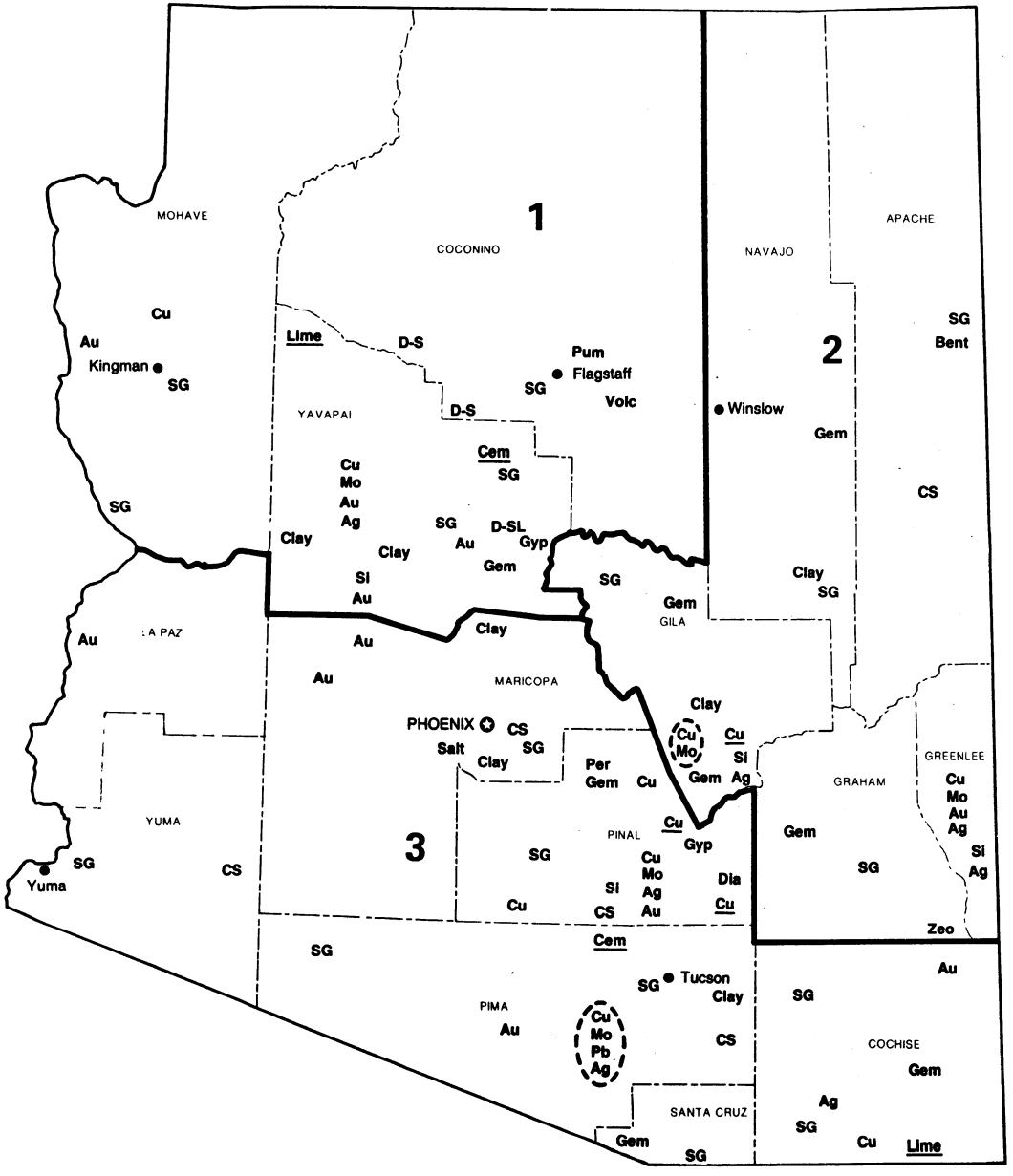
[11]All national ranking information that follows in this Arizona copper discussion is from J. L. W. Jolly. Copper. U.S. Bureau of Mines 1991 Annual Report.

[12]Lucas, J. M. Gold. U.S. Bureau of Mines 1991 Annual Report.

[13]Reese, R. G., Jr. Silver. U.S. Bureau of Mines 1991 Annual Report.

[14]Austin, G. T. Gemstones. U.S. Bureau of Mines 1991 Annual Report.

ARIZONA



LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Au	Gold
Bent	Bentonite
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper
Cu	Copper plant
D-S	Dimension Sandstone
D-SL	Dimension Slate
Dia	Diatomite
Gem	Gemstones
Gyp	Gypsum
Lime	Lime plant
Mo	Molybdenum
Pb	Lead
Per	Perlite
Pum	Pumice
Salt	Salt
SG	Sand and Gravel
Si	Silica
Volc	Volcanic cinder
Zeo	Zeolite

Concentration of mineral operations

Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Arizona Portland Cement Co., a subsidiary of Onada Cement Co. Ltd.[12]	Box 338 Rillito, AZ 85654	Quarry and dry-process, four-rotary-kiln plant	Pima.
Phoenix Cement Co.[12]	Box 428 Clarkdale, AZ 86324	Quarry and dry-process, three-rotary-kiln plant	Yavapai.
Clays:			
Building Products Co.	4850 West Buckeye Rd. Phoenix, AZ 85043	Open pit mines	Maricopa, Navajo, Yavapai.
Clinton-Campbell Contracting Inc.	1814 South 7th Ave. Phoenix, AZ 85007	do.	Maricopa and Pima.
Engelhard Corp.	Box 155 Sanders, AZ 86512	Surface strip mine	Apache.
McKusick Mosaic Co.	Route 1, Box 35-D Globe, AZ 85501	Surface mine	Gila.
United Dessicants, a division of United Catalyst Inc.	Box 32370 Louisville, KY 40232	Surface strip mine	Apache.
Copper:			
ASARCO Incorporated:			
Hayden Unit	Box 98 Hayden, AZ 85235	Smelter and acid plant	Gila.
Mission Complex[345]	Box 111 Sahuarita, AZ 85629	Open pit mines and mill	Pima.
Ray Unit[356]	Box 8 Hayden, AZ 85235	Open pit mine, dump- and heap-leach, precipitation, SX-EW plants	Pinal.
Silver Bell Unit	Marana, AZ 85653	Leach dumps and precipitation plant	Pima.
Cyprus Metals Co., a division of Cyprus Minerals Co.:			
Cyprus Badgad Copper Corp.[56]	Box 245 Bagdad, AZ 86321	Open pit mine, mill, dump-leach, SX-EW plant	Yavapai.
Cyprus Casa Grande Corp.	Box 15009 Casa Grande, AZ 85222	In situ mine and SX-EW plant	Pinal.
Cyprus Miami Mining Corp.	Box 4444 Claypool, AZ 85532	Dump- and heap-leach, SX-EW, smelter, refinery, rod mill	Gila.
Cyprus Mineral Park Corp.	HC-37 Box 500 Kingman, AZ 86401	Dump-leach and precipitation plant	Mohave.
Cyprus Sierrita Corp.[356]	Box 527 Green Valley, AZ 85622	Open pit mines, mill, leach dumps, SX-EW plants	Pima.
Magma Copper Co.:			
Corporate Headquarters	7400 North Oracle Rd. Tucson, AZ 85704	Offices	Do.
Pinto Valley Div.[356]	Box 100 Miami, AZ 85539	Open pit mine, mill, leach dumps, in situ leach, SX-EW	Gila.
San Manuel Div.[23567]	Box M San Manuel, AZ 85631	Underground mine, mill, in situ and heap leaching, SX-EW	Pinal.
Superior Div.[35]	Box 37 Superior, AZ 85273	Underground mine and concentrator	Do.
Phelps Dodge Corp.:			
Corporate Headquarters	2600 North Central Ave. Phoenix, AZ 85004-3015	Offices	Maricopa.
Copper Queen Branch	Highway 92 Bisbee, AZ 85603	Leach dumps, in situ leaching, precipitation plant	Cochise.

See footnotes at end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Copper—Contined:			
Phelps Dodge Corp.—Continued:			
Morenci Branch[3 5 6]	4521 State Hwy 191 Morenci, AZ 85540	Open pit mine, mills, dump-leach, precipitation, and SX-EW plants	Greenlee.
Gold:			
A. F. Budge Ltd.	Box 938 Jerome, AZ 86331	Underground mine and tailings leach	Maricopa and Yavapai.
Cyprus Copperstone Gold Corp.	Box A1 Parker, AZ 85344	Open pit mine, agitation leach	La Paz.
Republic Goldfields Corp.	Box 361 Congress, AZ 85332	Underground mine	Yavapai.
Gypsum:			
National Gypsum Co:			
Gold Bond Building Products Div.	Box 20863 Phoenix, AZ 85036	Plant	Maricopa.
Feldman Quarry	Star Route, Box 3990 Winkelman, AZ 85292	Open pit mine and crushing plant	Pinal.
Pinal Gypsum Co.	Box 99 Coolidge, AZ 85228	Open pit mine	Do.
Superior Companies[1 2]	100 West Coolidge Phoenix, AZ 85013	Quarries and plant	Apache, Pinal, Yavapai.
Western Gypsum	Box 850 St. George, UT 84770	Open pit mine and crushing plant	Mohave.
Western Organics Inc.	Box 6876 Phoenix, AZ 85005	Open pit mine	La Paz.
Iron oxide pigment:			
Swansea Minerals Inc.	6360 East Rose Circle Dr. Scottsdale, AZ 85251	Mine tailings	Do.
Lime:			
Chemstar Inc.[2]	2800 North 44th St., #400 Phoenix, AZ 85008	Quarries and lime kilns	Cochise and Yavapai.
Perlite:			
Harborlite Inc.	Box 960 Superior, AZ 85273	Open pit mine and plant	Pinal.
Nord Perlite Co., a subsidiary of Nord Resources Corp.	Box 127 Superior, AZ 85273	do.	Do.
Therm-O-Rock Industries Inc.[8]	6732 West Willis Rd. Chandler, AZ 85226	Plant	Maricopa.
Pumice:			
Arizona Tufflite Inc.	2432 West Peoria, #1081 Phoenix, AZ 85029	Open pit mine	Coconino.
Chem-Stone	2215 West Mountain View Phoenix, AZ 85021	do.	Do.
Salt:			
Morton Salt Co., a subsidiary of Morton International Inc.	13000 West Glendale Ave. Glendale, AZ 85307-2408	Solution mining and solar evaporation	Maricopa.
Sand and gravel (construction):			
Arizona Crushers Inc.	Box 9129 Phoenix, AZ 85024	Pits	Do.
Blue Circle West Inc.	2625 South 19th Ave. Phoenix, AZ 85009	do.	Do.
CalMat Co. of Arizona, a subsidiary of CalMat Co.	Box 52012 Phoenix, AZ 85072	Pits and plants	Do.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel (construction)—Continued:			
Earth Products Inc.	Box 278 Humboldt, AZ 86329	Pits and Plants	Yavapai.
FNF Construction Inc.	Box 5005 Tempe, AZ 85280	Pits	Gila and Mohave.
Granite Construction Co.	Box 27557 Tucson, AZ 85726	do.	Pima.
Peter Kiewit Sons Co.	2525 West Beryl Ave., #100 Phoenix, AZ 85021	do.	Maricopa and Pima.
Phoenix Redi-Mix Co.	3635 South 43d Ave. Phoenix, AZ 85009	do.	Do.
Salt River Sand & Rock[2]	Box 728 Mesa, AZ 85211	do.	Do.
The Tanner Companies	Box 52124 Phoenix, AZ 85072	Pits and plants	Coconino, La Paz, Maricopa, Pima, Pinal, Yavapai, Yuma.
Sand and gravel (industrial):			
Arizona Silica Sand Co.	Box 108 Houck, AZ 86506	Open pit mine	Apache.
Stone (crushed):			
Arizona Quality Granite	7401 West Villa Rita Dr. Peoria, AZ 85345	Quarry and plant	Maricopa.
Georgia Marble of Arizona	4901 East Drexel Rd. Tucson, AZ 85706	do.	Pima.
Western Arizona Rock Products Inc.	Box 178 Dateland, AZ 85333	do.	Yuma.
Stone (dimension):			
American Sandstone (a divison of Blaser Corp.)	Box 1154 North Highway 89 China Valley, AZ 86323	Quarries and plant	Coconino and Yavapai.
Drake Stone Products	Box 11676 Prescott, AZ 86304	Plant	Yavapai.
Dunbar Stone Co.	Box 246 Ash Fork, AZ 86320	Quarries and plant	Coconino, Maricopa, Mohave, Yavapai.
Harley Gray Stone Co.	Box 323 Paulden, AZ 86334	Quarries	Coconino.
Hudman Stone	9640 W. Picture Rock Rd. Tucson, AZ 84743	do.	Do.
Outland Resources Inc.	Box 4105 Kingman, AZ 86402	do.	Mohave.
Western States Stone Co.	2830 Grand Ave. Phoenix, AZ 85017	do.	Coconino, La Paz, Maricopa, Mohave, Yavapai.
Stone (smelter flux):			
Arizona Flux Mines Inc.[5]	Box 26706 Tucson, AZ 85726	Underground mine	Greenlee.
Silica Mines Inc.[3 9]	Box 332 Oracle, AZ 85623	Open pit mine	Pinal.
Queenstake Resources Ltd.[5 9]	Box 217 Willcox, AZ 85644	Underground mine	Cochise.
Triple Nichol Inc.[5]	Rural Route 1, Box N123 Globe, AZ 85501	Surface and underground mines	Gila and Pinal.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Vermiculite (exfoliated):			
W. R. Grace & Co., Construction Products Div.	4220 W. Glenrosa Phoenix, AZ 85019	Plant	Maricopa.
Therm-O-Rock Industries	6732 West Willis Rd. Chandler, AZ 85226	do.	Do.
Zeolite:			
GSA Resources[1]	Box 509 Cortaro, AZ 85652	Surface strip mine	Cochise.
UOP	115 North 5th St. Grand Junction, CO 81502	do.	Do.

[1]Also clays.
[2]Also crshed stone.
[3]Also gold.
[4]Also lead.
[5]Also silver.
[6]Also molybdenum.
[7]Also lime.
[8]Also vermiculite (exfoliated).
[9]Also copper.

THE MINERAL INDUSTRY OF ARKANSAS

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Arkansas Geological Commission for collecting information on all nonfuel minerals.

By Doss H. White, Jr.,[1] and William V. Bush[2]

Arkansas's nonfuel mineral production in 1991 was reported at $361 million, according to data received by the U.S. Bureau of Mines. The State's mineral value was $58 million higher than the $303 million reported in 1990. A dramatic increase in the value of bromine and crushed stone production offset declines in the value of several other mineral commodities.

Despite the recession, the State advanced from 33d to 26th in its national ranking in total mineral value. Arkansas was the only State with bromine and diamond production.

TRENDS AND DEVELOPMENTS

For the past 2 years, bromine, sand and gravel, and stone have been the three major mineral commodities produced in Arkansas. These three usually account for more than 75% of the State's mineral value. Bromine and bromine compounds have different markets than the other two major commodities, which are the basic raw materials for the construction industry. In years when construction activity and the demand for construction mineral commodities is down, the demand for bromine and its many compounds helps to insulate Arkansas's mineral value from severe declines. With both bromine and stone value increasing almost $94 million, a $4 million decrease in sand and gravel had a negligible effect on the State's total mineral value.

During the year, expansion activity was announced in both the industrial minerals and metals sectors. In the industrial minerals sector, Great Lakes Chemical Corp. announced plans to expand the production capabilities of several bromine compounds.

In October, Agricultural Minerals Corp. (AMC) announced that it would go

TABLE 1
NONFUEL MINERAL PRODUCTION IN ARKANSAS[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Abrasives[2]	metric tons	W	W	W	W	W	$154
Bromine[e]	thousand kilograms	W	W	177,000	$97,350	170,000	167,000
Clays	metric tons	871,313	$17,391	989,383	21,578	[3]856,582	[3]8,048
Gemstones		NA	4,041	NA	1,503	NA	1,846
Sand and gravel:							
Construction	thousand short tons	[e]7,500	[e]25,500	9,663	35,475	[e]8,300	[e]31,100
Industrial	do.	545	5,507	742	7,209	746	7,738
Stone:							
Crushed[4]	do.	18,791	76,419	[e]17,800	[e]76,900	22,140	101,427
Dimension	short tons	W	W	W	W	13,932	1,128
Combined value of baxuite (1989-90), cement, clays (fire, 1991), gypsum (crude), lime, stone [crushed dolomite and traprock (1991), crushed slate and dolomite (1989-90)], talc and pyrophyllite (1989-90), tripoli, vanadium (1989-90), and values indicated by symbol W		XX	253,051	XX	62,625	XX	42,543
Total		XX	381,909	XX	302,640	XX	360,984

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.
[3]Excludes certain clays; kind and value included with "Combined value" data.
[4]Excludes certain stones; kind and value included with "Combined value" data.

public on the New York Stock Exchange as Agricultural Minerals Co. LP. AMC owns the nitrogen fertilizer plant at Blytheville. The plant was purchased from Agrico in 1990.

In the metals sector, Nucor Corp. chose the community of Hickman as the location for its second thin-slab casting mill. The $300 million greenfields plant, scheduled for startup in mid-1993, will be the second hot-rolled sheet steel mill in the United States to use the thin-slab casting technology.

In November, Nucor-Yamato Steel Co. finalized agreements with several major equipment suppliers for its Blytheville mill expansion. The $150 million expansion, scheduled for completion in 1994, will increase the mill's annual capacity to approximately 1.6 million metric tons.

Noranda USA Inc., an aluminum foil producer, announced plans to install two 40,000-pound batch-type annealing furnaces at its plant in Newport.

EMPLOYMENT

Total nonfarm employment in the State in 1991 totaled almost 937 million. This was an increase over the 924 million noted in 1990. Employment in the mining sector was approximately 4,000, down from the 4,300 reported in 1990.[3]

REGULATORY ISSUES

In 1991, Arkansas had 10 properties on the U.S. Environmental Protection Agency (EPA) National Priorities List of hazardous waste sites. Two were, directly or indirectly, mineral related. The Frit Industries site at Walnut Ridge in Lawrence County was an active fertilizer plant. Remedial work to correct water pollution problems was underway at yearend. The second site, in Sebastian County north of Fort Smith, was a closed industrial and solid waste landfill in an abandoned coal mine. Remedial action was completed in 1991.

In December, Reynolds Metals Co. received the necessary permits from EPA to proceed with a $40 to $50 million commercial-scale facility to convert aluminum smelter potliners into environmentally acceptable landfill material at its closed smelter at Arkadelphia.

Arkansas State officials and citizens groups were protesting the exploratory drilling for lead in the Mark Twain National Forest in Missouri. A National Park Service study indicated that the aquifer in the proposed lead exploration area was the "sole source" aquifer for part of northern Arkansas. Arkansas citizens and officials were concerned that the drilling and future mining "could contaminate the water supply in southern Missouri and Northern Arkansas." The controversy was ongoing at yearend.

A proposal to fuel a cement plant's kilns with hazardous waste brought petition drives by two citizens groups requesting a public hearing to disclose what substances would be burned and discharged into the environment if the plant was permitted to burn the waste.

LEGISLATION AND GOVERNMENT PROGRAMS

Bills passed by the 1991 Arkansas Legislature had no direct effect on the Arkansas mineral industry. At yearend, however, the Arkansas Department of Pollution Control and Ecology (PC&E) conducted public hearings to allow for public comment on proposed regulations for the surface mining of nonfuel minerals. Provisions in the proposed regulations would allow PC&E greater flexibility in the types of bonding for mining permits and in determining acceptable reclamation plans.

The Arkansas Geological Commission (AGC), Little Rock, completed the moving of drill cores and cuttings to its new well sample library building. AGC personnel continued work on an earthquake-related project in the New Madrid Seismic Zone to document the history and nature of landslides on Crowleys Ridge in northeastern Arkansas.

A special emphasis was placed on industrial minerals in 1991. The AGC participated in an industrial minerals workshop sponsored by the U.S. Geological Survey and State geological surveys in the midcontinent. The workshop focused on the importance of considering the location of industrial mineral deposits in planning. Urban expansion has not, in past years, taken into consideration the need for industrial minerals in rebuilding the infrastructure of the metropolitan areas.

The AGC continued to collect oil and gas data under an agreement with surrounding States to compile and publish a Regional Gas Atlas. Projected completion date was 1992.

The Arkansas Mines Division, headquartered in Fort Smith, performed routine safety inspections on coal, metal, and nonmetal mines in the State. The Division also provided certification and refresher training in all phases of mining. Division personnel conducted safety and health reviews of mining plans submitted for proposed underground mining and provided the same reviews on drilling projects for the Arkansas Gas Commission.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Abrasives (Natural).—The State's ranking advanced from second to first among the three States producing natural abrasives. Novaculite was the principal rock type mined; Garland and Hot Springs Counties were the principal producing counties. Blocks of novaculite were mined by surface methods and then cut to shape using diamond saws; final shapes were obtained by sawing and grinding. Some crude novaculite was shipped to Europe and Japan for finishing. Arkansas producers marketed whetstones, hones, scrapers, and files. Output and value fell considerably below that reported in 1990; the downturn was caused by tight money resulting from the recession.

Bromine.—Approximately 40% of the world's bromine was produced in Arkansas in 1991, and for the past

several years the State has been the only domestic producer. Production totaled 170 million kilograms valued at $167 million. Bromine sales accounted for 46% of the State's mineral value in 1991.

Four firms, Arkansas Chemical Inc., Dow Chemical U.S.A., Ethyl Corp., and Great Lakes Chemical Co., composed the State's bromine industry. All four are in Columbia and Union Counties. Ethyl owns Dow, and Great Lakes is part owner of Arkansas Chemical Co.

The Smackover Formation, containing bromine-bearing brines, underlies much of southwestern Arkansas. The four companies recovered the brine through 7,000- to 8,000-foot-deep wells drilled into the bromine horizon. When pumped to the surface, chlorine-laden steam was reacted with the brine to liberate bromine. A fraction was refined and recovered as elemental bromine marketed to chemical manufacturers. Much of the production was used to produce chemicals for agricultural pest control, water treatment, fire control, and oilfield fluids.

During the year, a Great Lakes subsidiary, OSCA Inc., acquired Venezuela's leading supplier of clear drilling fluids. A second subsidiary, Great Lakes Chemical (Europe) Ltd., acquired a state-of-the-art fine chemicals manufacturing facility in Konstanz, Germany.[4]

Cement.—The State advanced from 27th to 25th among the 38 portland cement-producing States and 15th among the 33 States with masonry cement production. This occurred despite a decline in output and value for both cement types. Cement sales accounted for less than 10% of the State's mineral value in 1991.

The Arkansas cement industry consisted of two firms, Ash Grove and Holnam Inc. The former operated the Foreman plant at Foreman, while the latter operated the Okay Cement Plant near Saratoga. The two companies operated five wet-process kilns. Materials for clinker manufacture, limestone, clay and sand, were obtained from instate sources.

Late in 1991, Holnam Inc., Dundee, MI, announced plans to burn hazardous waste in its Okay plant near the eastern shore of Lake Millwood in Howard County. Two groups of concerned citizens, Arkansas Public Policy Panel Inc. and Friends United for a Safe Environment, began a petition drive requesting, "... a public hearing for the cement company to disclose what substances will be burned at the facility and discharged into the environment."[5]

Clays.—The State slipped from 14th to 16th place ranking among the 44 clay-producing States. The Arkansas clay industry, 10 firms in 10 counties, produced common clay, fire clay, and kaolin. Output of the three clay types, 856,000 metric tons, was valued at $8 million, a decrease of 133 million tons and $13.5 million below that reported in 1990.

Common Clay and/or Shale.—Production was reported by 7 companies operating 16 mines in a 9-county area. The three leading counties, in decreasing order of tonnage, were Crittenden, Hot Springs, and Montgomery. The three accounted for almost 85% of the clay and shale produced. Major end uses, as reported by the companies, were for (1) common brick, (2) concrete block, (3) roofing granules, (4) structural concrete, and (5) face brick. These end uses accounted for almost 90% of the production.

In November, Acme Brick Co., a subsidiary of Texas-based Justin Industries, purchased Elgin Butler Brick Co. The purchase included "...brick manufacturing assets, related properties, and inventory." Elgin Butler was to retain its glazed tile production facility.[6]

Fire Clay.—One firm mined fire clay in Pulaski County. Value and tonnage were concealed.

Kaolin.—Production was reported by three firms in Pulaski County, and Arkansas ranked third nationally in kaolin output. Both calcined and unprocessed kaolin was marketed. Major end uses, in descending order of tonnage, were for use in (1) grogs, (2) aluminum sulfate manufacture, and (3) as a pesticide and related product carrier. Output fell from 283,000 metric tons to 233,000 metric tons, and value plummeted from $18.8 million to $5.4 million.

Gemstones.—Arkansas was one of the leading gemstone- and mineral-producing States in the Nation. Diamonds and quartz crystals were two of the minerals of interest to the collector.

The Crater of Diamonds State Park near Murfreesboro was the principal site of diamond collecting on the North American Continent. A 4.33-carat white diamond was discovered in March, and a park visitor found a 6.23-carat yellow diamond in November. The long-term controversy over drilling and commercial mining within the park continued. In August, a Federal Appeals Court heard arguments by lawyers for two diamond mining companies that drilling in the park would "not necessarily lead to commercial mining or detract from recreation." The court was scheduled to decide in 1992 whether to uphold a decision made in 1990 by the U.S. District Court to halt test drilling in the park. Opponents claim that the drilling violated Federal law.

Quartz crystal mines in the Hot Springs area were open to collectors for a fee. The mines also sold specimens locally and to rock shops throughout the country. Both experienced and amateur mineral collectors visited the State to collect its varied mineral assemblage.

Gypsum.—The State ranked ninth among the 21 gypsum-producing States. Output and value were concealed, but production fell below the 1990 level while value increased slightly. Two firms mined gypsum in Howard and Pike Counties. The gypsum, associated with the DeQueen limestone member of the Trinity Group, consisted of three gypsum beds with an average minable thickness of almost 20 feet. The two companies, Harrison Gypsum Co., Pike County, and Briar Gypsum Co., Howard County,

operated surface mines and crushing facilities. Briar Gypsum was a subsidiary of Boral Ltd. of Australia. Harrison's output was sold to cement companies for use in cement clinker manufacture. Briar Gypsum's production was calcined and used in the manufacture of wallboard. A third firm, Temple Inland Forest Products Co., purchased gypsum mined in Oklahoma for wallboard manufacture.

Lime.—Arkansas ranked 28th among the 32 lime-producing States. One firm, Arkansas Lime Co. in Independence County, produced hydrated and quicklime from locally mined limestones. Sales were to the sugar and crude oil refining industries, water purification plants, and paper manufacturers. Sales of both quick and hydrated lime were lower than those in 1990.

Quartz.—Arkansas was the only State with production of quartz lascas, a low-impurity quartz used as a feedstock for fused and cultured quartz production. Coleman Quartz Inc., Jessieville, was the only known domestic producer, and 1991 production was about 7% higher than that of 1990. The company mined quartz feedstock during the summer months and processed lascas throughout the year. After mining, the quartz was crushed, sized, and transported to a processing plant where it was rinsed in oxalic acid and deionized water to remove external contaminants. Final processing included sorting, drying, and examination on a light table to identify any remaining impurities. The material was shipped to cultured quartz crystal producers in 45-kilogram (100-pound) bags.

Arkansas was also the leading State in natural quartz crystal production, and much of the area where the crystals occurred was within the Ouachita National Forest in the western part of the State. Mining was administered by the U.S. Forest Service.

In June, a Montgomery County woman was fined $500 and sentenced to 6 months in the Federal penitentiary for mining quartz without the required lease. Two others had pleaded guilty to similar charges, but had not been sentenced. A Forest Service spokesperson stated that the agency would seek warrants on at least four other illegal mine operators.[7]

TABLE 2
ARKANSAS: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Riprap and jetty stone	728	3,403	$4.67
Filter stone	119	552	4.64
Coarse aggregate, graded:			
Concrete aggregate, coarse	520	2,417	4.65
Bituminous aggregate, coarse	360	2,109	5.86
Bituminous surface-treatment aggregate	58	295	5.09
Railroad ballast	333	2,128	6.39
Fine aggregate (-3/8 inch):			
Stone sand, concrete	W	W	4.92
Stone sand, bituminous mix or seal	355	1,762	4.96
Screening, undesignated	1,005	3,928	3.91
Coarse and fine aggregate:			
Graded road base or subbase	2,779	11,023	3.97
Unpaved road surfacing	238	1,150	4.83
Crusher run or fill or waste	220	681	3.10
Other construction materials[2]	1,801	12,718	7.06
Agricultural: Agricultural limestone[3]	191	1,574	8.24
Chemical and metallurgical: Cement manufacture	W	W	4.87
Special: Other fillers or extenders[4]	291	2,479	8.52
Other miscellaneous uses[5]	1,457	3,733	2.56
Unspecified:[6]			
Actual	5,326	20,593	3.87
Estimated	6,357	30,882	4.86
Total	[7]22,140	101,427	4.58

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes granite, limestone, miscellaneous stone, and sandstone, excludes a minor amount of dolomite and traprock withheld to avoid disclosing company proprietary data.
[2]Includes withheld amounts for fine aggregate (-3/8), and roofing granules.
[3]Includes poultry grit and mineral food.
[4]Includes mine dusting or acid water treatment, and asphalt fillers or extenders.
[5]Includes withheld amounts for chemical and metallurgical, and abrasives.
[6]Includes production reported without a breakdown by use and estimates for nonrespondents.
[7]Data do not add to total shown because of independent rounding.

Sand and Gravel.—Arkansas ranked 32d among the 50 sand and gravel-producing States, and sales of sand and gravel accounted for 11% of Arkansas's mineral value in 1991. The estimated production of both construction and industrial sand and gravel, 8.2 million metric tons (9 million short tons), fell below the 9.4 million metric tons (10.4 million short tons) reported by the sand and gravel industry in 1990. Estimated value, $38.8 million, was $3.9 million below that reported for 1990.

Construction.—Production of construction sand and gravel is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This report contains estimates for 1989 and 1991 and actual data for 1990.

Production was estimated at 7.5 million metric tons (8.3 million short tons) valued at $31.1 million. This was

a decrease from the 8.8 million metric tons (9.7 million short tons) valued at $35.5 million reported in 1990.

During the last full year with industry data, 40 companies operated 68 mines in a 33-county area. Twenty-three stationary and 23 portable processing plants were in operation during that year. The three leading sand and gravel-producing counties were Ouachita in the south-central part of the State and Little River and Sevier in the southwest corner.

Industrial.—Four firms reported industrial sand production from pits in Crawford, Hempstead, Izard, and Miller Counties. Approximately 92% of the output was sand, and the remainder was gravel. Principal sales were to the foundry, glassmaking, roofing granule, and sandblasting industries. Output, 677 million metric tons valued at $7.7 million, exceeded the production and value, 673 million metric tons valued at $7.2 million, of industrial sand mined in 1990.

Stone.—The production of stone is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This report contains actual data for 1989 and 1991 and estimates for 1990.

Arkansas crushed stone statistics are compiled by geographical districts as depicted in the State map. Table 3 presents end-use statistics for Arkansas's two districts.

Crushed.—The State ranked 21st among the 49 States with a crushed stone industry. The value of crushed stone produced in 1991 accounted for 28% of the State's total, and crushed stone value ranked second behind bromine in sales. Production and value were reported at 20.0 million metric tons (22.1 million short tons) valued at $101.4 million. The 1990 estimate was 16.1 million metric tons (17.8 million short tons) valued at $76.9 million.

Production was reported by 34 companies operating 52 quarries in a 28-county area.

TABLE 3

ARKANSAS: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2	
	Quantity	Value	Quantity	Value
Construction aggregates:				
Coarse aggregates (+1 1/2 inch)[2]	138	615	710	3,340
Coarse aggregates, graded[3]	572	2,780	700	4,170
Fine aggregates (-3/8 inch)[4]	383	1,213	999	4,586
Coarse and fine aggregates[5]	2,378	9,459	860	3,394
Other construction materials	W	W	W	W
Agricultural[6]	191	1,574	—	—
Chemical and metallurgical[7]	—		W	W
Special[8]	W	W	W	W
Other miscellaneous uses	233	1,986	3,294	16,834
Unspecified:[9]				
Actual	3,192	12,418	2,134	8,175
Estimated	614	3,010	5,743	27,872
Total	7,701	33,055	14,440	68,371

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[1]Excludes dolomite and traprock; withheld to avoid disclosing company proprietary data.
[2]Includes riprap and jetty stone and filter stone.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[5]Includes graded road base or subbase, unpaved road surfacing, crusher run (select material or fill), and roofing granules.
[6]Includes agricultural limestone and poultry grit and mineral food.
[7]Includes cement manufacture.
[8]Includes asphalt fillers or extenders, mine dusting or acid water treatment, abrasives, and other fillers or extenders.
[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.

The predominate stone types produced during 1991 were granite, 8.9 million metric tons (42%); limestone, 5.9 million metric tons (25%); and sandstone, 3.7 million metric tons (16%). Dolomite, traprock, and "other" stone types accounted for the remainder (17%).

Granite was produced by two companies in Pulaski and Pope Counties in the central and western part of Arkansas. Limestone was mined and crushed in 13 counties; the leading counties in terms of output were Independence, Little River, and Washington. Sandstone was mined and crushed at quarries in 13 counties; the leading sandstone-producing counties were Sebastian, Crawford, and Clarke.

Dolomite was mined in Lawrence County, traprock in Hot Springs, and "other" stone production was reported from Garland, Montgomery, Polk, Pulaski, and Saline Counties.

The crushed stone industry reported sales for (1) graded road base, (2) cement manufacture, (3) riprap and jetty stone (4) bituminous aggregate, and (5) construction aggregate.

Dimension.—Arkansas's dimension stone industry, composed of three companies, operated five quarries in Independence, Logan, and Sebastian Counties. Limestone-marble and sandstone were the stone types quarried. The principal stone shapes produced included cut/veneer stone, rough blocks, and flagging. Output and value were higher than those reported in 1989 and 1990.

Talc.—The State ranked seventh among the nine States with talc production. The Milwhite Co. mined talc at a surface operation in Saline County. The run-of-mine ore was trucked to a mill at Bryant where it was milled into products sold as a filler, for use in roofing materials, for inclusion in tennis court surfacing and pipeline coating

TABLE 4
ARKANSAS: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991[1]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	24	7,578	$30,081	$3.97	20	6,492	$26,422	$4.07
Dolomite	1	W	W	3.45	—	—	—	—
Granite	5	7,404	30,254	4.09	8	9,880	49,296	4.99
Traprock	—	—	—	—	—	—	—	—
Sandstone	11	3,259	13,171	4.04	15	4,119	17,080	4.15
Slate	1	W	W	37.26	—	—	—	—
Miscellaneous stone	4	552	2,913	5.28	7	1,650	8,629	5.23
Total[2]	XX	18,791	76,419	4.07	XX	22,140	101,427	4.58

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Excludes dolomite and traprock; withheld to avoid disclosing company proprietary data.
[2]Data may not add to totals shown because of independent rounding.

compounds, and in brake shoe manufacture. The Bryant mill also processed soapstone mined in Texas for use by the insecticide carrier and ceramics industries. The company reported that no rock was processed in 1991; all shipments were from stockpile.

Tripoli.—Arkansas was one of four States producing tripoli, a cryptocrystalline mineral composed of almost pure silica. Production was by one company from a mine near Hot Springs. Crude tripoli, mined by surface methods from a 40-foot-thick deposit, was trucked to a mill in Hot Springs. The material was ground, dried, and air separated into sized products. Sales were to the abrasives and filter industries. Production and value fell below those reported in 1990.

Other Industrial Minerals.—In addition to the commodities listed in table 1 and described previously, several were either recovered as byproducts from other mineral processing or shipped to Arkansas from out-of-State or foreign sources for processing or finishing into higher value products.

Ammonia was produced by Nitrogen Products Inc., which brought a revamped 210,000-short-ton-per-year ammonia plant on-stream at Helena. Royster Co., under contract with the Dutch-owned bank NMB, was the plant operator. In March, Agricultural Minerals Corp. assumed control of the Agrico nitrogen fertilizer plant at Blytheville.

Dimension stone was shipped into Arkansas for finishing, primarily as grave markers and monuments. Mineral pigments, both natural and synthetic, were shipped to the State's clay companies for use in brick coloring.

Synthetic graphite was produced by the Great Lakes Carbon Group and Superior Graphite Co. The two firms operated plants in Ozark and Russellville, respectively, to produce graphite electrodes, using petroleum coke as the principal raw material.

Sulfur was recovered as a byproduct of industrial manufacturing or processing. MKP Operating Co., Lafayette County, recovered sulfur during petroleum refining, and the Ethyl Corp. recovered sulfur during bromine extraction at its Columbia County complex.

Vermiculite was exfoliated by Strong-Lite Products Corp. at a plant in Pine Bluff. Crude vermiculite was obtained from mines in South Carolina and other States.

Metals

The year marked the first in decades in which no metal mining was reported. Bauxite production terminated in 1990, and the State's single vanadium producer processed scrap rather than vanadium ore.

Aluminum.—Aluminum Co. of America's (Alcoa) aluminum chemicals plant at Benton, Saline County, was the only aluminum operation in Arkansas. The plant received alumina, processed from West African bauxite, from its plant at Port Comfort, TX. During the year, the work force was cut by almost 300 employees as Alcoa struggled to remain competitive.

Iron and Steel.—Arkansas's two iron and steel producers, Arkansas Steel Associates and Nucor-Yamato Steel Co., had a combined annual capacity of 870,000 short tons. Each operated a two-furnace minimill. The Nucor operation in Blytheville was the largest mill with a 650,000-short-ton-per-year capacity.

In November, Nucor reached agreements with several equipment suppliers for a $150 million expansion at its Blytheville operation. The expansion, announced in March, will increase the mill's annual capacity to about 1.6 million short tons. The expansion is scheduled to be completed in 1994 and will allow the facility to roll wider flange beams up to 40 inches and 260 pounds per foot.[8]

At yearend, work was under way on a new, $300 million mill at Hickman. The facility, scheduled for startup in mid-1993, will produce about 1 million short tons per year. The facility will have the ability to cast slabs 2 inches thick and 61

inches wide. A six-stand mill will roll the slabs without reheating to produce coils up to 60,000 pounds. Thicknesses will be in the 0.05-inch to 0.07-inch range.[9]

Vanadium.—The Nation's only vanadium mine and mill were located a few miles south of Hot Springs. U.S. Vanadium, a subsidiary of Strategic Minerals Corp. of Danbury, CT, operated the complex. In 1991, the mine was not worked; plant feed was spent catalysts and vanadium residues.

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[2]Assistant State Geologist, Arkansas Geological Commission, Little Rock, AR.

[3]U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings. V. 39, No. 5, May 1992, p. 132.

[4]Great Lakes Chemical Corp. 1991 Annual Report, p. 7.

[5]Little River News. Hazardous Waste Burning Concerns Groups About Lake. Nov. 14, 1991.

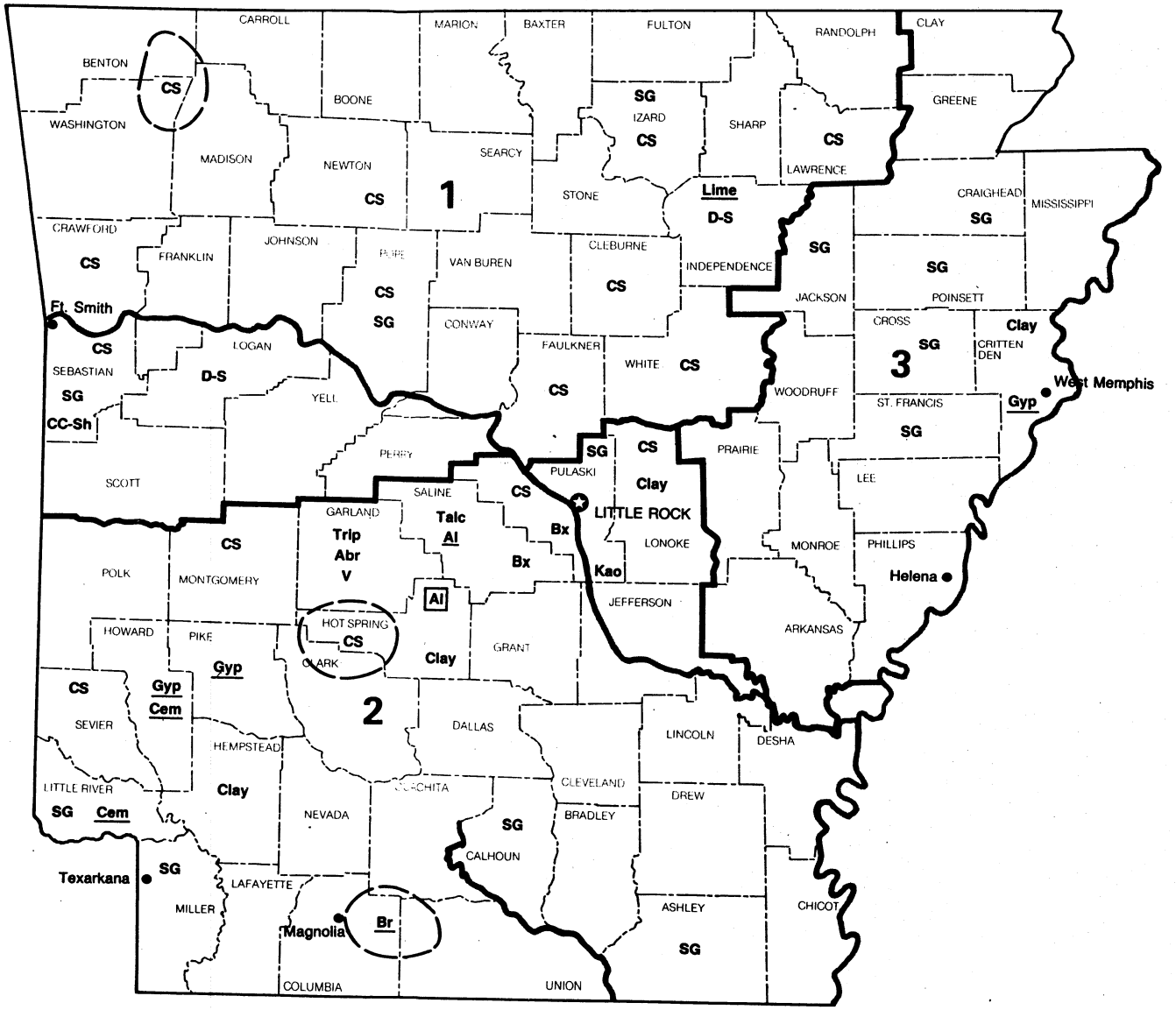
[6]Arkansas Gazette. Acme Brick Acquires Firm. Nov. 12, 1991.

[7]Pulaski County Democrat. Woman Fined $500 Gets 6-Month Term. June 7, 1991.

[8]American Metal Market. Nucor-Yamata Steel, Suppliers Reach Pacts. V. 99, No. 220, Nov. 14, 1991.

[9]———. Nucor Picks Ark. Site for Construction. V. 99, No. 39, Feb. 21, 1991.

ARKANSAS



LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Abr	Abrasives
Al	Alumina plant
Al	Aluminum plant
Br	Bromine plant
Bx	Bauxite
CC-Sh	Common Clay & Shale
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-S	Dimension Shale
Gyp	Gypsum plant
Kao	Kaolin
Lime	Lime plant
SG	Sand and Gravel
Talc	Talc minerals
Trip	Tripoli
V	Vanadium
	Concentration of mineral operations

Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Abrasives:			
Oilstones and whetstones:			
Hiram A. Smith Whetstone Co. Inc.	1500 Sleepy Valley Rd. Hot Springs, AR 71901	Quarry	Garland.
Tripoli:			
Malvern Minerals Co. Inc.	Box 1246 Hot Springs, AR 71901	Mine	Do.
Bromine:			
Arkansas Chemicals Inc.	Route 6, Box 98 El Dorado, AR 71730	Brine wells and plant	Union.
Dow Chemical U.S.A.	2030 Dow Center Midland, MI 48640	do.	Columbia.
Ethyl Corp., Arkansas Div.	Box 729 Magnolia, AR 71753	do.	Do.
Great Lakes Chemical Corp.	Box 2200 West Lafayette, IN 47906	do.	Union.
Cement:			
Arkansas Cement Corp., a subsidiary of Ash Grove Cement Co.[1]	Box 25900 Overland Park, KS 66225	Plant	Little River.
Ideal Cement Co., a subsidiary of Ideal Basic Industries Inc.[1]	Box 8789 Denver, CO 80201	do.	Howard.
Clays:			
Acme Brick Co., a division of Justin Industries Inc.	Box 425 Fort Worth, TX 76101	Pits and plants	Hot Spring and Sebastian.
Arkansas Lightweight Aggregate Corp.	El Dorado, AR 71730	Pit and plant	Crittenden.
Eureka Brick & Tile Co.	Box 379 Clarksville, AR 72830	Mine	Johnson.
A.P. Green Refractories Co., a subsidiary of USG Corp.	Box 164069 Little Rock, AR 7726	Pit and plant	Pulaski.
Gypsum:			
Harrison Gypsum Co. Inc.	Box 336 Lindsay, OK 73052	Mine	Pike.
Weyerhaeuser Co., Dierks Div.	Route 4, Box 78 Nashville, AR 71852	Mine and plant	Howard.
Lime:			
Arkansas Lime Co., a subsidiary of Rangaire Corp.[1]	Box 2356 Batesville, AR 72501	Quarry and plant	Independence.
Perlite:			
Strong-Lite Products Corp.	Box 8029 Pine Bluff, AR 71611	Plant	Jefferson.
Sand and gravel:			
Construction:			
Beazer USA	Box 6657 Shreveport, LA 71136	Pits and plant	Little River, Ouachita, Pike.
Boorhem-Fields Inc.	Box 2196 Little Rock, AR 72203	do.	Calhoun, Craighead, Poinsett, St. Francis.
Industrial:			
Gifford-Hill & Co. Inc.	Box 6615 Shreveport, LA 71136	do.	Miller.
Unimin Corp.	Box 29 Guion, AR 72540	do.	Izard.

See footnotes at end of table.

TABLE 5-Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone:			
Granite:			
McGeorge Contracting Co. Inc.	Box 7008 Pine Bluff, AR 71611	Quarries and plant	Pulaski.
Minnesota Mining & Manufacturing Co.	3M Center, 223-4N-05 St. Paul, MN 55144	Quarry and plant	Do.
Limestone:			
McClinton-Anchor Co., a subsidiary of Ashland Oil Inc.	Box 756 Fayetteville, AR 72701	Quarries and plant	Benton, Madison, Washington.
Midwest Lime Co.	Box 2608 Batesville, AR 72501	Quarry and plant	Independence.
Sandstone:			
Arkhola Sand & Gravel Co.,[1] a subsidiary of Ashland Oil Inc.	Box 1627 Fort Smith, AR 72901	Quarries and plant	Crawford and Sebastian.
H M B Construction Co.	Box 5606 Texarkana, TX 75501	Quarry and plant	Sevier.
M & M Rock Co. Inc.	Box 1190 Conway, AR 72032	do.	Faulkner, Perry, White.
Sulfur (recovered):			
Ethyl Corp., Arkansas Div.	Box 729 Magnolia, AR 71753	Sulfur recovered in bromine extraction	Columbia.
Phillips Petroleum Co.	724 Adams Bldg. Bartlesville, OK 74004	Sulfur recovered as a byproduct of petroleum refining	Lafayette.
Talc:			
The Milwhite Co. Inc.[2]	Box 15038 Houston, TX 77020	Mine and plant	Saline.
Vanadium:			
Strategic Minerals Corp.	Route 6, Box 943 Hot Springs, AR 71901	Mine and mill	Garland.
Vermiculite (exfoliated):			
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	Plant	Pulaski.
Strong-Lite Products Corp.	Box 8029 Pine Bluff, AR 71611	do.	Jefferson.

[1]Also produced limestone.
[2]Also produced slate.

THE MINERAL INDUSTRY OF CALIFORNIA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the California Department of Conservation, Division of Mines and Geology, for collecting information on all nonfuel minerals.

By Fred V. Carrillo,[1] James F. Davis,[2] and John T. Alfors[3]

California ranked second among the States, after Arizona, in the value of nonfuel minerals produced in 1991, accounting for almost 10% of the U.S. total. The value of the commodities produced during the year decreased about 9% to $2.5 billion, following last year's 4% decline. California was the sole producer of boron and tungsten and led all States in the production of asbestos, portland cement, diatomite, calcined gypsum, rare-earth concentrates, and construction sand and gravel. It was second in natural calcium chloride, gold, magnesium compounds, pumice, industrial sand and gravel, and soda ash.

TRENDS AND DEVELOPMENTS

Industrial minerals comprised 80% of the State's nonfuel mineral production value. In 1991, 35 mineral commodities, including 9 metals, were produced in California. Lower industrial minerals prices and a reduction in the State's construction activity caused another drop in the total production value, similar to that of the previous year.

EMPLOYMENT

According to the California Department of Employment Development, the California nonfuel mining industry employed 7,900 workers in December 1991, down about 12% from that of the previous year. Of these, 1,900 were metal mining jobs and 6,000 were nonmetallic mineral mining jobs.

REGULATORY ISSUES

San Benito County became the first county in the State to initiate a per ton "business license" tax on minerals, imposing a 5-cent-per-ton tax on minerals mined in the county for use in road repair. The mineral tax was initiated last year under Senate bill 2557, which granted counties new authority to raise revenue.

The State Water Resources Control Board committed $500,000 toward a "short term" remedy for the Penn Mine pollution in Calaveras County. The money was to come from a State fund made up of money from fines levied in California for water pollution violations.

EXPLORATION ACTIVITIES

Precious-metals exploration was undertaken in several areas throughout the State despite lower silver and gold prices during the year. Initial exploratory work was begun at the Idaho-Maryland Mine near Grass Valley in Nevada County. The program included water removal, mine rehabilitation, and underground exploration drilling. Kennecott Corp. and Canyon Resources explored property in the Panamint Range west of Death Valley. Arizona Star Resource Corp. drilled its Imperial County project 40 miles northwest of Yuma, Arizona, outlining two gold prospects designated the Indian Rose Deposit and the Ocotillo Deposit. Tenneco Minerals drilled a U.S. Forest Service area near Antelope Valley.

Exploration for gold in the State was also reported by Glamis Gold and Brenna Resources Ltd. in the Randsburg district in Kern County and by Siskon Gold Corp. at the San Juan gold deposit in Nevada County.

LEGISLATION AND GOVERNMENT PROGRAMS

A new law (Senate bill 83) was passed in the California Legislature and signed by the Governor eliminating plastic or PVC pipe usage for mining claim markers. The new law specified that only wood, stone, or solid metal markers can be used to mark claims on Federal lands in the State and also reduced the number of markers required for outlining a claim to five. Another bill (Assembly bill 213) clarified the type of mining wastes that are exempt from hazardous waste management laws.

During fiscal year 1991, the University of California received allotment grants of $148,000 under the Mining and Minerals Research Institute program (MMRI). Programs under MMRI included Generic Mineral Technology Centers and Mineral Industry Waste Treatment and Recovery.

FUELS

California continued to rank fourth among oil-producing States, behind Texas, Alaska, and Louisiana, respectively.

During 1991, California's crude oil production increased for the first time in 6 years. Production totaled 350.8 million barrels of oil, compared with 350.7 million barrels in 1990. The State total included 296.0 million barrels of oil from onshore fields and 54.8 million barrels from offshore fields. Production from Federal offshore fields (31.6 million

TABLE 1
NONFUEL MINERAL PRODUCTION IN CALIFORNIA[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Boron minerals	metric tons	1,114,000	$429,806	1,093,919	$436,176	1,240,158	$442,531
Cement (portland)	thousand short tons	10,911	642,020	10,032	604,080	e8,702	e522,120
Clays	metric tons	2,195,830	39,243	2,163,515	2,40,217	2,074,707	2,27,464
Gemstones		NA	2,982	NA	1,501	NA	10,450
Gold[3]	kilograms	29,804	366,595	29,607	368,300	29,873	348,919
Gypsum (crude)	thousand short tons	1,734	13,066	W	W	W	W
Lime	do.	395	24,503	345	19,425	307	20,389
Mercury	metric tons	W	W	(4)	(4)	(4)	1
Pumice	do.	79,000	4,612	71,739	5,088	61,237	4,372
Rare-earth metal concentrates	do.	W	W	W	W	16,465	W
Sand and gravel:							
Construction	thousand short tons	e138,300	e670,800	132,214	626,000	e101,900	e489,100
Industrial	do.	2,426	43,863	2,452	48,055	2,104	41,690
Silver[3]	metric tons	21	3,650	21	3,209	W	W
Stone:							
Crushed	thousand short tons	54,887	238,034	e42,500	e200,600	45,816	216,156
Dimension	short tons	28,829	5,564	e30,077	e5,213	44,757	5,254
Combined value of asbestos, barite (1990), calcium chloride (natural), cement (masonry), clay [fuller's earth, (1990-91)], copper, diatomite, feldspar, iron ore [byproduct material (1989), usable], magnesium compounds, mica (crude, 1991), molybdenum, perlite, potash, salt, soda ash, sodium sulfate (natural), talc and pyrophyllite, titanium concentrates (ilmenite), tungsten ore concentrates, and values indicated by symbol W		XX	369,664	XX	r421,820	XX	403,592
Total		XX	2,854,402	XX	r2,779,684	XX	2,532,038

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" data.
[3]Recoverable content of ores, etc.
[4]Less than 1/2 unit.

barrels) increased by 1.7 million barrels. California's natural gas production increased from 364.8 billion cubic feet in 1990 to 383.6 billion cubic feet in 1991, the first increase since 1985.

Enhanced, heavy-oil recovery operations using injected steam resulted in notable production increases in three San Joaquin Valley fields: Midway-Sunset (2.3 million barrels), Cymric (1.4 million barrels), and Lost Hills (1.4 million barrels). As in 1990, the Midway-Sunset field was the top oil producer in the State, with a total of 61.4 million barrels, its highest production total since discovery in 1894.

The number of new oil, gas, and exploratory wells drilled in 1991 decreased to 2,242 wells from the 2,476 wells drilled in 1990. The number of new wells completed to production increased from 1,638 wells in 1990 to 1,732 in 1991. Although no new field discoveries were reported during the year, three new pools in oilfields and two new pools in gasfields were discovered, and the productive limits were extended seven times in oilfields.

Geothermal activity lessened in California during 1991, as new well drilling continued to be slow. According to the U.S. Bureau of Land Management (BLM), 19 wells were permitted on Federal lands during Federal fiscal year 1991 (October 1990-September 1991), compared with 43 wells permitted the year before. Eight geothermal production wells were completed on non-Federal California lands in 1991, compared with 10 wells in 1990, according to the California Department of Conservation.

New well drilling at the Geysers Geothermal Field failed to increase the field's overall production. Moderate activity occurred during the year at the Salton Sea Field in the Imperial Valley. Low-temperature geothermal exploration and development were also slow in 1991.

Once again, the California Energy Commission's (CEC) Geothermal Grant and Land Program provided most State-financed expenditures earmarked for such activities. Three applications for exploratory projects were granted during the year; one in the City of Twenty-Nine Palms, one in the city of Loma Linda, and one in Mammoth Lakes.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Boron Minerals.—California remained the sole source of domestic boron mineral production. Boron minerals sales valued at more than $440.0 million were 1% higher than those of 1990. Production of mineral concentrates and chemicals increased from 1,093,919 metric tons in 1990 to 1,240,140 metric tons in 1991. Production from four California plants was principally from Kern County, with the balance from San Bernardino County.

The U.S. Borax and Chemical Corp. began consolidation of its Los Angeles headquarters and Anaheim research offices in the Valencia area to be closer to its mining operations at Boron, north of Edwards Air Force Base. Newport Mineral Ventures of Maryland acquired the Death Valley Billie Mine from American Borate Co. in February and began limited operations in April.

American Borate Co. reported mining a limited amount of colemanite from its Billie Mine in Death Valley National Monument, which was milled at Newport Mineral Venture's Amargosa Valley mill in Clark County, Nevada.

Calcium Compounds.—California was a distant second to Michigan, the leading State in natural calcium chloride production. National Chloride Co. of America, Leslie Salt Co., and Hill Brothers Chemical Co. produced calcium chloride from dry-lake brine wells in San Bernardino County. Hill Brothers Chemical also produced calcium chloride from a second operation near Cadiz Lake.

Cement.—California continued to lead all States in the production of cement. Portland cement was the State's most valuable mineral commodity in 1991, with an estimated value of more than $522 million.

Clays.—Clay production in 1991 decreased slightly from that of the previous year to 2.07 million metric tons (2.31 million short tons) valued at more than $27 million. Common clay and shale comprised the bulk of the clays produced, but higher valued bentonite, fuller's earth, and kaolin production accounted for 65% of the value of California's clay production, reported to total $27,464,000. Principal uses were for brickmaking, portland cement, ceramics, pet waste absorbents, and in structural concrete. Clay production was reported from 41 pits in 18 counties throughout the State.

Diatomite.—California retained its lead as the principal State in diatomite production during 1991, despite a 4% reduction in total output. The major producer, Manville Products Corp., sold its Celite subsidiary, which operated the worlds' largest diatomaceous earth mining facility on 5,000 acres south of Lompoc in Santa Barbara County to New York-based Alleghany Corp.

Production was also reported from Santa Barbara County by Grefco Inc. and from Shasta County by Dicalite Corp.

Feldspar.—California ranked fourth in production and second in value for national feldspar in 1991. The quantity of feldspar sold decreased about 33% from that of 1990. Production of a feldspar-silica mixture was reported by U.S. Silica Co. in San Diego County and CISCO in Orange County.

Gypsum.—Calcined gypsum output from six plants continued the State's ranking as the number one producer of calcined gypsum in the Nation, while mines in Imperial, Kern, San Bernardino, San Luis Obispo, and Ventura Counties contributed to its ranking as the fifth largest crude gypsum producer. Byproduct gypsum was reported in Contra Costa and San Joaquin Counties. Continued weakness in the wallboard market caused most plants to operate well below capacity level.

California's 1991 production of calcined gypsum dropped 20% from that of 1990 to a reported production of 1,620,000 short tons in 1991, valued at $21,180,000. Crude gypsum production was also lower. U.S. Gypsum's Plaster City Mine and plant in Imperial County was the State's leading producer as well as the leading individual mine in the United States.

Gypsum was calcined by four companies at six plants in the State, principally for the manufacture of gypsum wallboard and plaster. Crude gypsum was mined at five locations in Imperial, Kern, San Bernardino, San Luis Obispo, and Ventura Counties.

Lime.—Lime production of 307,000 short tons was 38,000 short tons below 1990's reported production. Higher prices resulted in an increase in value from $19.4 million in 1990 to $20.4 million in 1991. Chemstar Inc., with plants in Contra Costa and Los Angeles Counties, was the State's largest producer of hydrate and quicklime. Quicklime was also produced in Monterey County at the National Refractories and Minerals Corp. Natividad plant.

Holly Sugar Corp. used quicklime at four plants in Santa Barbara, Imperial, San Joaquin, and Glenn Counties. Spreckles Sugar Co. used quicklime at its Woodland plant, and Delta Sugar Corp. used hydrate at its Clarksburg plant. Marine Magnesium Co., formerly Merck Chemical Co., used quicklime from its Sonora plant.

Pumice.—Following a national trend in which pumice sold in the United States in 1991 decreased about 10% from that of the previous year, California's 1991 pumice production declined 15% to 61,000 metric tons, with a value of $4,372,000. California pumice producers included: California Industrial Minerals

TABLE 2

CALIFORNIA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Riprap and jetty stone	1,028	9,548	$9.29
Filter stone	251	958	3.82
Coarse aggregate, graded:			
Concrete aggregate, coarse	1,708	9,212	5.39
Bituminous aggregate, coarse	1,932	12,970	6.71
Bituminous surface-treatment aggregate	186	2,517	13.53
Railroad ballast	1,097	6,667	6.08
Other graded coarse agggregate	W	W	1.22
Fine aggregate (-3/8 inch):			
Stone sand, concrete	530	2,809	5.30
Stone sand, bituminous mix or seal	844	3,886	4.60
Screening, undesignated	1,264	7,088	5.61
Coarse and fine aggregates:			
Graded road base or subbase	7,349	35,864	4.88
Unpaved road surfacing	270	1,429	5.29
Terrazzo and exposed aggregate	51	503	9.86
Crusher run or fill or waste	2,216	7,596	3.43
Other construction materials[2]	1,649	5,539	3.36
Roofing granules	400	1,976	4.94
Agricultural: Poultry grit and mineral food[3]	80	1,013	12.66
Chemical and metallurgical:			
Cement manufacture	15,686	53,588	3.42
Lime manufacture	110	1,085	9.86
Flux stone	8	60	7.50
Chemical stone	W	W	15.35
Glass manufacture	W	W	16.00
Sulfur oxide removal	W	W	13.62
Special:			
Asphalt fillers or extenders	281	1,485	5.28
Whiting or whiting substitute	10	150	15.00
Other fillers or extenders	384	1,663	4.33
Other miscellaneous uses[4]	166	1,997	12.03
Unspecified:[5]			
Actual	2,572	14,514	5.64
Estimated	5,743	32,039	5.58
Total	[6]45,816	216,156	4.72

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes dolomite, granite, limestone, marble, miscellaneous stone, quartzite, sandstone, shell, slate, traprock, and volcanic cinder and scoria.
[2]Includes withheld amounts for coarse aggregate, graded, roofing granules, and lightweight aggregate (slate).
[3]Includes agricultural limestone, and other agricultural uses.
[4]Includes withheld amounts for chemical and metallurgical, and other specified uses not listed.
[5]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[6]Data do not add to total shown because of independent rounding.

Co. in Madera County, Glass Mountain Pumice Inc. in Siskiyou County, and the major producer, U.S. Pumice Co. in Mono County. Principal uses of pumice were as abrasives, in concrete aggregate, and in building and landscaping. Lesser amounts of pumice were used as diluents and in stonewashing. California remained second in the Nation, after Oregon, as the largest source of pumice.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1988 and 1990 and estimates for 1991.

California construction sand and gravel and crushed stone statistics are compiled by geographical districts as depicted in the principal mineral-producing localities map.

Several controversial sand and gravel operations were granted permits to begin mining during the year. CalMat Co. received permission from the Poway City Council to double its size of operations at the Beeler Canyon Quarry in San Diego County. Hillsdale Rock Co. Inc. was granted a permit to mine a hilltop quarry north of San Juan Bautista in San Benito County. The Army Corp of Engineers granted Kiewit Pacific Co. permission to mine 500,000 cubic yards of gravel from Balkes Bar in Del Norte County for use in the Redwood Bypass. Syar Industries Inc. was granted a use permit in April to mine sand and gravel from a 2-mile stretch of the Russian River near Geyserville, Sonoma County. Kaiser Sand and Gravel Co. was granted a new permit to continue mining its quarry east of Pleasanton in Alameda County. XTRA Power Co. was granted a 30-year use permit to mine sand and gravel from Cottonwood Creek in Tehama County. Granite Construction Co. began construction of a paving material plant at its quarry on Pacheco Pass Highway in San Benito County.

Industrial.—California was second among the States in the production of industrial sand and gravel despite a decrease by more than 14%. Production remained high owing to demands from local industry, particularly the glass container industry and the distance of

TABLE 3

CALIFORNIA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregates (+1 1/2 inch)[1]	W	W	2	W	520	5,464	W	W
Coarse aggregates graded[2]	W	W	22	59	408	4,396	W	W
Fine aggregates (-3/8 inch)[3]	—	—	—	—	W	W	W	W
Coarse and fine aggregates[4]	W	W	759	3,516	1,734	8,544	1,614	9,328
Other construction materials	106	438	910	4,271	422	1,883	1,316	7,612
Agricultural[6]	—	—	—	—	—	—	—	—
Chemical and metallurgical[8]	—	—	W	W	—	—	—	—
Special[9]	—	—	—	—	—	—	—	—
Other miscellaneous uses	W	W	—	—	—	—	W	W
Unspecified:[10]								
Actual	—	—	—	—	159	920	441	2,718
Estimated	—	—	—	—	680	2,256	—	—
Total[3]	106	438	1,693	7,846	3,924	23,463	3,371	19,657

	District 5		District 6		District 7		District 8	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates								
Coarse aggregates (+1 1/2 inch)[1]	13	46	W	W	W	W	—	—
Coarse aggregates, graded[2]	10	90	830	8,459	2,001	6,034	—	—
Fine aggregates (-3/8 inch)[3]	W	W	W	W	629	2,370	—	—
Coarse and fine aggregates[4]	225	1,119	1,263	7,087	2,287	7,551	—	—
Other construction materials	109	965	113	667	313	1,102	(5)	(5)
Agricultural[6]	39	573	(7)	(7)	—	—	—	—
Chemical and metallurgical[8]	(7)	(7)	—	—	(7)	(7)	3,730	17,431
Special[9]	(7)	(7)	(7)	(7)	(7)	(7)	—	—
Other miscellaneous uses	174	1,785	68	265	3,548	12,043	—	—
Unspecified:[10]								
Actual	340	1,866	—	—	102	2,051	—	—
Estimated	194	784	1,186	4,012	—	—	—	—
Total[11]	1,025	7,934	3,460	20,490	8,880	31,151	3,730	17,431

See footnotes at end of table.

TABLE 3—Continued

CALIFORNIA CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

	District 9		District 10		District 11		District 12	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregates (+1 1/2 inch)[1]	166	1,342	5	40	W	W	W	W
Coarse aggregates, graded[2]	687	4,346	—	—	352	2,211	W	W
Fine aggregates (-3/8 inch)[3]	532	2,956	—	—	475	3,669	W	W
Coarse and fine aggregates[4]	231	907	W	W	684	1,487	1,054	5,668
Other construction materials	605	2,147	12	53	169	1,147	1,039	5,479
Agricultural[6]	(7)	(7)	(7)	(7)	—	—	—	—
Chemical and metallurgical[8]	8,188	23,168	(7)	(7)	—	—	—	—
Special[9]	(7)	(7)	(7)	(7)	—	—	—	—
Other miscellaneous uses	29	260	105	1,625	—	—	—	—
Unspecified:[10]								
Actual	784	3,856	—	—	826	2,397	—	—
Estimated	3,397	23,593	60	314	226	1,080	—	—
Total[11]	14,619	62,575	182	2,032	2,732	11,991	2,093	11,147

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes riprap and jetty stone, and filter stone.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface treatment aggregate, railroad ballast, and other graded coarse aggregate.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[4]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run or fill or waste, roofing granules, and lightweight aggregate (slate).
[5]Less than 1/2 unit.
[6]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[7]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[8]Includes cement manufacture, glass manufacture, lime manufacture, flux stone, chemical stone for alkali works, and sulfur oxide removal.
[9]Includes asphalt fillers or extenders, whiting or whiting substitute, and other fillers or extenders.
[10]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[11]Data may not add to totals shown because of independent rounding

TABLE 4

CALIFORNIA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	91	29,963	$120,613	$4.03	28	20,062	$84,363	$4.21
Dolomite	5	676	8,382	12.40	3	131	1,117	8.53
Marble	1	(1)	1	3.93	3	583	2,931	5.03
Shell	1	W	W	6.94	1	W	W	6.81
Granite	53	8,734	38,325	4.39	134	8,504	38,419	4.52
Traprock	10	6,089	32,679	5.37	36	9,466	63,131	6.67
Sandstone and quartzite	19	5,298	21,879	4.13	10	3,541	10,171	2.87
Slate	1	W	W	1.50	2	W	W	56.55
Volcanic cinder and scoria	9	740	3,368	4.55	23	491	2,517	5.13
Miscellaneous stone	16	3,335	12,531	3.76	31	3,010	12,777	4.24
Total[2]	XX	54,887	238,034	4.34	XX	45,816	216,156	4.72

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

California from the traditional production areas in the Midwest.

Corona Industrial Sand Co., Owens-Illinois, Simplot Industries, and Unimin were the four largest producers of glass sand in the region, with major operations in Riverside County, Amador County, and Contra Costa County, respectively. Lone Star Industries Inc., Monterey County, was the major supplier for the sandblasting industry in the region. Simplot Industries also supplied a large portion of the foundry sand consumed.

In the State, the most important sources of industrial sand were the Ione formation of Eocene age in northern California, the Silverado (Paleocene) and Tejon (Eocene) formations in southern California, and the Eureka quartzite of Middle Ordovician age in central California.

Stone (Crushed).—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1990 and actual data for 1989 and 1991.

Crushed stone production in the State during 1991 was 45,816,000 short tons valued at about $216 million, a 16.5% drop from production reported in 1989. Principal uses of crushed stone were in cement manufacture, concrete and bituminous aggregate, and road base. Additional important uses included riprap, jetty stone, and fillers and extenders. The top five California producers of crushed stone were, in descending order of tonnage produced, Beaser West Inc., Southdown Inc./Southwest Portland Cement Co., Syar Industries Inc., Granite Rock Co., and CalMat Co. More than 100 operations were reported statewide from 271 quarries.

Other Industrial Minerals.—KCAC Inc.'s Joe Asbestos Mine near King City in San Benito County was the State's sole producer of asbestos. Barite was crushed and ground at Standard Industrial Mineral's Laws Mill in Inyo County and Geo International's plant in Sacramento County.

California potash production was from the near-surface brines at Searles Lake. Two seawater magnesia operations in Monterey and San Mateo Counties accounted for all of California's magnesium compounds production in 1991. Mica was produced at one operation in Mono County. Leslie Salt Co., which produced salt from plants in Alameda, Napa, San Bernardino, and San Mateo Counties, was merged into its parent, Cargill Inc., in September.

Metals

Gold.—California retained its ranking as the second largest gold-producing State as output increased slightly to 29,873 kilograms of gold valued at $348,919,000. The Homestake Mining Co.'s McLaughlin Mine in Napa County and Consolidated Goldfields Mesquite Mine in Imperial County were the State's two largest gold producers. Gold Fields Operating Co. celebrated the pouring of the 1 millionth ounce of gold at its Imperial County Mesquite Mine in April with an opening of its Mesquite Mine Overlook Trail, which introduces the public to the mine and its unique desert environment.

Amax Gold Inc. began construction of milling facilities at its Hayden Hill Mine, northwest of Susanville in Lassen County in early fall. Eastmaque Gold Mines Ltd. operated both milling and heap-leach pads at its American Girl Mine in Imperial County as a joint venture with Morrison Knudsen Corp.

Royal Gold Inc. continued mining the original Sixteen to One Mine near Downieville. Glamis Gold Ltd.'s Picacho Mine operations concentrated on waste removal and mining ore from the Dulcina pit and on the construction of the 1.8-million-ton capacity Site #4 leach pad and recovery unit. Brush Creek Mining and Development Co., Inc. began production at the Ruby Mine located in Sierra County.

Lode gold production was reported from 16 operations throughout the State in Calaveras, Imperial, Inyo, Kern, Napa, Sierra, San Bernardino, and Tuolumne Counties, and from 5 placer operations in Nevada, San Bernardino, Sierra, and Yuba Counties.

Iron Ore.—Small shipments of iron ore were reported in the State by four operators. Direct iron ore shipments were made from Standard Industrial Minerals Inc.'s Tecopa (Beck) Mine and CalMat Co.'s Baxter Mine, both in San Bernardino County. P. W. Gillibrand Co. produced concentrates at its Soledad Canyon sand and gravel operation in Los Angeles County, and Yuba Natural Resources recovered concentrates from sand and gravel operations in Yuba County. The Kaiser Steel Eagle Mountain operation in Riverside County was permanently closed.

Rare-Earth Minerals and Metals.—California's rare-earth markets experienced a decline in 1991, affected by the recession and strong competition from foreign sources. Molycorp Inc. mined bastnasite at its Mountain Pass open pit. Production of 16.5 tons (18,150 short tons) of rare-earth oxides in concentrate was reported by Mining Engineering, a decrease from the reported 22.7 tons (24,750 short tons) produced in 1990.

Silver.—Silver production was reported from 18 lode and 2 placer operations in the State, principally as a byproduct of gold production. Total output of 21 metric tons (665,835 troy ounces) valued at more than $3 million was similar to that of the previous year, but about 10% lower in value because of declining silver prices. Coca Mines Inc.'s Cactus Mine in Kern County and Homestake's McLaughlin Mine in Napa County were the largest silver producers in California; both were from byproduct gold mining.

Tungsten.—California was the sole U.S. producer of tungsten concentrates in 1990. U.S. Tungsten Corp., Bishop, CA, continued to be the principal company in California tungsten concentrates production. The Pine Creek

Mine and mill operated on an intermittent basis at levels below capacity to provide supplemental feedstock to the company's ammonium paratungstate conversion facility. Imported concentrate was the primary source of raw material.

Curtis Tungsten Inc., Upland, CA, was the only other company producing tungsten concentrate. The first concentrate delivered from the Andrew Tungsten Mine in the San Gabriel Mountains, north of Los Angeles, was announced in February 1990.

Other Metals.—California copper production resulted solely as a byproduct of tungsten refining at U.S. Tungsten Corp.'s Pine Creek Mine in Inyo County. Mercury production was practically nil, with less than one-half unit from Napa County, the only quantity reported sold during the year. All of the State's 1991 molybdenum production also was recovered as byproduct from U.S. Tungsten's Pine Creek operation. No lead or zinc production was reported in 1991.

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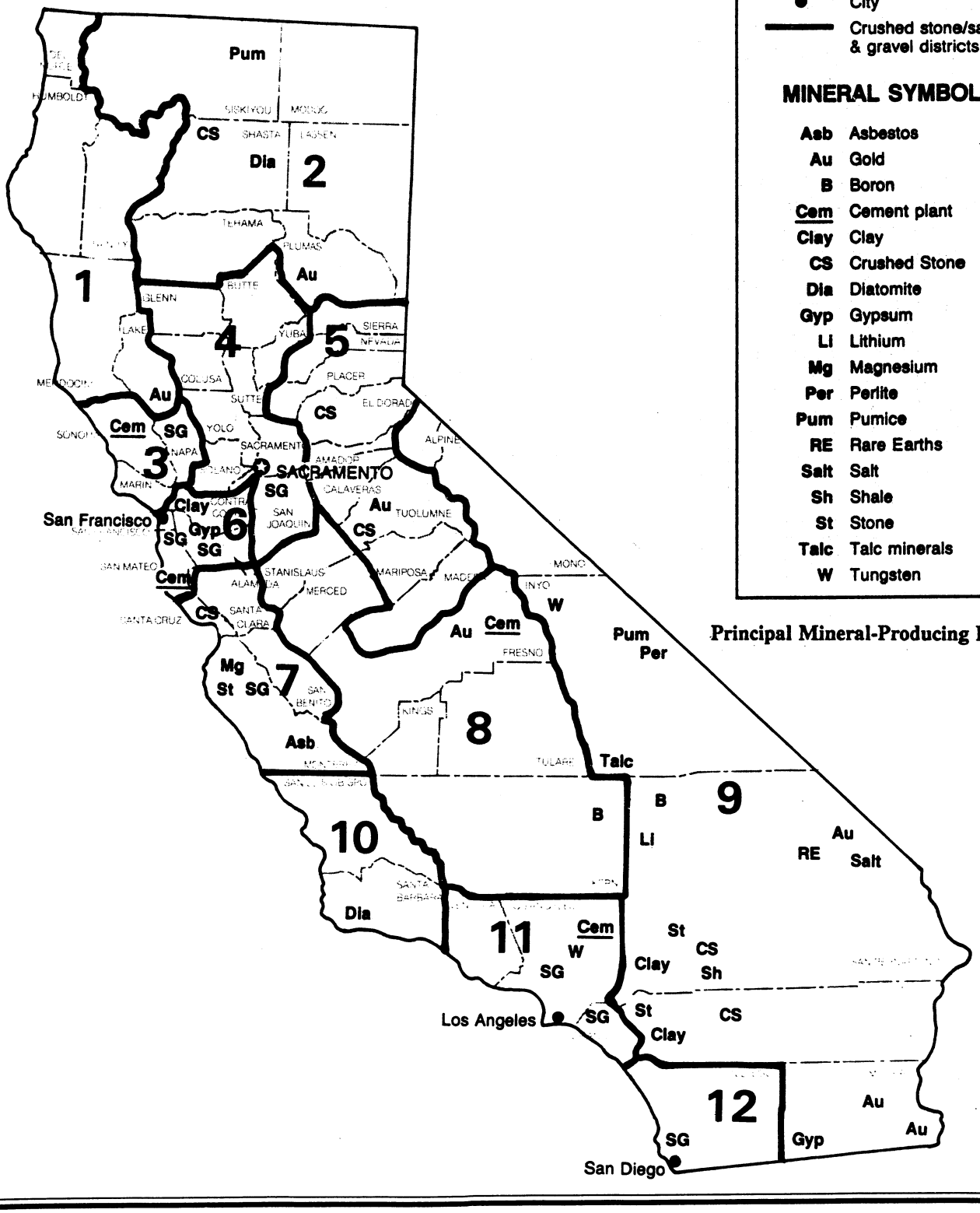
[1]State Mineral Officer, U.S. Bureau of Mines, Reno, NV. He has 26 years of mineral-related government experience and has covered the mineral activities in California for 10 years. Assistance in the preparation of the chapter was given by Marguerite Roberto, program assistant.

[2]State geologist, California Department of Conservation, Division of Mines and Geology, Sacramento, CA.

[3]Geologist, California Department of Conservation, Division of Mines and Geology, Sacramento, CA.

CALIFORNIA


LEGEND
State boundary
County boundary
Capital
City
Crushed stone/sand & gravel districts
MINERAL SYMBOLS
Asb Asbestos
Au Gold
B Boron
Cem Cement plant
Clay Clay
CS Crushed Stone
Dia Diatomite
Gyp Gypsum
Li Lithium
Mg Magnesium
Per Perlite
Pum Pumice
RE Rare Earths
Salt Salt
Sh Shale
St Stone
Talc Talc minerals
W Tungsten
Principal Mineral-Producing Localities
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SACRAMENTO
San Francisco
Los Angeles
San Diego
Pum
CS
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Au
Cem
SG
Clay
Gyp
Mg
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Asb
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Li
RE
Salt
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HUMBOLDT
SISKIYOU
MODOC
SHASTA
LASSEN
TEHAMA
PLUMAS
BUTTE
GLENN
LAKE
YUBA
SIERRA
NEVADA
COLUSA
PLACER
SUTTER
EL DORADO
YOLO
NAPA
SONOMA
MARIN
SOLANO
AMADOR
CALAVERAS
SAN JOAQUIN
TUOLUMNE
SAN MATEO
STANISLAUS
ALAMEDA
MERCED
MARIPOSA
MADERA
MONO
INYO
SANTA CRUZ
SANTA CLARA
FRESNO
SAN BENITO
KINGS
TULARE
SAN LUIS OBISPO
SANTA BARBARA
KERN

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Asbestos:			
Calaveras Asbestos Corp.	Box 127 Copperopolis, CA 95228	Surface mine and plant	Calaveras.
KCAC Inc.	Box K King City, CA 93930	do.	San Benito
Boron minerals:			
Kerr-McGee Chemical Corp[1]	Kerr-McGee Center Oklahoma City, OK 73125	Evaporators and plant	San Bernardino.
United States Borax & Chemical Corp.	3075 Wilshire Blvd. Los Angeles, CA 90010	Surface mine and plant	Kern.
Calcium chloride:			
Leslie Salt Co.,[2] a subsidiary of Cargill Inc.	Box 5621 Minneapolis, MN 55440	Solar evaporators	San Bernardino.
National Chloride Co. America	Box 604 Norwalk, CA 90650	do.	Do.
Cement:			
CalMat Co.[3]	3200 San Fernando Rd. Los Angeles, CA 90065	Plants	Various.
Mitsubishi Mining & Cement Co. (Kaiser Cement Corp.)	300 Lakeside Dr. Oakland, CA 94612	do.	Do.
Southwestern Portland Cement Co.[4]	Box 937 Victorville, CA 93292	Plant	San Bernardino.
Clays:			
Excel-Mineral Co., Inc.	Box 878 111 South La Patera Lane Goleta, CA 93116	Pits	Kern.
Gifford-Hill & Co. Inc.	Box 832 Riverside, CA 92592	do.	Do.
Riverside Cement Co.[5] (Beazer West Inc.)	Box 832 Riverside, CA 92592	do.	Various.
Lightweight Processing Co.	715 North Central Ave. Suite 321 Glendale, CA 91203	do.	Ventura.
Lincoln Clay Products Co.	Box 367 Lincoln, CA 95648	Pit	Placer.
Lone Star Industries Inc., Pacific Region, Santa Cruz plant[5]	11555 Dublin Canyon Rd. Pleasanton, CA 94566	Pit	Santa Cruz.
Port Costa Materials Inc.	Box 5 Port Costa, CA 94569	Pit	Contra Costa.
Diatomite:			
Grefco Inc.	3435 Lomita Blvd. Torrance, CA 90509	Surface mine and plant	Santa Barbara and Shasta.
Manville Products Corp.	2500 Miguelito Rd. Lompoc, CA 93436	do.	Santa Barbara.
Feldspar:			
California Silica Products Co.[6]	Box 249 31302 Ortega Highway San Juan Capistrano, CA 92693	do.	Orange.
U.S. Silica Co.	3231 Oceanside Dr. Oceanside, CA 92054	Mine and plant	San Diego.
Gold:			
Gold Fields Mining Corp.[7]	HCR 75 Glamis 100 Brawley, CA 92227	Surface mine	Imperial.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Gold—Continued:			
Homestake Mining Co.[7]	650 California St. San Francisco, CA 94108	Surface mine and plant	Napa.
Gypsum:			
U.S. Gypsum Co.	Plaster City, CA 92269	do.	Imperial.
Lime:			
Chemstar Inc.[8]	901 Mariners Island Blvd. Suite 425 San Mateo, CA 94404	do.	Monterey.
National Refractories & Minerals Corp.	Box 1938 Salinas, CA 95039	do.	Do.
Perlite:			
American Perlite Co.	11831 Vose St. North Hollywood, CA 91605	Surface mine and mill	Los Angeles.
Pumice:			
U.S. Pumice Co.	20219 Bahama St. Chatsworth, CA 91311	Mine and mill	Mono.
Rare Earths:			
Molycorp Inc.	Union Oil Center 461 South Boylston St. Los Angeles, CA 91017	Surface mine	San Bernardino.
Sand and gravel (construction):			
CalMat Co.[9]	3200 San Francisco Rd. Los Angeles, CA 90065	Pits	Various.
Beazer West Inc.	Box 832 Riverside, CA 92502	do.	Do.
Owl Rock Products Co.	Box 330 Arcadia, CA 91006	do.	Do.
A. Teichert & Sons Inc., Teichert Aggregates	Box 15002 Sacramento, CA 95851	do.	Do.
Granite Construction Co.	Box 900 Watsonville, CA 95077	do.	Do.
Sodium compounds:			
Kerr-McGee Chemical Corp.	Box 367 Trona, CA 93562	Plant	San Bernardino.
Stone:			
Beazer West Inc.	Box 832 Riverside, CA 92502	Quarries	Various.
Tungsten ore and concentrate:			
U.S. Tungsten Corp., a subsidiary of Strategic Minerals Corp. (Stratcor)[10]	Route 2 Bishop, CA 93514	Underground mine and plant	Inyo.
Vermiculite (exfoliated):			
W. R. Grace & Co.	1114 Avenue of the Americas New York, NY 10036	Plants	Alameda and Orange.

[1]Also lime, potassium salts, sodium carbonate, and sodium sulfate.
[2]Also salt.
[3]Also clays, gypsum, and iron ore.
[4]Also clays.
[5]Also cement and industrial sand.
[6]Also industrial sand.
[7]Also silver.
[8]Also magnesium compounds.
[9]Also stone.
[10]Also molybdenum.

THE MINERAL INDUSTRY OF COLORADO

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Colorado Geological Survey for collecting information on all nonfuel minerals.

By Eileen K. Peterson[1] and James A. Cappa[2]

The value of nonfuel minerals produced in Colorado in 1991 was about $338 million, a decrease of more than 12% from the value of production in 1990, according to data reported to the U.S. Bureau of Mines. The continued effects of an economic slowdown on metal values were evident for copper, gold, lead, molybdenum, silver, and zinc. Unit values for sand and gravel also fell in 1991. Modest increases in values for cement, gypsum, lime, and crushed stone did not offset the declines in the metals sector of the nonfuel mineral industries. Nationally, the State fell from 23d to 31st in total nonfuel mineral value, and from 1.16% to 1.12% of the U.S. total. The principal minerals produced, in order of value, were construction sand and gravel, molybdenum, portland cement, crushed stone, and gold. Among the six metals produced, only gold showed an increase in quantity of production.

TRENDS AND DEVELOPMENTS

Business trends in Colorado continued to buck the national downward trend during 1991. Exports of Colorado manufactured goods rose 3.8% in 1991 to $3.38 billion. For the fifth year in a row, business failures in Colorado were down; the 1991 figure showed a 7% decrease from the number of failures in 1990.

Despite the Statewide economic upturn, the value of all minerals produced in the State in 1991 fell $126 million, with coal production alone accounting for $50 million of the decreased value. Colorado's nonfuel mining industry continued a downward trend that began in 1989, in both production and value. At the beginning of 1991, 25 of the Nation's major gold-producing companies had headquarters in Denver. By the end of the year, that number had fallen owing to company mergers and departures. When Hecla Mining Co. acquired CoCa Mines Inc., it closed the CoCa Denver office.

TABLE 1
NONFUEL MINERAL PRODUCTION IN COLORADO[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	265,435	$2,064	262,292	[2]$1,864	[2]263,866	[2]$1,964
Gemstones		NA	240	NA	66	NA	287
Gold[3]	kilograms	3,448	42,411	r2,357	r29,176	3,181	37,154
Peat	thousand short tons	W	412	W	W	W	396
Sand and gravel (construction)	do.	e25,300	e104,000	24,938	86,541	e26,400	e88,200
Silver[3]	metric tons	W	W	23	3,557	20	2,565
Stone:							
Crushed	thousand short tons	[4]7,261	[4]32,435	[4] e7,600	[4] e36,100	8,401	41,022
Dimension	short tons	5,310	398	e8,490	e1,394	W	W
Combined value of cement, clay (bentonite, 1990-91), copper, gypsum (crude), helium (Grade-A, 1990-91), lead, lime, molybdenum, perlite, sand and gravel (industrial), stone (crushed traprock, 1989-90), vanadium (1989-90), zinc, and values indicated by symbol W		XX	275,765	XX	227,586	XX	166,817
Total		XX	457,725	XX	386,284	XX	338,405

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" data.
[3]Recoverable content of ores, etc.
[4]Excludes certain stones; kind and value included with "Combined value" data.

Newmont Mining Corp. and Newmont Gold Co. laid off employees to cut operating costs. Newmont also considered a merger with American Barrick Resources Corp. of Canada to share operating costs at western gold mines. By yearend, however, the companies had dissolved merger talks. Several companies were attempting to diversify into nongold metals until gold prices rise, although other metal prices were not of much financial assistance. Other companies looked to industrial minerals for stability.

During the year, the State's newest and largest gold producer came on-line after a 4-year permitting process that included settling water disputes and continued opposition by some local residents and environmental groups. The San Luis gold mine was developed by Battle Mountain Gold Co. near Colorado's oldest town, San Luis, in Costilla County, one of the State's poorest economic regions. Costilla County had an unemployment rate of 12% compared with the State average of 5.4%. Battle Mountain expected 70% of the employees at the San Luis mine project to be hired locally.

Production of industrial minerals increased slightly with continued improvements in the commerical and private construction businesses. During 1991, 14,071 residential units valued at more than $1.5 billion were permitted for construction and 38 hotels valued at almost $68 million were permitted. Permitted commercial buildings were valued at $300 million. Work on the new Denver International Airport and Interstate 70 provided a strong base for commercial construction activity. Construction at the new Denver airport is expected to require 5.4 to 9.1 million metric tons (6 to 10 million short tons) of aggregate, 1.4 million metric tons (1.5 million short tons) of asphalt pavement, and thousands of cubic yards of ready-mix concrete.

EMPLOYMENT

In 1991, Colorado's mining employment, including coal and oil and gas production, totaled 19,400, down a little more than 2% from that of 1990. Nonfuel mining employment averaged 2,373 with an additional 1,008 people employed in mills and preparation plants. Coal mining and processing accounted for an additional 1,832 employees. Average annual pay for mining employees in Colorado was $45,078, a 5.9% increase from that of 1990.

Colorado led the Mountain-Plains States with an average annual pay level for all employment sectors of $23,981, a 4.7% increase in average pay over that of 1990. The average unemployment rate for 1991 was about 5.4% despite reaching a 17-year record-low unemployment rate of 4.3% at one point during the year.

In the 1990-91 academic year, Colorado School of Mines graduates' average starting salaries were $35,061, a 5.6% jump from the 1989-90 average starting salary. The number of organizations recruiting increased from 160 in 1989-90 to 174 in 1990-91. Placement of graduates had reached 85.5% at the end of May.

According to U.S. Department of Labor statistics, injuries reported from Colorado nonfuel surface and underground mines included 98 injuries resulting in lost workdays and 83 injuries not resulting in lost workdays during 3.6 million employee-hours worked. Coal mines in Colorado reported 1 fatality, 124 injuries resulting in lost workdays, and 69 injuries not resulting in lost workdays during 3.16 million employee-hours worked.

REGULATORY ISSUES

At least two Colorado counties passed new development regulations to protect natural areas and landmarks and examine compatibility with existing land uses when considering mining permits. The ability of the counties to enforce the new regulations and the probability of lawsuits were questions not fully answered during development of the regulations.

Paramount Communications Inc., former operator of the Eagle Mine at Gilman in Eagle County, was cited by the U.S. Environmental Protection Agency (EPA) for mine seepage into the Eagle River between 1989 and 1990. A $35 million cleanup of the Eagle River has been under way since 1988. A water-treatment plant along the Eagle River was replaced this year with a more efficient unit. The Eagle Mine was operated from about 1894 until 1981 with production of copper, gold, lead, silver, and zinc. In 1971, the mine was the Nation's second largest zinc producer; by 1977, the mine ceased producing zinc because of low zinc prices and depleted ore reserves. Limited production of other metals continued until 1981.

The U.S. Supreme Court let stand a ruling that barred Colorado from enforcing its $42 million cleanup plan for rivers and creeks polluted by releases from the Idarado Mining Co. mine near Telluride in San Miguel County. Although Colorado had a court approved cleanup plan for the Idarado site, it was not given authority to require implementation of the plan. The court let stand a ruling that only the Federal Government had the authority to seek such cleanup orders. Idarado had been doing remedial reclamation at the site pending outcome of a lawsuit filed by the State concerning natural resource damages.

The court decision also impacted the State's ability to force cleanup at the ASARCO Incorporated Globeville Smelter in Denver. During the year, Asarco paid Occupational Safety and Health Administration (OSHA) fines and agreed to improve safety conditions at the plant where workers had been exposed to higher than allowed levels of cadmium, lead, and tellurium. Earlier tests at the smelter indicated that almost 40% of the workers showed signs of cadmium poisoning. The Colorado Department of Health had filed a lawsuit against Asarco for cleanup of the Globeville area where past activities at the smelter have resulted in surface contamination of soils. Tests by the Colorado Department of Health found no evidence of heavy-metal contamination in neighborhood children.

With the onslaught of legalized gambling in Central City and Black Hawk in Gilpin County, the EPA and the

Colorado Department of Health moved forward with plans for hazardous waste cleanup in Clear Creek and Gilpin Counties. Three Superfund cleanup sites are within the city limits of Black Hawk and Central City and potential liability for cleanup had affected land sales in the cities. During the year, the agencies announced plans to collect discharge from the three Superfund sites and pipe it to a point below the local municipal wastewater-treatment plant. This action was proposed to lessen the risk of direct human exposure. Additional actions on these Superfund sites will be studied by the EPA. Owners of mine waste piles have 1 year to decide on remining and/or reprocessing the waste before they will be required to put in soil caps to seal the waste piles. Mine drainage and ground water at the Argo Tunnel, another Superfund site in Clear Creek County, will be processed through a traditional water-treatment plant to remove almost 544 kilograms (1,200 pounds) of heavy metals daily. Passive water treatment was recommended for the Burleigh Tunnel in Silver Plume. No action was planned for several other tunnels in the two-county area. Additional studies of inactive mine sites in the counties will be conducted in the future.

In Pitkin County, Aspen area residents continued to fight the EPA plans for a $13 million cleanup of the Smuggler Mine Superfund site. Residents believed the cleanup would cause health hazards rather than solve them. As a result of city council actions, the EPA has postponed the cleanup until at least 1993. The EPA also formally agreed not to sue area homeowners for cleanup costs associated with the proposed removal and replacement of topsoil the EPA claims is contaminated with lead.

Leadville area residents remain skeptical of EPA plans for cleaning up the Lake County town site. The EPA claims of health hazards from arsenic, cadmium, and lead in the soil were not believed by all residents. An attempt by the EPA to collect soil samples has been stymied by some residents refusing access to their property. Asarco, operator of the Black Cloud Mine southeast of Leadville, has spent about $20 million cleaning up discharge from the Yak Tunnel Superfund site even though the company has not operated in the drainage.

Uranium tailings cleanup in Grand Junction (Mesa County), Gunnison (Gunnison County), and near Rifle (Garfield County) started during the year. More tailings than were expected were found at the sites, and cleanup is expected to last longer than the 1994 deadline set by Congress. A new Department of Transportation regulation concerning the amount of picocuries per gram allowed before tailings are classified as hazardous materials rather than radioactive waste halted removal of the tailings in May. Movement of tailings with lower levels of radioactivity resumed in late summer.

The Nation's first new commerical hazardous-waste landfill in 7 years opened in southeastern Adams County near Last Chance. The Last Chance landfill began receiving hazardous wastes from a Superfund cleanup site the day it opened. Heavy metals and contaminated fluids were mixed with concrete dust and fly ash from powerplants and stored in lined pits.

The U.S. Bureau of Land Management (BLM) halted long-term leasing of landfill sites in Colorado following out-of-State court decisions that held the agency responsible for contamination of soils and underground water supplies related to a leased landfill site. Many of Colorado's small towns and counties have relied on the cheap BLM leases to fulfill landfill needs.

The BLM announced proposed new rules expanding reclamation bonding requirements for mining operations causing 2 hectares (5 acres) or less of surface disturbance per year. The new bonding requirements were intended to protect against unnecessary or undue degradation of the land and to ensure proper reclamation. Proposed bonding caps were $1,000 per 0.405 hectare (per acre) for exploration or $2,000 per 0.405 hectare (per acre) for mining activities.

A suit filed in Federal Court by land owners in Montezuma and Dolores Counties failed to gain them ownership of $500 million worth of carbon dioxide underlying their land. The suit had challenged what the 1914 Congress meant by "gas" when it passed the Homestead Law. A 10th U.S. Circuit Court of Appeals ruling that the deposits belong to the Federal Government was upheld.

A Federal judge ruled that the U.S. Government was not liable in the deaths of 15 miners in a 1981 Colorado coal mine explosion. Families of the miners had filed a suit against the Government for not enforcing regulations of the Mine Safety and Health Administration.

EXPLORATION ACTIVITIES

After completing a drilling program in 1990 and announcing plans to build a mill at Silver Cliff, Custer County, Tenneco Minerals dropped development plans and returned the property to Hecla Mining. The move is believed to have been part of a massive restructuring at Tenneco. In the same area, CoCa Mines identified two bulk tonnage silver deposits containing an estimated 5.3 million metric tons (5.8 million short tons) grading 68 grams of silver per metric ton (2.42 troy ounces per short ton).

Challenger Gold planned to renew exploration drilling on Baca Land Grant properties in Saguache County. Challenger Gold had suspended exploration work for 1 year to settle legal problems.

A BHP Utah-Caprock Corp. joint venture completed five drill holes on the Caprock property in North Park, Jackson County. Caprock reported resources of 297,500 metric tons (328,000 short tons) averaging 12.3% zinc and lead, with some copper and silver. Before the 1991 drilling, there was an indicated reserve of 719,000 metric tons (783,000 short tons) of 7% zinc plus copper, lead, and silver.

Canyon Resources Corp. and joint-venture partners have spent more than $4.4 million on exploration on their 9,550-hectare (23,600-acre) Tennessee Pass property in Lake and Eagle Counties. Both precious-metal and base-metal mineralization was discovered at several locations. Late in 1991, Canyon was attempting to find new joint-venture partners and renew exploration.

A $600,000 drilling program was completed by Teck Resources, a subsidiary of Vancouver-based Teck Corp., for titanium oxide in the Powderhorn Carbonatite Complex in Gunnison County. Teck plans to obtain bulk samples for metallurgical testing in 1992.

Kennecott Exploration Co. had an agreement with Energetics Inc. that allowed them the option to conduct exploration for gold in the Jamestown mining district in Boulder County, including some drilling. Kennecott also planned to drill seven test bores looking for copper, lead, silver, and zinc in the Spring Creek area of Gunnison County. U.S. Forest Service (Forest Service) approval of the application to drill was received in February.

LEGISLATION AND GOVERNMENT PROGRAMS

The U.S. Legislature passed H.R. 1182 allowing Pitkin and Eagle Counties to trade 526 hectares (1,300 acres) of patented mining claims owned by the counties for 53 hectares (132 acres) belonging to the Forest Service. The patented mining claims are in the White River National Forest near Aspen. Because title to the mining claims is unclear, the bill would give claimants on the counties mining patents 6 years, rather than the usual 18 months, to file claims under the Quiet Title Act. Final action on the bill is expected in 1992.

The State legislature enacted a number of bills affecting mineral development, including House bill 1115 that established new fees and fee structures for permit applications and annual inspections of mining operations in the State. House bill 1214 extended the income tax credit for purchases for Colorado coal until the year 2005. Senate bill 131 provides for a sales tax credit on mine equipment purchased in designated enterprise zones. Senate bill 177 requires concurrent reclamation on all noncoal mine sites, where feasible, and removed the financial warranty cap for operations between 0.8 and 4 hectares (2 and 10 acres) in size.

The U.S. Bureau of Mines Denver Research Center studied mine subsidence over abandoned underground mines in El Paso County to determine the extent to which remote-sensing techniques can be used to identify subsidence features. The Bureau and the Colorado School of Mines studied the use of an on-board computer and ultrasonic sensors to automatically guide an articulated dump truck.

A three-way land exchange in Colorado and South Dakota was completed between Homestake Mining Co., the Forest Service, and Summit County and several ski resorts. Homestake traded 5,261 hectares (13,000 acres) of land in Spearfish Canyon, Lawrence County, South Dakota, to the Forest Service for 351 hectares (868 acres) of Forest Service land in Summit County. Homestake then sold the Colorado land to resorts and Summit County for $8.5 million and received $2 million in timber credits from the Forest Service. The $10.5 million in compensations received by Homestake equals the appraised value of the land in South Dakota. Public pressure in South Dakota and new limits on mining in that area have made any mining in the area traded by Homestake nearly impossible.

A 6,761-hectare (16,707-acre) parcel of land formerly in the Pinon Canyon training site, Baca County, was signed over by the U.S. Army to the Forest Service. The area is known for one of the world's longest sets of dinosaur tracks. The land will be added to the Comanche National Grasslands to be administered by the Forest Service. The parcel is expected to be withdrawn from mineral development.

The Secretary of the Department of the Interior overruled a BLM recommendation to include the Handies Peak and Red Cloud Peak Wilderness Study Areas, Hinsdale County, in the Federal Wilderness System. The Secretary based the decision not to include the areas in the Wilderness System on U.S. Bureau of Mines and U.S. Geological Survey reports that the areas contained minerals estimated to be worth $4.9 billion, including copper, gold, lead, silver, and uranium.

Meanwhile, the Colorado Wilderness Act of 1991, which would add 259,000 hectares (640,000 acres) of wilderness in Colorado, was approved by the U.S. Senate Energy and Natural Resources Committee. By yearend, the bill had not been approved by the House.

The Solar Energy Research Institute (SERI) in Golden became a National Laboratory during the year. The new name for the facility will be the National Renewable Energy Laboratory (NREL). The lab will have an annual budget of $95 million, a staff of 500, and will be the only National Laboratory devoted to finding environmentally safer fuels and electricity. Research projects in 1991 included a solar-powered blast furnace and conversion of a closed nuclear powerplant to use natural gas and solar power. Coors Ceramics Co. and NREL have a $2.7 million research agreement to experiment with the manufacture of silicon carbide powder through the use of a solar-powered furnace.

During 1991, the Colorado Geological Survey (CGS) continued work on coalbed methane research in the San Juan and Sand Wash Basins. The CGS cooperated with the U.S. Geological Survey to continuously core drill two holes into the 26.6-million-year-old Creede Caldera to gain a better understanding of one of the most mineral-rich areas in the world. The CGS started work on a mineral occurrence map of the State. CGS also worked on the "Atlas of Major Rocky Mountain Gas Reservoirs" and a guide to "Gold Panning and Gold Placering in Colorado." The latter will complement the recent CGS publication "Gold Occurrences of Colorado." For fiscal year 1991-92, about $135,000, or 12%, of the Survey's budget came from Federal grants or contracts.

Reclamation work supervised by the Colorado Mined Land Reclamation Division included cleanup of mill and mine tailings and sealing a tunnel near St. Elmo in Chaffee County.

U.S. Bureau of Mines personnel at the Intermountain Field Operations Center in Denver continued work on accessing the mineral potential of Federal lands in Colorado. During the year, the first draft

of the 849,870-hectare (2.1 million-acre) San Juan National Forest report was submitted for review. The final draft study of columbium and tantalum in Colorado was in technical review. Fieldwork was completed and report work started on the Leadville 2° quadrangle, and a mineral investigation of the Lowry Air Force Base was begun.

An allotment grant of $148,000 from the U.S. Bureau of Mines was received by the Mining and Mineral Resources Research Institute at the Colorado School of Mines under provisions of Public Laws 98-409 and 100-483. The purpose of the institute is to coordinate and administer training and research in mining, mineral resources, minerals development, and mineral processing.

The Colorado School of Mines also received a $770,000 Federal grant to study computer models used in ground water management. The models will be used to show how water carries contaminants, including ground water contamination, from inactive mines.

According to the U.S. Minerals Management Service, Colorado received $54 million in 1991 as the State's share of revenues collected from mineral leases on Federal lands within the State, the third highest State share in the Nation. About 34% of Colorado's 26.9 million hectares (66.5 million acres) is public land.

The U.S. Office of Surface Mining Reclamation and Enforcement awarded a $1.1 million abandoned mine lands grant to the State to help reclaim abandoned mines and restore the surrounding land and water to their natural state.

FUELS

Colorado coal mines produced about 1.8% of the Nation's total coal production in 1991. Twelve underground and 5 surface coal mines produced about 16 million metric tons (17.74 million short tons) of coal, down from 17.3 million metric tons (19.1 million short tons) in 1990. Colorado's coal reserves, about 15.4 billion metric tons (17 billion short tons), underlie about 28% of the State and represent the eighth largest demonstrated coal reserve in the Nation.

During 1991, Mid-Continent Resources Inc.'s underground Coal Basin Mine near Redstone, Pitkin County, closed permanently after 34 years of operations. Mid-Continent could not find a buyer for the financially troubled mine, and 433 employees were let go in February. Cyprus Minerals Co. sold a 15% equity interest in its Orchard Valley Mine near Paonia, Delta County, to Mitsubishi Corp. of Japan. KN Energy sold the Golden Eagle Mine near Trinidad, Las Animas County, to Entech Inc., a wholly owned unit of Montana Power Co. A proposed coal mine near New Castle, Garfield County, is still on hold, facing permitting problems and a company bankruptcy. The proposed mine was designed for hydraulic mining.

The Colorado Oil and Gas Commission reported 1991 oil production at 31.2 million barrels. Total natural gas production was 295 million cubic feet; 247.5 million cubic feet was conventionally produced gas and 47.5 million cubic feet was coalbed methane. Carbon dioxide production reported to the commission was about 278.9 million cubic feet. Oil and natural gas well completions during the year dropped almost 16% from 1990 levels.

Oil shale production in Colorado suffered severe setbacks in 1991. The last oil shale project in western Colorado closed in June when Unocal Corp. shut down a $650 million oil shale production facility, idling about 700 workers in the Parachute area of Garfield County. The plant operated for almost 5 years and produced about 4.5 million barrels of synthetic crude. The plant, however, never reached the minimum production levels needed to be financially viable. Oil production from the plant had been guaranteed by the Federal Government for 10 years, through 1992. In January, Occidental Petroleum Corp. announced its withdrawal from a proposed $200 million oil shale demonstration project near Meeker, Rio Blanco County. The proposed project would have employed about 200 people on a permanent basis.

Late in the year, Congress imposed a 1-year moratorium on the sale of prime oil shale land in Colorado. Colorado's congressional delegation had requested the moratorium fearing the land would be sold and never used for oil shale development. The sale of about 97,128 hectares (240,000 acres) in Colorado and Utah was halted.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Copper, Lead, Silver, and Zinc.—In 1991, each of these metals was produced as a byproduct of gold production at one or more of the gold mines operating in Colorado. Production of copper, lead, silver, or zinc was reported in Costilla, Gilpin, Lake, Rio Grande, San Juan, and Teller Counties. Compared with 1990 production figures, copper fell more than 34%, lead fell about 12%, silver rose about 16%, and zinc fell 12%.

Asarco and Resurrection Mining Co. continued to produce 770 to 816 metric tons of ore per day (850 to 900 short tons per day) at the 9,070-metric-ton-per-day (1,000-short-ton-per-day) capacity Black Cloud Mine and mill near Leadville, Lake County. Average ore grades were 2.4 grams of gold per metric ton, 52.4 grams of silver, 3.64% lead, and 7.87% zinc.[4] Asarco's annual report for 1991 indicated 5,806 metric tons (6,400 short tons) of contained lead, 13,427 metric tons (14,800 short tons) of contained zinc, 414 kilograms (13,300 troy ounces) of gold, and 9,952 kilograms (320,000 troy ounces) of silver were produced from the Black Cloud Mine in 1991. The mine and mill complex employees 160 people.

Monument Resources, of Castle Rock, Douglas County, negotiated with Homestake and State officials during the year concerning the possible purchase of Homestake's Bulldog Mountain silver mine above Creede, Mineral County. The mine was placed on standby in 1985; silver prices in recent years have not provided an incentive to reopen the mine.

Gold.—Total gold output in the State rose almost 36% from that of 1990 despite mine closures and temporary shutdowns. Gold production was reported to the U.S. Bureau of Mines from six mines, one each in Costilla, Gilpin, Lake, Rio Grande, San Juan, and Teller Counties. The Summitville Consolidated Mining Co. (Galactic Resources Ltd.) Summitville Mine in Rio Grande County reported the largest production, followed by the Battle Mountain Gold Co. San Luis Gold Mine in Costilla County.

Colorado's newest and largest gold producer, the San Luis Gold Mine in Costilla County, came on-line in 1991. Opening of the mine followed a State Water Judge's decision, late in 1990, that allowed Battle Mountain Gold to use water formerly designated for agricultural use. The $54 million mining and milling operation came on-line in late April, and the first bar of gold was poured in May. The operation is expected to employ about 100 people, including about 80 from the Costilla County area, when the operation is at full production. Battle Mountain can run 4,535 metric tons (5,000 short tons) of ore per day through its milling operation. Gold production is expected to reach 1,897 kilograms (61,000 troy ounces) per year. The mining and milling operations are expected to last 7 to 10 years.

The San Luis mining property was mined in 1890 for lead and silver. Asarco leased the property in 1931 and 1959, and Inspiration Consolidated Copper Co. leased it in 1968. Earth Sciences Inc. (ESI) of Golden, CO, leased the property in 1972 and delineated two ore zones. Battle Mountain optioned the property from ESI in 1987 and exercised its option that same year with ESI retaining a 3.5% interest.

Total minable reserves at the San Luis project are estimated at 10.98 million metric tons (12.1 million short tons) of ore grading an average 1.13 grams of gold per metric ton (0.04 troy ounce per short ton). The deposit contains an estimated 13,219 kilograms (425,000 troy ounces) of recoverable gold. Production costs are estimated at $206 per troy ounce. The project is a typical open pit mining operation with two pits being worked 24 hours per day. The carbon-in-leach milling plant has a rated capacity of 4,463 metric tons (4,920 short tons) per day and was recovering 92% of the gold when production started in May. Tailings from the milling operation are treated with sulfuric acid to liberate and volatilize the cyanide and are pumped to a lined 81-hectare (200-acre) impoundment with an underdrain system that returns water to the mill for reuse.[3]

The Summitville Gold Mine in Rio Grande County continued to be plagued by environmental problems in 1991. Galactic Resources (parent company of Summitville Consolidated Mining) reported continued operating losses resulting from both a cracked cyanide leach pad, first detected in 1989, and low gold prices. A crack in the dike containing cyanide leaching solution resulted in the heap-leach operation being shut down for most of 1989, and a change in mining contractors resulted in less ore being placed on the leach pad and lower than expected gold recoveries in 1990. In March 1991, Galactic Resources decided not to resume mining operations at Summitville because of ongoing environmental and gold recovery problems that resulted in gold production in 1990 of only 50% of that expected. By May, the company had decided the mine would operate for one more summer to recover about 907,000 metric tons (1 million short tons) of gold bearing ore. In November, the State Department of Health confirmed there had been at least two more cyanide leaks from the leaching operation and some fines were assessed. Mining was completed in October but leaching operations were expected to continue into 1992. Summitville was the largest gold producer in Colorado prior to startup of the San Luis project in Costilla County.

A 1990 decision by Echo Bay Mines Ltd. to write off its entire investment in the Alta Bay joint-venture Sunnyside Mine in San Juan County was seen by some as an indication of things to come in 1991. Indeed, in January, the San Juan County Mining Venture operators laid off 25 people employed at the underground mine where copper, gold, lead, silver, and zinc had been mined for a century. Factors affecting the layoff included increased costs from vendors and smelters, increased cost of employees benefits, and lower base metal prices. In May, the operators announced that because of continuing depressed metal prices the mine would be shut down in July with 137 of the remaining 148 employees being laid off. The remaining employees will perform minor maintenance and continue exploration. Closure of the mine was postponed until August to finish mining of some defined ore reserves. In November, Alta Gold relinquished its 40.2% effective interest in the Sunnyside Mine to Echo Bay in return for interest in four other properties. As a result of the mine closure, Silverton is expected to lose one-third of its residents and the county will lose 25% to 30% of its tax revenues.

In Teller County, better mining news came from the Cripple Creek mining district. During the 100th anniversary year of the discovery of gold in this district, the Cripple Creek & Victor Gold Mining Co. Joint Venture announced a major expansion in the company's reserves. Pikes Peak Mining Co. (subsidiary of NERCO Minerals Co.), with an 80% effective interest, and Golden Cycle Gold Corp. form the joint venture. NERCO acquired Texasgulf Minerals and Metals Inc. and its 64% share of the joint venture from Societe National Elf Acquitaine in August 1989. Later that year, NERCO phased out mining operations and concentrated on exploration because the venture had nearly exhausted its supply of gold ore. NERCO has reportedly spent $25 million in the past 2 years acquiring land in the Cripple Creek mining district and expanding operations.

Based on 45,720 meters (150,000 feet) of exploration drilling in 1990, the joint venture announced in January that they had substantial near-surface gold deposits in the district. According to Golden Cycle news releases, the Cresson deposit alone has almost 10 million metric tons (11 million short tons) at an average gold

grade of 1.3 grams per metric ton (0.047 troy ounce per short ton), with a 0.8 gram of gold per metric ton (0.03 troy ounce per short ton) cutoff, for a total of 15,987 kilograms (514,000 troy ounces) of contained gold. Additional gold reserves were identified in the Wildhorse, Ironclad, and Globe Hill deposits. NERCO estimated there was a total of 20,839 kilograms (670,000 troy ounces) in the Cripple Creek district. The company planned to do 91,440 meters (300,000 feet) of drilling in the district in 1991.

Accelerated mine planning and metallurgical activities were conducted in 1991 to determine the economics of mining the deposits. By April, the joint venture had announced plans to begin mine development and construction in May and begin ore production in August or September. About $7.5 million of mining equipment was immediately available from NERCO's idled Candelaria silver mine in Nevada. Mining operations started in June at the Globe Hill deposit. Crushing and leaching was initiated at a rate of 9,070 metric tons (10,000 short tons) per day, and a new 3.6-million-metric-ton-capacity (4-million-short-ton-capacity) leach pad was completed for $2.5 million and began receiving ore in December. Existing processing facilities for ongoing dump-leaching operations in the district provided a ready opportunity to start mining quickly. The existing work force of 55 will be expanded to about 140 as work progresses. The company expected to be processing ore at a rate of 1.36 million metric tons (1.5 million short tons) per year by the third quarter of 1991.

Late in 1991, the company announced that the Cresson ore body, the largest identified target in the district, had about 31,100 kilograms (1 million troy ounces) of contained gold. Dimensions of the deposit are approximately 1,524 meters by 610 meters (5,000 feet by 2,000 feet) and mineralization is open along length and at depth. Metallurgical tests indicated the deposits are amenable to heap leaching with an estimated recovery of 65%.

At yearend, the joint venture had an estimated 37,010 kilograms (1.19 million troy ounces) of contained gold reserves in the Cripple Creek mining district. Plans for 1992 included an additional 137,160 to 146,300 meters (450,000 to 480,000 feet) of drilling, including exploration of deeper targets. NERCO has an additional 3,400 kilograms (109,000 troy ounces) of contained gold at the company's 100%-owned Victory Mine in the same district.

In El Paso County, an attempt to recover gold from 13.15 million metric tons (14.5 million short tons) of crushed gold and silver ore in western Colorado Springs failed. Australia Pacific Minerals NL, spent $13.5 million buying the 116-hectare (288 acres) parcel and tailings in 1989. Golden Cycle had operated a mill on the site until 1949. Australia Pacific planned to recover 7,277 kilograms (234,000 troy ounces) of gold and 16.4 metric tons (528,000 troy ounces) of silver from tailings left on the old mill site. The company was unable to raise the needed funding for the proposed heap-leach recovery project and pay off a loan assumed when the company acquired the land and tailings.

During the year, Solution Gold Ltd. produced its first gold from reprocessing old mine tailings in the Central City area of Gilpin County. The company began building processing facilities in June 1990 and was producing gold in April 1991. Gold was recovered from old tailings and mine dumps, including the Kokomo and Druid Mines. Because the company is operating near the head of a watershed, removing hundreds of thousands of tons of acidic mine wastes is expected to improve water quality far downstream, to the pleasure of State and Federal agencies. The EPA was looking at the operation as one possible way to clean up mine wastes that are releasing acid mine drainage in Gilpin and Clear Creek Counties. A $95,000 Federal grant was awarded to Solution Gold for reclamation efforts at the company's current operation site. Solution Gold is heap leaching with cyanide to recover gold at a facility that can handle 226,795 metric tons (250,000 short tons) of material. The Gilpin County Commission approved company plans to install a second heap-leach pad. With about 33 employees, Solution Gold was the largest mining employer in the county.

Also in Gilpin County, Franklin Consolidated Mining Co. Inc. announced that Adonos Resources Inc., Toronto, Canada, would provide $850,000 to place the Franklin gold, silver, and base metal mine at Idaho Springs in production. Under the 50-50 joint-venture agreement, Adonos would act as operator of the mine. Mineral extraction will be by direct cyanidation of mill ore followed by flotation of lead and zinc.

Late in the year, it was announced that plans were under way for a new mill at the Two Brothers Mine, now being developed between Idaho Springs and Central City. The proposed mill would utilize gravity and flotation processes to recover gold, iron, lead, and zinc. Mine and mill developers have spent $3 million to develop the underground mining operation and plan to do some custom milling when the mill is operational. Much of the mill equipment will come from the Boodle Mill in Gilpin County. The Boodle Mill was closed partly because of insufficient quantities of water to operate after gambling interests acquired water rights in the Central City and Black Hawk areas.

Goldrush Mining Corp., Vancouver, Canada, was attempting to raise capital to dewater the Bates-Hunter Mine at the Golden Mile project near Central City, Gilpin County.

In Park County, Alma American Mining Corp. terminated its participation in the Alma London Ltd. Liability Co. that had been doing exploration at the underground London Mine. Control of the mine was returned to London Mine Venture, previous operator of the mine (jointly held by Boulder Gold Inc. and Cobb Resources Inc.). The joint-venture project included more than 426 meters (1,400 feet) of drifting and about 4,267 meters (14,000 feet) of core drilling. Alma American concluded the reserves developed during exploration would require higher gold prices to warrant reopening the mine, previously closed in 1989 after having been in production for

a little more than 1 year. Sixteen employees working at the mine were laid off by the closure. There are an estimated 320,000 metric tons (353,000 short tons) of in situ and surface stockpiled ore grading 4.8 grams of gold per metric ton (0.14 troy ounce per short ton) at the mine.[4]

Also in Park County, a proposed gliderport development was shelved after BLM records were reviewed. Antra Resources Corp. has had a mining claim on the same tract of land for 11 years. Antra has been surveying and sampling the site for placer gold and gravel extraction.

Molybdenum.—Both production and value of molybdenum fell again in 1991. Climax Molybdenum Co., a unit of Climax Metals Co. (subsidiary of AMAX), operated the Henderson Mine in Clear Creek County and the Climax Mine on the Lake and Summit Counties boundary.

After about 15 years of operations at the Henderson Mine, Climax was nearing completion of a $40 million modernization of the mining and milling operations undertaken to reduce costs and improve productivity. The ongoing modernization project has resulted in a reduction of workers needed, a reduction by 50% of operating costs, and a dramatic improvement in safety performance. The upgrades are expected to be completed in 1992.

Plans to expand operations at the company's Climax Mine in 1991 were put on hold and underground operations were suspended as planned in May. Open pit mining was to resume in the fall of 1991; however, the date was revised to late 1993. During the year, ore processing facilities at the Climax Mine were consolidated and redesigned for a 22,680-metric-ton-per-day (25,000-short-ton-per-day) capacity. Despite closing the underground operations, about 200 people continued to be employed at the mine complex where reclamation work was under way.

Lake County officials learned during the year that a 5th Judicial District judge had ruled in favor of Climax in a tax refund case. The county owes the company a $2.2 million tax refund for excess property taxes collected on the Climax Mine.

Climax received the 1991 Colorado Environmental Engineering award for significant environmental improvements at the company's Keystone Mine in Gunnison County. Climax acquired the property in 1977 after finding a large deposit of molybdenum. The property is inactive, and Climax spent $1.6 million to stabilize tailings in the area and $11 million to install a water-treatment plant to restore Coal Creek. The mine had been operated by various companies since 1880 for copper, gold, lead, silver, and zinc.

Vanadium-Uranium.—Umetco Minerals Corp. temporarily closed two mines in Colorado; the Sunday Mine near Naturita, Nucla County, and the Dove Creek Mine near Dove Creek, Dolores County. The mines were put on standby basis until the company decides if they will be reopened. Low uranium prices and an influx of cheap foreign uranium were blamed for the mine closure. Umetco is a wholly owned subsidiary of Union Carbide Co.

Other Metals.—Golden Aluminum Co., a subsidiary of the Adolph Coors Co. of Golden, operated an aluminum rolling mill in Fort Lupton, Weld County. The plant used patented technology to manufacture aluminum sheet for rigid packaging. The company was formed to capitalize on the parent company's expertise in aluminum can manufacturing and recycling. The Fort Lupton mill was upgraded during 1991 and operated at full capacity, 31,752 metric tons (70 million pounds) annually, for most of the year.

CF&I Steel Corp., Pueblo, filed for chapter 11 bankruptcy protection in late 1990 citing problems funding the company's pension plans. The plan reportedly was underfunded by $142 million. CF&I received $10 million in financing from Congress Financial Corp. to cover unforeseen cash requirements. Continued decreased demand for steel products in the rail and energy industries resulted in net losses in excess of $15.7 million for the Pueblo steel mill in 1991.

Asarco has operated the Globe Smelter in north Denver for more than 100 years. In 1991, Asarco recovered cadmium as a byproduct of the extraction and refining of zinc metals from sulfide ore concentrates.

Industrial Minerals

The State's industrial minerals sector manufactured (cement) or produced 13 different industrial minerals in 1991. The top three, in terms of value, were (1) construction sand and gravel, (2) portland cement, and (3) crushed stone.

Cement.—Cement production was estimated to have risen only slightly in 1991. Holnam Inc. operated a dry-process plant at Laporte, Larimer County, that produced portland cement and a wet-process plant at Portland, Fremont County, that produced both portland and masonry cement. Southwestern Portland Cement Co. operated a dry-process plant at Lyons, Boulder County, that produced both portland and masonry cements.

During 1991, Holnam started cement production at a second kiln at the company's Portland plant to add 154,000 metric tons (170,000 short tons) of cement production at that plant. The second kiln was put back in operation because of the increased demand for cement. Holnam recently completed updating computer automation at the Portland Cement Plant.

Holnam absorbed Denver-based Ideal Basic Industries in a 1990 merger, and Anschultz Corp. filed a suit against the company in 1991 over alleged wrong doing during the merger. Anschultz is a minority shareholder of Holnam and Ideal.

Clays.—Clay production rose slightly in 1991 but did not recover to 1989 production levels. Production of common clay, fire clay, and bentonite clay were

reported from one or more of the following counties: Boulder, Douglas, El Paso, Elbert, Fremont, Jefferson, and Pueblo. The clays were used as waterproof sealants, common and face bricks, and in mortar and cement manufacturing.

Western Aggregates Inc., a subsidiary of Inco United States (an operating unit of Inco Ltd., Canada), officially opened its new lightweight aggregate plant near Boulder, Boulder County, in May. The 382,300-cubic-meter-per-year (500,000-cubic-yard-per-year) quarry and plant began production in January. Reserves at the quarry are believed to be adequate for 60 years of production. About 50% of the production is expected to be used in concrete block masonry, the rest in precast, prestressed, and ready-mixed concrete.

Gypsum.—Two companies continued to produce gypsum in Colorado. Both production and value of crude gypsum returned to 1989 levels. Colorado Lien Co. produced crude and byproduct gypsum in Larimer County, and Eagle Gypsum Products produced crude gypsum at a mine in Eagle County.

Eagle Gypsum produced wallboard at a plant opened in 1990 in Eagle, about 4.8 kilometers (3 miles) from the company mine. Some coarse gypsum from the mine is shipped by rail to cement plants in the State.

A proposed alabaster (a massive form of gypsum) mine between Carbondale and Redstone, in Pitkin County, drew opposition from environmental groups and some local residents. Pitkin County Commissioners had denied a special use permit for the proposed mine in the White River National Forest. The mine owner planned to file a lawsuit late in the year challenging the county's authority to control Forest Service land.

Lime.—Calco Inc. announced during the year that the company had completed acquisition and permitting of 100 years of high-grade chemical limestone reserves. Calco mined limestone and produced lime in Chaffee County.

Peat.—Four companies produced peat in three counties during 1991. Production fell slightly from 1990 levels at the mines in Boulder, El Paso, and Park Counties.

Perlite.—Grefco Inc. mined perlite in New Mexico and expanded it at a processing plant at Antonito, Conejos County. Persolite Products mined perlite near Rosita, Custer County, and operated an expansion plant near Florence, Fremont County. Production in 1991 fell slightly below 1990 levels. Sales were to the filter, plaster, concrete aggregate, low-temperature and cavity-fill insulation, horticulture aggregate, and filler industries.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only: data for odd-numbered years are based on annual company estimates. This chapter contains estimated data for 1989 and 1991 and actual data for 1990.

Estimated 1991 sand and gravel figures were up almost 6% from surveyed production figures for 1990. Construction activities at the new Denver International Airport are expected to be reflected in increased production figures in 1992. The four leading counties in sand and gravel production were Adams, El Paso, Larimer, and Weld. The major producers were Western Mobile Inc., Mobile Premix Co., and Cooley Gravel Co. Major uses were for road base, concrete aggregate, and asphaltic concrete.

Colorado sand and gravel producers continued to encounter strong opposition to planned expansions and even stronger opposition to any plans for new sand and gravel operations. Several new sand and gravel pits proposed in Jefferson County were facing long permitting processes during the year. Numerous permits for expansions of existing pits were denied by counties throughout the State.

Cooley Gravel (subsidiary of English China Clay) received an award from the Colorado Mined Land Reclamation Board for outstanding reclamation work at a former gravel operation near Morrison, Jefferson County. Cooley Gravel had mined gravel at the pit for 35 years before reclaiming the 260-hectare (640-acre) site for a golf course, recreational park, and wildlife habitat. In 1991, Cooley Gravel operated three mining sites, one each in Thornton, Sedalia, and Morrison. A proposal to expand the Thornton gravel mining operation was rejected by the Adams County Commissioners in 1991 because of incompatibility with neighboring land uses.

In Boulder County, a lawsuit over a proposal to expand a gravel mining operation went to the Colorado Supreme Court. The court ruled that State Board of Land Commissioners' decisions concerning use of State lands are subject to regulation by local authorities.

Western Paving Construction Co., a subsidiary of Western Mobile, operated a 30-car unit train to move gravel from Boulder County to hot-mix asphalt plants in the metro Denver area. About 362,880 metric tons (400,000 short tons) is moved each year between mid-April and November. Use of the unit train allows the company to move aggregate over a distance that would be prohibitive with truck haulage.

Industrial.—Three firms continued to produce industrial sand or gravel in Arapahoe, El Paso, and Larimer Counties. Production and value both decreased slightly from 1990 figures.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only: data for even-numbered years are based on annual company estimates. This report contains actual data for 1989 and 1991 and estimated data for 1990.

Crushed.—Stone production in 1991 rose more than 25% from the last surveyed year, 1989, and value increased almost $8.6 million from 1989 figures. The four leading counties, Boulder, El Paso, Jefferson, and Larimer, accounted for about 90% of the total tonnage.

TABLE 2
COLORADO: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch): Riprap and jetty stone[2]	252	1,234	$4.90
Coarse aggregate, graded:			
Concrete aggregate, coarse	1,029	5,371	5.22
Bituminous aggregate, coarse	368	2,047	5.56
Bituminous surface-treatment aggregate	W	W	5.07
Railroad ballast	W	W	5.55
Fine aggregate (-3/8 inch):			
Stone sand, concrete	W	W	3.75
Stone sand, bituminous mix or seal	538	1,701	3.16
Screening, undesignated	92	212	2.30
Coarse and fine aggregates:			
Graded road base or subbase	431	1,795	4.16
Unpaved road surfacing	W	W	3.74
Terrazzo and exposed aggregate	45	208	4.62
Crusher run or fill or waste	104	178	1.71
Other construction materials[3]	323	1,589	4.92
Agricultural:			
Agricultural limestone	39	374	9.59
Poultry grit and mineral food	30	345	11.50
Chemical and metallurgical: Cement manufacture[4]	766	4,149	5.42
Special: Mine dusting or acid water treatment[5]	60	609	10.15
Unspecified:[6]			
Actual	3,311	17,661	5.33
Estimated	1,012	3,551	3.51
Total[7]	8,401	41,022	4.88

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes granite, limestone, marble, miscellaneous stone, quartzite, sandstone, traprock, and volcanic cinder and scoria.
[2]Includes macadam and filter stone.
[3]Includes withheld amounts for coarse aggregate, graded, fine aggregate (-3/8 inch), and coarse and fine aggregates.
[4]Includes lime manufacture, flux stone, and sulfur oxide removal.
[5]Includes whiting or whiting substitute, and other fillers or extenders.
[6]Includes production reported without a breakdown by use and estimates for nonrespondents.
[7]Data may not add to totals shown because of independent rounding.

Major producers were Western Mobile, Cooley Gravel, and Continental Materials Corp. Most of the production was used for concrete aggregate and concrete manufacturing. Unit values ranged from $1.71 to $15.00 with an overall average of $4.88 per short ton. Crushed stone production included granite, limestone, marble, quartzite, sandstone, and volcanic scoria.

Castle Concrete, a subsidiary of Chicago-based Continental Materials Corp., worked with El Paso County and the State to determine what long-term reclamation will be required for three quarries the company operated in the Colorado Springs area. Two of the quarries were active in 1991. There was, however, strong local sentiment for closing the remaining quarries.

Colorado Aggregate Co., a subsidiary of Hecla Mining, mined volcanic scoria at operations in Costilla County. The scoria ranged in color from bright red to black and was used in landscaping products and gas grill briquettes.

Dimension.—Three firms quarried granite, marble, or sandstone in 1991; Colorado Watertown Corp., Colorado Yule Marble Co., and Loukonen Brothers Stone Co. Production was up significantly from 1990 with rough quarried blocks accounting for most of the production. Stone was quarried in Boulder, Gunnison, and Larimer Counties.

The historic Yule Marble Quarry, in Gunnison County, was reopened in late 1990 by Colorado Yule Marble. The initial annual production rate was about 3,537 cubic meters (125,000 cubic feet); at full production the quarry will produce about 7,080 cubic meters (250,000 cubic feet) of white marble. Two shifts of workers were quarrying the deposit 5 days per week. Six grades of marble were mined and trucked 67.6 kilometers (42 miles) to Glenwood Springs to a railroad siding. At the present rate of mining, reserves at the quarry could last 300 years. Marble from the quarry has been used at the Tomb of the Unknown Soldier, Lincoln Memorial, and the Colorado State Capital Building. The quarry had been closed since 1941.

Plans to mine a black marble deposit along Conundrum Creek, in the Maroon Bells-Snowmass Wilderness, near Aspen in Pitkin County, drew opposition from many groups. The mining claims cover about 190 hectares (472 acres) and were quarried from the early 1900's to the 1940's. The Forest Service determined an Environmental Impact Statement would be required and a special-use permit must be approved before mining can start.

Sodium Compounds.—In March, NaTec Resources Inc. of Houston began production in northwestern Colorado at the world's only nahcolite mining and processing operation. The plant has an annual production capacity of 113,400 metric tons (125,000 short tons) and processes naturally occurring sodium bicarbonate. The company uses in situ solution mining to recover nahcolite. The product is sold for use to reduce stack emissions of sulfur dioxide at coal-burning powerplants, including Public Service Co. of Colorado's Cherokee plant in Denver. NaTec holds Federal leases to about 3,320 hectares (8,200 acres) near

TABLE 3

COLORADO: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	(2)	1	W	W	—	—
Coarse aggregates, graded[3]	W	W	—	—	—	—
Fine aggregates (-3/8 inch)[4]	—	—	W	W	—	—
Coarse and fine aggregates[5]	W	W	W	W	—	—
Other construction materials	30	106	149	531	—	—
Agricultural[6]	—	—	(7)	(7)	—	—
Chemical and metallurgical[8]	(7)	(7)	(7)	(7)	—	—
Special[9]	(7)	(7)	(7)	(7)	—	—
Other miscellaneous uses	12	37	768	4,494	—	—
Unspecified:[10]						
Actual	—	—	—	—	—	—
Estimated	—	—	398	1,752	—	—
Total[11]	43	144	1,314	6,777	—	—

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	165	847	W	W	—	—
Coarse aggregates, graded[3]	997	5,496	W	W	—	—
Fine aggregates (-3/8 inch)[4]	440	1,486	W	W	—	—
Coarse and fine aggregates[5]	460	1,755	76	228	W	W
Other construction materials	—	—	817	3,669	49	213
Agricultural[6]	—	—	(7)	(7)	—	—
Chemical and metallurgical[8]	10	55	(7)	(7)	9	31
Special[9]	—	—	(7)	(7)	—	—
Other miscellaneous uses	—	—	96	860	—	—
Unspecified:[10]						
Actual	2,126	1,2429	1,184	5,231	—	—
Estimated	614	1,799	—	—	—	—
Total[11]	4,812	23,868	2,173	9,988	58	244

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap and jetty stone, filter stone.
[2]Less than 1/2 unit.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[5]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run (select material and fill).
[6]Includes agricultural limestone and poultry grit and mineral food.
[7]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[8]Includes cement manufacture, lime manufacture, flux stone, and sulfur oxide removal.
[9]Includes mine dusting or acid water treatment, whiting or whiting substitute, and other fillers or extenders.
[10]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[11]Data may not add to totals shown because of independent rounding.

Rifle, Garfield County, with more than 77 million metric tons (85 million short tons) of proven reserves of nahcolite.

Denison Resources Ltd. reportedly evaluated nahcolite resources in the Piceance Creek basin and proposed to build a plant in 1993. Production is expected to start in 1994.

Other Industrial Minerals.—Several industrial minerals mined in other States or countries were shipped to Colorado for processing into higher value products or to be used in the manufacturing of other consumer products.

Nitrotec produced Grade-A helium at its plant near Burlington, Kit Carson County, but did not produce liquefied helium. Production was up slightly from that of 1990. Conoco Inc. produced sulfur as a byproduct of petroleum refining in Adams County. U.S. Zeolites processed zeolites mined in Wyoming at a plant near Fort Collins, Larimer County.

[1]Mining engineer, U.S. Bureau of Mines, Denver, CO. She has 16 years of mineral-related work with the government. Assistance in the preparation of the chapter was given by Pat LaTour, editorial assistant.
[2]Chief, Minerals and Mineral Fuels, Colorado Geological Survey, Department of Natural Resources, Denver, CO.
[3]Rocky Mountain Paydirt. May 1991, pp. 4A-6A.
[4]Mining Engineering, May 1992, p. 430.

TABLE 4
COLORADO: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989[1]				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	24	4,157	$14,686	$3.53	18	3,175	$13,863	$4.37
Marble	—	—	—	—	1	W	W	5.13
Granite	5	1,809	8,936	4.94	9	4,353	22,766	5.23
Traprock	—	—	—	—	1	W	W	4.29
Sandstone and quartzite	6	266	1,283	4.82	9	369	1,558	4.22
Volcanic cinder and scoria	3	258	3,980	15.43	1	W	W	5.26
Miscellaneous stone	3	771	3,551	4.61	2	W	W	5.89
Total[2]	XX	7,261	32,435	4.47	XX	8,401	41,022	4.88

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Excludes traprock; withheld to avoid disclosing company proprietary data.
[2]Data may not add to totals shown because of independent rounding.

COLORADO

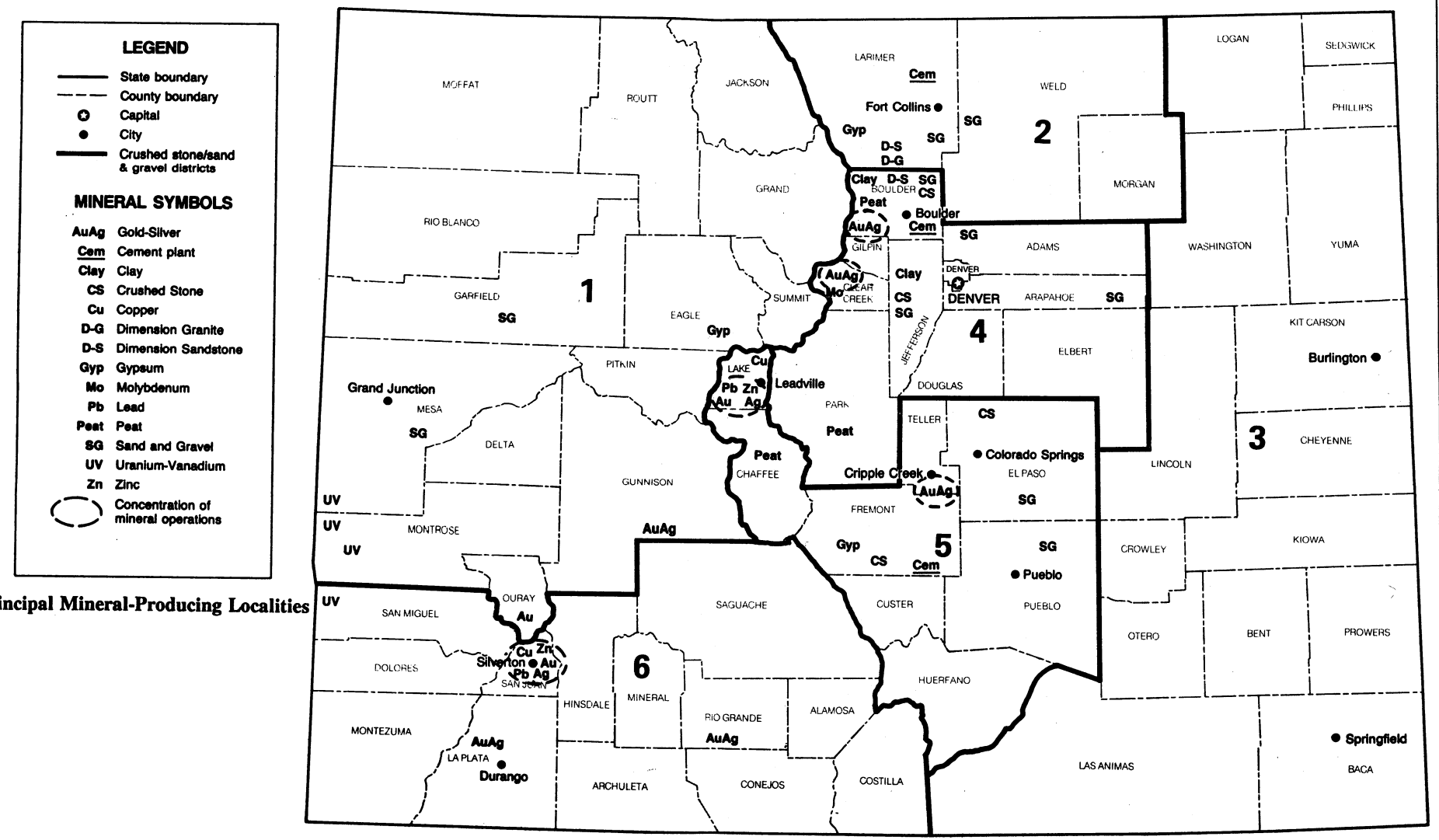
LEGEND
State boundary
County boundary
Capital
City
Crushed stone/sand & gravel districts
MINERAL SYMBOLS
AuAg Gold-Silver
Cem Cement plant
Clay Clay
CS Crushed Stone
Cu Copper
D-G Dimension Granite
D-S Dimension Sandstone
Gyp Gypsum
Mo Molybdenum
Pb Lead
Peat Peat
SG Sand and Gravel
UV Uranium-Vanadium
Zn Zinc
Concentration of mineral operations
Principal Mineral-Producing Localities
MOFFAT
ROUTT
JACKSON
LARIMER
Cem
Fort Collins
Gyp
SG
D-S
D-G
WELD
2
LOGAN
SEDGWICK
PHILLIPS
MORGAN
Clay D-S SG
CS
BOULDER
Peat
AuAg
Boulder
Cem
GRAND
RIO BLANCO
GILPIN
ADAMS
WASHINGTON
YUMA
AuAg
Mo
CLEAR CREEK
Clay
CS
SG
DENVER
ARAPAHOE
SG
GARFIELD
SG
1
SUMMIT
EAGLE
Gyp
JEFFERSON
4
ELBERT
KIT CARSON
Burlington
PITKIN
LAKE
Cu
Pb Zn
Au Ag
Leadville
DOUGLAS
Grand Junction
MESA
SG
DELTA
PARK
Peat
TELLER
CS
Colorado Springs
EL PASO
3
CHEYENNE
LINCOLN
Peat
CHAFFEE
Cripple Creek
AuAg
SG
UV
GUNNISON
FREMONT
UV
MONTROSE
AuAg
Gyp
CS
Cem
5
SG
Pueblo
CROWLEY
KIOWA
UV
OURAY
Au
SAGUACHE
CUSTER
PUEBLO
SAN MIGUEL
Cu
Zn
Silverton
Au
Pb Ag
DOLORES
SAN JUAN
6
HINSDALE
MINERAL
RIO GRANDE
AuAg
ALAMOSA
HUERFANO
OTERO
BENT
PROWERS
MONTEZUMA
AuAg
LA PLATA
Durango
ARCHULETA
CONEJOS
COSTILLA
LAS ANIMAS
Springfield
BACA

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Holnam Inc.[1]	Box 8789 750 17th St. Denver, CO 80201	Plants	Fremont and Larimer.
Southwestern Portland Cement Co.[1]	1111 South Colorado Blvd. Denver, CO 80222	Plant	Boulder.
Clays:			
General Refractories Co.	600 Grant St., Room 3000 Pittsburgh, PA 15219	Pits	Pueblo.
Lakewood Brick & Tile Co.	1325 Jay St. Lakewood, CO 80214	Pits and plant	Fremont and Jefferson.
G. W. Parfet Estate Inc.	1213-1/2 Washington Ave. Golden, CO 80401	Pits	Jefferson.
Robinson Brick Co.	Box 5243 Denver, CO 80217	Pits and plant	Douglas, Elbert, El Paso, Jefferson.
Gold:			
ASARCO Incorporated[2]	Box 936 Leadville, CO 80461	Mine and mill	Lake.
Battle Mountain Gold Co.	Box 310 San Luis, CO 81152	do.	Costilla.
Cripple Creek & Victor Gold Mining Co.[3]	Box 191 Victor, CO 80860	Mine dump heap leaching	Teller.
Summitville Consolidated Mining Co. Inc., a subsidiary of Galactic Resources Inc.[3]	Box 2G Del Norte, CO 81132	Open pit, vat leaching, carbon-pulp plant	Rio Grande.
Sunnyside Gold Corp., a subsidiary of Echo Bay Mines Ltd.[2]	Box 177 Silverton, CO 81433	Mine and mill	San Juan.
Gypsum:			
Eagle Gypsum Products	Box 980 Gypsum, CO 81637	Mine and plant	Eagle.
Lime:			
Calco Inc.	Box 1044 Salida, CO 81201	do.	Chaffee.
The Western Sugar Co., a subsidiary of Tate and Lyle PC.	555 17th St. Denver, CO 80202	Plants	Morgan and Weld.
Molybdenum:			
AMAX Inc.	1707 Cole Blvd. Golden, CO 80401	Mines and mills	Clear Creek, Grant, Lake.
Peat:			
Hyponex Corp.	Box 586 Fountain, CO 80817	Bog	El Paso.
Universal Peat Sand & Gravel Inc.	1557 South Ingalls St. Lakewood, CO 80226	Bog	Park.
Perlite:			
Grefco Inc, Building Products Div.	Box 308 Antonito, CO 81120	Plant	Conejos.
Persolite Products Inc.	Box 105 Florence, CO 81226	Mine and plant	Custer and Fremont.
Sand and gravel:			
Construction:			
Cooley Gravel Co. (J. L. Shiely Co.)[1]	Box 5485 Terminal Annex Denver, CO 80217	Pits and plants	Adams, El Paso, Jefferson.
Elam Construction Co. Inc.	1225 South 7th St. Grand Junction, CO 81501	do.	Mesa, Moffat, Pitkin, Routt.

See footnotes at end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued:			
Construction—Continued:			
Albert Frei & Sons Associates	11521 Brighton Rd. Henderson, CO 80640	Pits and plants	Adams, Clear Creek, Garfield, Weld.
Western-Mobile Inc.[1]	Box 5183TA Denver, CO 80217	do.	Boulder, El Paso, Jefferson, Larimer, Pueblo, Weld, and others.
Industrial:			
Colorado Lien Co.	Box 1961 Fort Collins, CO 80522	Pit and plant	Larimer.
Colorado Silica Sand Inc.	Box 15615 Colorado Springs, CO 80935	do.	El Paso.
Stone:			
Crushed:			
Castle Concrete Co., a subsidiary of Continental Materials Corp.	Box 2379 Colorado Springs, CO 80901	Pits and plants	Do.
Dimension:			
Colorado Yule Marble Co.	1101 Village Road Suite A. Carbondale, CO 81623	Quarry	Gunnison.

[1]Also stone.
[2]Also copper, lead, silver, and zinc.
[3]Also silver.

THE MINERAL INDUSTRY OF CONNECTICUT

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the State Geological and Natural History Survey of Connecticut, Department of Environmental Protection, for collecting information on all nonfuel minerals.

By Donald K. Harrison[1] and Robert J. Altamura[2]

The value of nonfuel mineral production in 1991 was $90.8 million, a $27 million decline from that of 1990. This decrease was largely attributable to a drop in output of crushed stone and construction sand and gravel, the State's leading mineral commodities. The 1991 value was the lowest since 1986 when the value totaled $80.5 million. Other mineral commodities produced included clays, feldspar, mica, industrial sand, and dimension stone. Other mineral commodities, although not mined in the State, are either processed or refined in the State.

In addition to firms actually mining in the State, Connecticut businesses sent $32 million in supplies to western U.S. mining operations in 1991. These businesses were vendors who manufactured equipment, chemicals, parts, and other products used at the mine sites.[3]

EMPLOYMENT

In 1991, the average number of workers employed in the minerals extractive industries in Connecticut was 769.[4] This included 270 workers at sand and gravel operations, 253 at stone operations, and 13 workers at other nonmetal mines. All of the mines were surface operations. In addition, 233 employees worked at mineral-related mills and preparation plants in the State.[5]

LEGISLATION AND GOVERNMENT PROGRAMS

During the 1991 State legislative session, a number of bills related to the use of explosives were introduced. These bills (Senate bills 616, 618, 620, 624, and 625) would have had a negative effect on mining. They proposed requiring plans for the reclamation of land used by businesses that use explosives; lowering allowable seismic vibration from explosives used at quarries; authorizing municipalities to establish an indemnification fund to reduce damages caused by the use of explosives; establishing arbitration panels to hear complaints by property owners concerning the use of explosives; and requiring completion of a preblast survey prior to the issuance of any permit for use of explosives. All the bills were referred to the Public Safety Committee for Action where they died.

Another bill (H.B. 6414) that would have required the mandatory use of recycled materials on State construction projects failed in the Appropriations Committee.

During 1991, the Connecticut General Assembly approved transportation bonds totaling $419 million. Bond

TABLE 1
NONFUEL MINERAL PRODUCTION IN CONNECTICUT[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gemstones		NA	$2	NA	$2	NA	$62
Sand and gravel (construction)	thousand short tons	e5,800	e24,700	8,542	37,943	e5,400	e24,800
Stone:							
Crushed[2]	do.	11,480	78,734	e10,200	e70,600	5,873	52,701
Dimension	short tons	W	W	W	W	17,326	1,739
Combined value of clays (common), feldspar, mica (scrap, 1990-91), sand and gravel (industrial), stone [crushed dolomite and other (1991), crushed granite (1989-90)], and values indicated by symbol W		XX	9,780	XX	9,348	XX	11,531
Total		XX	113,216	XX	117,893	XX	90,833

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain stones; kind and value included with "Combined value" data.

authorizations approved for highway and bridge projects included road resurfacing, $51.2 million; maintenance of State bridges, $159.5 million; interstate trade-in, $30.5 million; intrastate projects, $39.6 million; interstate projects, $28.3 million; and maintenance of bridges over railroads, $9.9 million. The Connecticut Department of Transportation budget also included $14.6 million for highway and bridge renewal and $30 million for the town and road fund. In addition, the General Assembly also approved sewer and water project bonds totaling $250 million. Both the transportation and sewer and water programs financed by the bonds will be helpful to Connecticut's construction aggregate industries, which rely heavily on a healthy construction industry.

The State Geological and Natural History Survey of Connecticut is the "research arm" of the Natural Resources Center of the State Department of Environmental Protection. The Director of the Center is also the State Geologist. The Survey continued the collection, interpretation, and distribution of information about the State's natural resources. Major efforts for the year included a continuation of the preparation of statewide earth science and biological maps. A principal effort was the continuation of work on statewide digital data sets for the Center's Geographic Information System (GIS).

Bedrock and surficial geological mapping was pursued through a cooperative program with the U.S. Geological Survey (USGS) Geologic Division and through a separately funded State program. Cooperatives with the USGS and the Minerals Management Service resulted in continued investigations of the Long Island Sound basin that included seismic profiling, sediment grab sampling, and interpretive mapping.

Work continued on a cooperative study with the Soil Conservation Service of the U.S. Department of Agriculture to digitize statewide soil maps for use in the GIS.

Through a cooperative effort with the USGS Water Resources Division, basic data collection of monitoring the quantity and quality of surface and ground waters, as well as water use, continued. Specific hydrological projects during the year included data collection and ground water modeling of two stratified drift aquifers for the purpose of protecting public water supply wells. In addition, the Survey's hydrologic group initiated a study of seasonal effects on stream-bottom infiltration near pumping centers. Precipitation continued to be monitored through a cooperative program with the National Oceanic and Atmospheric Administration, and drainage basins and lakes and ponds were digitized into the GIS.

A presentation of the results of a study on the evolution of mining and quarrying in Connecticut was presented at the Geological Society of America meeting held in Baltimore, MD.[6] An interdisciplinary geological investigation of an extremely large hydrothermal quartz deposit near the town of North Stonington continued.

The Connecticut State Geologist, together with the other New England State Geologists, investigated the future demand for construction aggregates—sand and gravel and crushed stone—in the six-State New England region. The aggregates demand study was initiated by the New England Governors' Council with funds provided by the U.S. Department of the Interior, Minerals Management Service. The study was the first of a two-part investigation to determine what potential difficulties may exist in establishing the availability of construction aggregates in New England. The first part of the investigation, which focused on aggregate demand and the problems faced by aggregate producers in opening new production facilities, was published in January 1992.[7] The second part of the investigation, which will focus on the location and quantities of sand and gravel deposits that are available for eventual development, will be initiated in 1992.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Calcium Metal.—Pfizer Inc. produced calcium metal at a plant in Canaan, Litchfield County. The company used the Pidgeon process in which high-purity calcium oxide and aluminum powder are compacted into briquettes and heated in vacuum retorts where the calcium metal is vaporized and collected in a water-cooled condenser.

Clays.—Two companies mined common clay and shale for use in manufacturing common and face brick. Production in 1991 was 10% higher than that in 1990. K-F Brick Co., a subsidiary of the Susquehanna Corp., mined Pleistocene glacial lake clay near South Windsor and Jurassic age shale near Suffield, both in Hartford County. In November, the Suffield Zoning and Planning Commission approved a permit extension for the company to continue its operations. The Michael Kane Brick Co., the State's other producer, operated an open pit mine in glacial lake clay in Middlesex County.

Feldspar.—At yearend, The Feldspar Corp., a wholly owned subsidiary of Zemux Corp., Asheville, NC, closed its Connecticut operations. The company, which began operating in the 1960's, operated three open pit pegmatite quarries and a froth flotation plant in the old Middletown Pegmatite District in Portland and Middletown, Middlesex County. In addition to the feldspar mined, the company also recovered byproduct mica and industrial sand. The company blamed the shutdown on factory closings in the glass manufacturing industry, which uses feldspar to add strength to glass and aids in the casting and firing of porcelain. Stiff price competition from Canadian rivals that imported nepheline syenite into the United States for feldspar extraction was another factor in the closing. In 1991, output of feldspar by The Feldspar Corp.

was down more than 30% from the previous year.

Gemstones.—Individual collectors and mineral clubs recovered gemstones in quarries and abandoned mine sites, primarily from pegmatites. The Middletown Pegmatite District in the central part of the State was one of the most popular gem-collecting sites. The queen of Connecticut's rare-metal mineral localities, the abandoned Strickland-Cramer pegmatite mines near Portland, was lost to collectors and students as a result of development. "Strickland" had been one of the most scientifically studied geologic deposits in the State.

Iodine.—Crude iodine was shipped to Connecticut by Uniroyal Chemical Co. Inc. at a plant near Middlebury, New Haven County. The crude iodine was used primarily to manufacture rubber, antioxidants, and organic chemical compounds.

Mica.—The Feldspar Corp. recovered scrap mica as a byproduct of feldspar mining operations in Middlesex, Middlesex County. Recovery of mica ceased at yearend because the company closed its feldspar mining and milling operations. The mica was sold as a filler and as an additive to well-drilling mud.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

In 1991, construction sand and gravel was the second leading mineral commodity produced and accounted for 27% of the State's mineral production value. Estimated output was 5.4 million short tons valued at $24.8 million. The estimated output in 1991 was 37% lower than that of 1990. The decline was largely attributable to the continuing depressed construction activity in the State.

Construction sand and gravel was produced by 63 companies from 67 operations in all 8 counties. Leading counties, in order of output, were Hartford, Litchfield, and New Haven. Major uses were for construction and roadbuilding.

Manchester Sand & Gravel Co. (MS&G), Manchester, was granted U.S. Bankruptcy Court permission to sell its Adams Street concrete plant to a Windham-based competitor. MS&G had filed for chapter 11 protection in July 1990, citing a downturn in the region's economy. Windham Sand & Stone will pay $1 million for the concrete plant and equipment of MS&G and $250,000 to MS&G for a noncompetition agreement. According to the agreement, for the next 10 years, the owner of MS&G agrees not to have an ownership interest in any company that produces ready-mix concrete in Manchester, East Hartford, South Windsor, Vernon, Glastonbury, Bolton, or Mansfield. In early January, MS&G received permission from the same court to sell its Enfield plant. The plant and several cement mixers were sold to Roncari Industries of East Granby (a major crushed stone producer in the State) for $800,000.[8]

In November, the Plainfield Planning and Zoning Commission unanimously voted to amend strict sand and gravel regulations that the same zoning board approved in 1990. The 1990 regulations lumped together existing grandfathered sand and gravel operations with those starting new businesses. The revised regulations grant those operations that existed before September 1972 the right to continue their operations without first obtaining commission approval. After the initial regulations were adopted, about 20 local sand and gravel operators had banded together and filed a lawsuit against the town contending that the regulations unfairly restricted their businesses.

In what is perhaps the first partnership of its kind in the State, a mining company, a municipality, and a private conservation organization have come together to preserve a rare ecosystem—one of only two glacial drawdown ponds along the entire length of the Connecticut River. When the last property in Glastonbury owned by the Newington-based Balf Co., a sand and gravel and crushed stone producer, is deeded to the town of Glastonbury in 1994, the Great Pond Preserve will encompass a 75-acre parcel of forested hillside, marsh, and pond. The pond's seasonally fluctuating waters provide critical habitat for a community of plants, reptiles, amphibians, and crustaceans. Balf also donated $25,000 to the Great Pond's conservancy stewardship fund, which provides money for managing the preserve. A company spokesperson for Balf indicated that the donations would mean that the company would forfeit profits from the millions of cubic yards of sand and gravel that it had once planned to mine at the site. However, despite the lost profit, the company felt mining the hill above the pond would be unconscionable.[9]

Industrial.—Two companies produced industrial sand in the State in 1991. U.S. Silica Co. of Connecticut quarried and processed hydrothermal quartz near Ledyard, New London County, and The Feldspar Corp. processed industrial sand as a byproduct of feldspar refining in Middletown, Middlesex County. Recovery of industrial sand by The Feldspar Corp. ceased at yearend because the company permanently closed its feldspar mining and milling operations in Connecticut. The plant provided industrial-grade glass sand to Anchor Hocking's Dayville glass plant in Windham County.

Stone.—Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Crushed.—Crushed stone was the State's leading mineral commodity produced and accounted for 58% of the State's total mineral value in 1991. Crushed stone production (predominantly

TABLE 2

CONNECTICUT: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch): Riprap and jetty stone[2]	19	165	$8.68
Coarse aggregate, graded[3]	973	14,979	15.39
Fine aggregate (-3/8 inch): Screening, undesignated[4]	3	19	6.33
Coarse and fine aggregate: Graded roadbase or subbase[5]	1,171	10,876	9.29
Unspecified:[6]			
Actual	1,462	10,441	7.14
Estimated	2,245	16,222	7.23
Total	5,873	[7]52,701	8.97

[1]Includes granite, limestone, and traprock, excludes a minor amount of dolomite and miscellaneous stone withheld to avoid disclosing company proprietary data.
[2]Includes filter stone.
[3]Includes concrete aggregate, coarse, and bituminous aggregate, coarse.
[4]Includes stone sand, concrete.
[5]Includes unpaved road surfacing, terrazzo and exposed aggregate, crusher run or fill or waste, and agricultural limestone.
[6]Includes production reported without a breakdown by use and estimates for nonrespondents.
[7]Data do not add to total shown because of independent rounding.

Jurassic-age basalt, which is commonly called traprock) declined by 43% from the estimated output in 1990. Crushed stone value also decreased by 25% over the same period. This decline was largely the result of a continuing building slump in the Northeast. In addition to traprock, limestone, marble, gneiss, quartzite, and granite were also quarried in the State for crushed stone. Crushed stone was mined in five of the State's eight counties. These counties, in order of decreasing output, were Hartford, New Haven, Litchfield, Windham, and New London.

The Connecticut Supreme Court in February overturned a lower court 1990 ruling that sided with three mining companies. In the 1990 ruling, the court ruled that the mining companies in Beacon Falls could bring crushed stone and sand and gravel to Beacon Falls from other towns for further processing. This ruling was the result of a lawsuit brought by the companies against a 1988 Beacon Falls Planning and Zoning Commission amendment that would have prohibited the companies from processing imported gravel. In the latest ruling, the Supreme Court ruled that because it could not be determined whether the processing of these materials was a principal nonconforming use, the town's ordinance was valid.

Early in the year, the East Granby Planning and Zoning Commission unanimously approved a zone change that allows Roncari Industries Inc. to plan a 64-acre addition to its quarry. The approval changed 87.3 acres of land that the company owns from an agricultural zone to a quarry zone. About 23 acres of the land will be left as a buffer around the crushed stone operation. In late 1990, the commission had rejected a company proposal to approve a zone change on 222 acres, which would have allowed the company to quarry for more than 50 years.[11]

Dimension.—Dimension granite was quarried in Hartford, Litchfield, New Haven, and Windham Counties, and dimension quartzite was quarried in Middlesex and Tolland Counties. The stone was sold as irregular-shaped stone, rough blocks, and cut stone.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related experience and has covered the mineral activities in Connecticut for the past 7 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]Geologist, State Geological and Natural History Survey of Connecticut, Department of Environmental Protection, Hartford, CT. Also at the Department of Geosciences, The Pennsylvania State University, University Park, PA.

[3]Fenton, R. Survey Shows Mining Law's Impact on Nonmining States. Am. Min. Cong. J., v. 78, No. 8, Aug. 1992, p. 7.

[4]"Average number of workers" is a summary of the average number of persons working at individual mining establishments during periods (not necessarily continuous) of active operations.

[5]U.S. Department of Labor, Mine Safety and Health Administration. Mine Injuries and Worktime Quarterly, Jan.-Dec. 1991, 33 pp.

[6]Altamura, R. J. Evolution of Mining and Quarrying in Connecticut. Geological Society of America Abstracts and Programs, v. 23, No. 1, 1991, p. 3.

———. Evolution of Mining and Quarrying in Connecticut: Permanent Exhibit on Display at the National Mining Museum and Hall of Fame, Leadville, CO, 1990.

[7]Construction Aggregates Demand in the New England States. The New England Governors' Conference Inc. in cooperation with Minerals Management Service, U.S. Department of the Interior, Boston, MA: The Conference (1992), 219 pp.

[8]Manchester Herald. MS&G Plant To Be Bought by Competitor. Feb. 1, 1991.

[9]Middletown Press. Unique Partnership Formed To Preserve Glacial Pond. Dec. 11, 1991.

[10]Hartford Courant. Zoning Change Approved. Jan. 23, 1991.

TABLE 3

CONNECTICUT: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991[1]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	6	W	W	$7.53	5	874	$7,672	$8.78
Dolomite	—	—	—	—	—	—	—	—
Granite	1	W	W	9.29	3	224	1,646	7.35
Traprock	10	9,720	$65,473	6.74	9	4,775	43,383	9.09
Miscellaneous stone	—	—	—	—	—	—	—	—
Total[2]	XX	11,480	78,734	6.86	XX	5,873	52,701	8.97

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Excludes dolomite and miscellaneous stone; withheld to avoid disclosing company proprietary data.
[2]Data may not add to totals shown because of independent rounding.

CONNECTICUT

LEGEND

State boundary
County boundary
Capital
City

MINERAL SYMBOLS

CC-Sh	Common Clay & Shale
CS	Crushed Stone
D-G	Dimension Granite
D-Q	Dimension Quartzite
Fel	Feldspar
Mica	Mica
SG	Sand and Gravel

Principal Mineral-Producing Localities

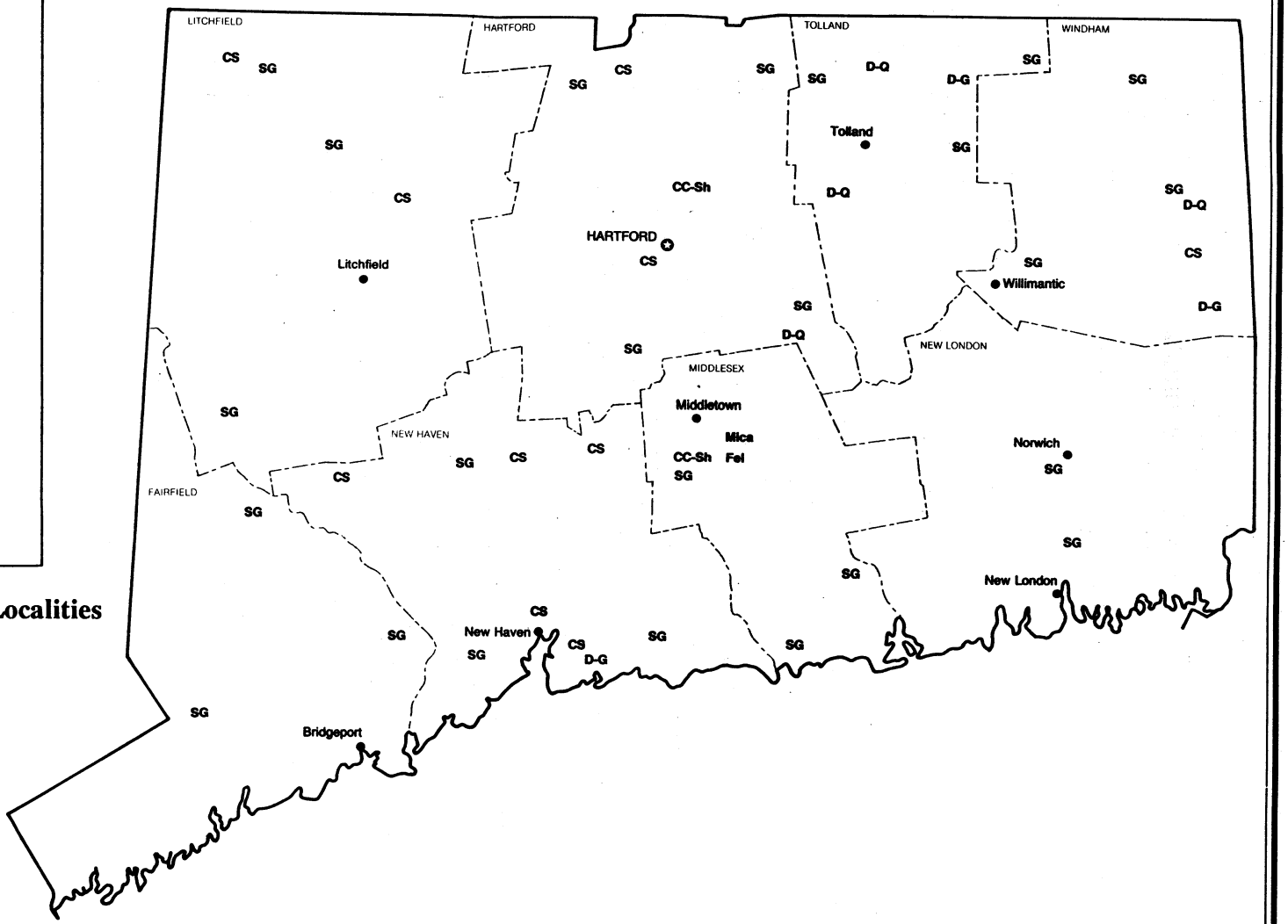

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
The Michael Kane Brick Co.	654 Newfield St. Middletown, CT 06457	Pit and plant	Middlesex.
K-F Brick Co.	Box 375 East Windsor Hill, CT 06028	do.	Hartford.
Feldspar:			
The Feldspar Corp.[1]	Box 99 Spruce Pine, NC 28777	Quarries and plant	Middlesex.
Sand and gravel (1990):			
Construction:			
Bakerville Lumber and Construction Co.	321 Maple Hollow Rd. New Hartford, CT 06057	Pit	Litchfield.
The Balf Co.	301 Hartford Ave. Newington, CT 06111	Pit	Hartford.
Connecticut Sand and Stone Corp.	7 West Main St. Plainville, CT 06062	Pit and plants	Hartford and Litchfield.
O&G Industries Inc.[2]	23 Casson Ave. Box 907 Torrington, CT 06790	Pit	Do.
R. A. Rawson Sand and Gravel Inc.	R.F.D. 1 Putnam, CT 06260	Pits and plant	Windham.
Industrial:			
U.S. Silica Co. of Connecticut	Box 187 Berkeley Springs, WV 25411	Pit and plant	New London.
Stone:			
Crushed:			
Allyndale Corp.	Box 265 East Canaan, CT 06024	Quarry	Litchfield.
The Balf Co.	301 Hartford Ave. Newington, CT 06111	do.	Hartford.
O&G Industries Inc.	23 Casson Ave. Box 907 Torrington, CT 06790	Quarries	Litchfield and New Haven.
Roncari Industries Inc.	1776 South Main St. East Granby, CT 06026	Quarry	Hartford.
Tilcon Tomasso Inc.	Box 67 909 Foxen Rd. North Branford, CT 06471	Quarries	Hartford, New Haven, Windham.
York Hill Trap Rock Quarry Co.	Westfield Rd. Meriden, CT 06450	Quarry	New Haven.
Dimension:			
Castellucci & Sons Inc.	99 Quarry Rd. Stony Creek, CT 06405	do.	Do.
R. B. Marriott & Sons Co.	Box 67 Oneco, CT 06373	do.	Windham.
Wayne C. Williams General Construction Inc.	110 Conklin Rd. Stafford Springs, CT 06076	do.	Tolland.

[1]Also crude mica and industrial sand.
[2]Also crushed stone.

THE MINERAL INDUSTRY OF DELAWARE

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Delaware Geological Survey for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.[1]

In 1991, Delaware produced about $5.1 million in construction sand and gravel. The State also produced magnesium compounds. Most of Delaware's mineral requirements were obtained from other States or imported from overseas.

A multimillion dollar road construction project in the Dover area boosted the State's economy. Sand and gravel mined in Delaware was used in the work. Crushed stone used in the project was shipped in from surrounding States.

TRENDS AND DEVELOPMENTS

The State's chemical industry and mineral manufacturing operations relied on out-of-State sources, both foreign and domestic, for raw materials. Some of the minerals used by these industries were received at the Port of Wilmington. In 1991, shipments received at the port increased for salt to 310,000 short tons from 268,000 tons in 1990 and for ilmenite ore from 53,000 tons to 56,000 tons. A drop in imports was reported for gypsum rock, from 364,000 tons in 1990 to 299,000 tons in 1991, and magnesite ore, from 44,000 tons to 38,000 tons. Also in 1991, about 29,000 tons of chrome ore and 39,000 tons of titanium slag were received at the port. Total cargo, including fuels received at the port, increased to 4.7 million tons from 4.5 million tons in 1990.[2]

The Delaware Department of Transportation continued work on a 12-year, $780 million program. In 1991, work on the Smyrna Bypass, the Dover Air Force Base Section, and a new bridge over the Chesapeake-Delaware Canal resulted in contract construction at an estimated cost of about $145 million. Delaware's sand and gravel industry, as well as construction aggregate producers in adjacent States, provided the raw materials used in this work. When completed, the new highway system was expected to relieve traffic congestion for motorists traveling to and from beach areas in southern Delaware.

In other developments, E. I. du Pont de Nemours & Co. increased output of chromium-dioxide magnetic particles at its Holly Run plant in Newport. The $5 million expansion project was expected to boost production capacity by 40% when completed in early 1992. Chromium dioxide was used as coating for audio, data, and video tapes.[3]

LEGISLATION AND GOVERNMENT PROGRAMS

Throughout the year, the Division of Water Resources (DWR) of the Department of Natural Resources and Environmental Control developed regulations governing extractive use operations. The new regulations, which were required by enactment of House bill 368 in 1990, authorized the DWR to develop, implement, and enforce regulations for the excavation of clay, sand, silt, gravel, and rock (stone) for the protection of ground water. The regulations were expected to be completed and finalized in 1992.

The Delaware Geological Survey (DGS) completed a report on the subsurface geology and hydrology near Lewes.[4] The publication focused on analyses of sedimentary rock samples, geophysical logs, and water samples from a 1,327-foot borehole that was drilled in the area. The DGS also continued a 4-year topographic mapping program with

TABLE 1
NONFUEL MINERAL PRODUCTION IN DELAWARE[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Gemstones		NA	$1	NA	$1	NA	$1
Sand and gravel (construction)	thousand short tons	e1,900	e6,200	2,184	6,967	e1,600	e5,100
Total[2]		XX	6,201	XX	6,968	XX	5,101

eEstimated. NA Not available. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Partial total, excludes values that must be concealed to avoid disclosing company proprietary data.

the U.S. Geological Survey for remapping the State.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Magnesium Compounds.—Delaware was one of only six States in the United States that produced magnesium compounds. Barcroft Co., a subsidiary of Rorer Group Inc., extracted magnesium compounds from seawater at a plant near Lewes. Output in 1991 declined by about 25% from that of 1990. Magnesium and aluminum hydroxides are used in the manufacture of antacid products and other pharmaceuticals.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

In 1991, an estimated 1.9 million short tons of construction sand and gravel was mined in Delaware. In the past 10 years, the State produced about 17 million tons of sand and gravel valued at $51 million. During that time, output ranged from a high of 2.3 million tons in 1987 to a low of 1.0 million tons in 1984.

In 1991, the DGS also reported an estimated production of about 7.7 million short tons of sand from State-owned lands. This output was used in the State Route 1 (SR-1) construction projects in the Dover and Smyrna areas (because this production was not reported to the Bureau, it was not included in table 1).

Metals

Steel.—CitiSteel USA Inc., owned by China International Trust & Investment Corp., continued its second year of operations at a mill in Claymont. The firm produced carbon plate steel at the mill formerly owned by Phoenix Steel Corp.

Reclaimed Metals and Materials.—The Delaware Solid Waste Authority, through a contract with Raytheon Service Co., operated a resource recovery plant at Pigeon Point, New Castle County. In 1991, about 245,000 short tons of municipal solid waste was processed at the facility. Recovered materials included 8,300 tons of ferrous metals and 670 tons of nonferrous metals (primarily aluminum).

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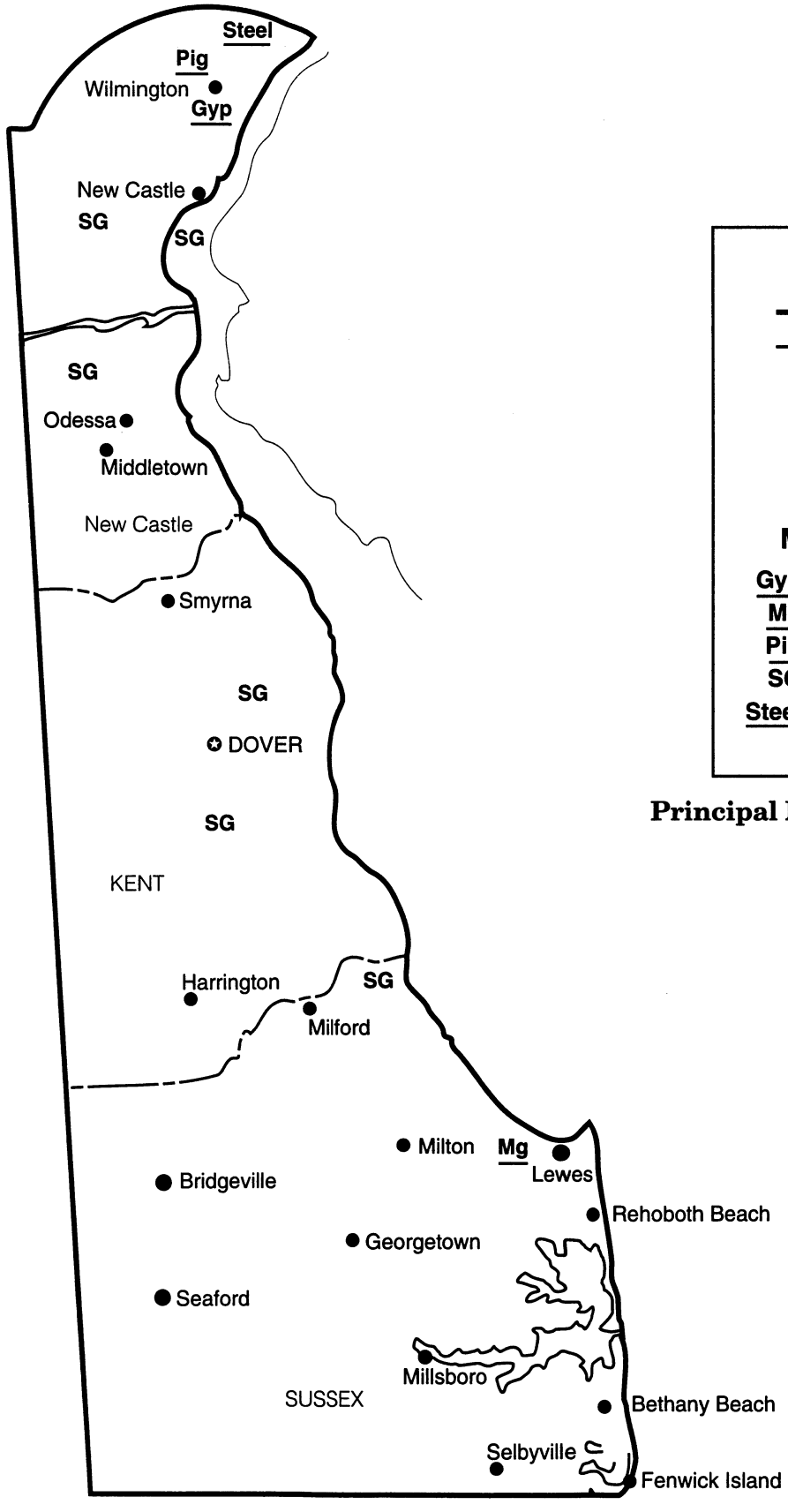
[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related and government experience and has covered the mineral activities in Delaware for 7 years. Assistance in the preparation of the chapters was given by Sally J. Stephenson, editorial assistant.

[2]Port of Wilmington, Delaware. Monthly Tonnage Report, June 1991. Port of Wilmington, P.O. Box 1191, Wilmington, DE 19899.

[3]American Metal Market. Plant Project Gets Go Sign From DuPont. V. 99, No. 93, May 5, 1991, p. 4.

[4]Benson, R. N., A. S. Andres, K. W. Ramsey, and J. H. Talley. Geologic and Hydrologic Studies of the Oligocene-Pleistocene Section Near Lewes, DE. DE Geol. Survey Report of Investigations 48, Newark, DE 19716, 34 pp.

DELAWARE



LEGEND

- State boundry
- County boundry
- Capital
- City

MINERAL SYMBOLS

Gyp	Gypsum plant
Mg	Magnesium metal plant
Pig	Titanium Dioxide pigments
SG	Sand and Gravel
Steel	Iron and Steel plant

Principal Mineral-Producing Localities

TABLE 2
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Gypsum (calcined):			
Georgia-Pacific Corp., Gypsum Div.	Wilmington Marine Terminal Box 310 Wilmington, DE 19805	Plant	New Castle.
Magnesium compounds:			
Barcroft Co.	40 Cape Henlopen Dr. Lewes, DE 19958	do.	Sussex.
Sand and gravel (construction):			
Contractors Sand & Gravel Co. Inc.	Box 2630 Wilmington, DE 19805	Pit	New Castle.
George & Lynch Inc.	113 West 6th St. New Castle, DE 19720	Dredge	Kent.
Parkway Gravel Inc.	4048 New Castle Ave. New Castle, DE 19720	Pit	New Castle.
Slaytons Sand & Gravel Inc.	Box P Felton, DE 19943	Pit	Kent.
Tilcon Inc.	Box 858 Dover, DE 19903	Pit	Do.
Steel:			
CitiSteel USA Inc.	4001 Philadelphia Pike Claymont, DE 19703	Mill (plate)	Do.
Sulfur (recovered):			
Texaco Inc.	Wrangle Hill Rd. Delaware City, DE 19706	Refinery (petroleum)	Do.
Titanium dioxide:			
E. I. du Pont de Nemours & Co. Inc.	1007 Market St. Wilmington, DE 19898	Corporate headquarters	Do.
Do.	Edgemoor, DE 19809	Plant (chemical)	Do.

[1]Also sand and gravel.

THE MINERAL INDUSTRY OF FLORIDA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Florida Geological Survey for collecting information on all nonfuel minerals.

By Doss H. White, Jr.[1] and Walter Schmidt[2]

In 1991, Florida's nonfuel mineral industry produced mineral commodities valued at $1.4 billion, a decrease of $172 million from the value reported to the U.S. Bureau of Mines in 1990. This was the second consecutive year that mineral sales declined. As a result of the recession, production and value of 7 of the 14 mineral commodities mined instate were lower than that reported for the previous year. Included were cement and stone, the second and third ranked commodities valuewise. Output rose while value fell for four commodities; included was phosphate rock, the leading commodity in terms of sales. Output declined but value increased for one, magnesium compounds, and both output and value increased for rare-earth metal concentrates and staurolite. Sales of the three leading commodities declined more than $115 million from the figures reported by industry in 1990.

The State continued as the world's leader in phosphate rock production and led the Nation in heavy-mineral output. Florida fell from fourth to fifth in total mineral value, but continued as the second leading State, behind California, in industrial mineral sales.

TRENDS AND DEVELOPMENTS

In 1981, Florida's mineral industry produced a record $1.7 billion of mineral commodities. Phosphate rock sales accounted for approximately 69% of the value, and the construction mineral commodities, cement, sand and gravel, and stone, accounted for an additional 28%.

Phosphate output fluctuated during the 1980's from 42.8 million metric tons in 1981 through a low of 29.7 million metric tons in 1986 to 36.2 million metric tons in 1991, according to the Florida

TABLE 1
NONFUEL MINERAL PRODUCTION IN FLORIDA[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Cement:							
Masonry	thousand short tons	477	$31,231	442	$27,777	e214	e$13,482
Portland	do.	4,357	207,857	3,954	186,404	e3,023	e142,081
Clays	metric tons	2563,687	246,941	2391,334	239,625	363,253	39,150
Gemstones		NA	W	NA	W	NA	6
Peat	thousand short tons	235	4,515	252	4,381	244	3,991
Sand and gravel:							
Construction	do.	e17,900	e55,500	18,472	59,123	e16,000	e51,400
Industrial	do.	681	7,768	520	7,024	551	5,989
Stone (crushed)	do.	83,995	341,397	e74,000	e317,400	359,132	3260,901
Combined value of clays (common), magnesium compounds, phosphate rock, rare-earth metal concentrates, staurolite, stone (crushed marl, 1991), titanium concentrates (ilmenite and rutile), zircon concentrates, and values indicated by symbol W		XX	913,054	XX	r924,788	XX	879,164
Total		XX	1,608,263	XX	r1,566,522	XX	1,396,164

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX. Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" data.
[3]Excludes certain stones; kind and value included with "Combined value" data.

Phosphate Council. Based on the average price per ton for Florida phosphate rock, the 1991 production accounted for about 60% of the State's total mineral value. In 1991, phosphate rock production increased 800,000 metric tons over the 1990 output, according to the Florida Phosphate Council, but the selling price declined. During the 1980's and early 1990's, price fluctuations by overseas producers and worldwide demand strongly influenced the selling price of Florida's phosphate rock.

The percentage of the State's total mineral value held by cement, sand and gravel, and stone increased from 1981 to 1987 when the sales of construction mineral commodities reached a record high, accounting for 46% of Florida's mineral value. The following year the trend reversed itself, and for 4 consecutive years the percentage of construction minerals in the State's total mineral picture has declined. In 1991, it fell to 34%. The decline was due to (1) the end of a booming construction period underway in the early to mid-1980's, (2) a soft real estate market due to overbuilding, and (3) the national recession. As ongoing construction projects were completed, construction employment began to decline in the fall of 1988 and continued into 1991.

Several developments, primarily phosphate related, were announced during the year. Farmland Industries Inc. sold one-half of its fertilizer operation and phosphate reserves near Bartow to Norsk Hydro, a Norwegian chemical manufacturer. Under the agreement, Farmland sold one-half interest in its Green Bay plant along with almost 8,000 acres of reserves at its proposed Hickory Mine in Hardee County. The new partnership will be named Farmland Norsk L.P. Norsk was also negotiating with Royster Chemical Co. to purchase the Tampa Bay ammonia terminal and pipeline. Royster filed for chapter 11 reorganization earlier in the year. Royster officials noted that the reorganization would have no effect on Royster's Mulberry fertilizer plant.

Consolidation Minerals Inc. withdrew its application to build a powerplant at its proposed mining and industrial operation in eastern De Soto County. Officials with Florida Power & Light refused to agree to purchase excess power from the facility.

IMC closed its Clear Springs Mine at the end of August, indicating that the mine was the least efficient of company operations. A company official noted that the mine could reopen in 1992.

In the metals section, E. I. du Pont de Nemours & Co. Inc. announced plans to expand its titanium mining activities near Starke. The expansion, scheduled for the Maxville property on the northern extension of the Trail Ridge deposit, was scheduled for completion in 1992.

In other metals activity, Florida Steel completed an expansion at its Tampa mill. The company installed a new three-strand billet caster.

EMPLOYMENT

Mining employment at the end of 1991 averaged 8,153 workers, down from the 8,916 reported at the end of 1990. Construction employment, 277,410 at yearend, was considerable lower than the 322,985 construction workers employed at the end of 1990.

REGULATORY ISSUES

Construction techniques for new gypsum stacks continued as a major issue between State officials and the phosphate mining companies. Approximately 500 million tons of byproduct gypsum from phosphate rock processing is stockpiled in Florida, the majority of which is in Polk County. The Federal Environmental Protection Agency announced that the ban against research into ways to safely use phosphogypsum would be lifted.[3]

LEGISLATION AND GOVERNMENT PROGRAMS

Although the 1991 Florida Legislature passed no bills that had a major impact on the State's mineral industry, it did take $27 million from the phosphate land reclamation trust fund. The action was taken to help the legislature balance the Florida budget. The trust fund, established in 1978, was financed with a portion of the taxes phosphate companies pay on the value of phosphate rock mined. When the legislature voted to take the $27 million, it agreed to pay back $23.7 million during a 3-year period beginning in 1993.

Legislation was introduced that would require the Florida Geological Survey (FGS) to create an advisory committee, including representatives from the oil industry, to review the old plugging design of oil wells abandoned prior to 1974. The review was intended to locate old wells with the potential to pollute underground sources of drinking water because of their antiquated plugging design. The committee was to review files and recommend a course of action, if any, to the 1993 legislature.[4]

FGS, an agency in the Department of Natural Resources is in Tallahassee. The survey maintains two oil and gas field offices in Fort Myers and Jay. The survey is divided into three sections: Geological Investigations, Mineral Resources and Environmental Geology, and Oil and Gas.

During the year, the survey completed several studies of interest to the mineral industry. These were published, either in full or abstract form, or placed on open-file. Included were studies on the sand, gravel, and heavy-mineral resource potential offshore between Cape Canaveral and the Georgia border and the mineral resources of Clay County and of Union and Bradford Counties.

Ongoing studies included investigations into sand, gravel, and heavy minerals offshore south of Cape Canaveral, shell-bearing units in southern Florida, and uranium associated with Florida peat deposits. Survey personnel were preparing a report on mines greater than 10 acres in the Suwannee River Water Management District and a geological assessment of the coastal wetlands processes of the Florida Big Bend. County mineral resource studies underway included those for Columbia, Hamilton, and Suwannee Counties. Also in preparation was an update of the

Industrial Minerals Directory of Florida and a Mineral Resources Map of Florida.

Personnel from the U.S. Bureau of Mines field office in Denver, CO, reviewed several environmental impact statements on Florida projects prepared by other Federal and Florida State agencies. The reviews were to ensure that mineral mining and processing facilities and mineral resources were adequately protected should the project(s) be addressed as proposed.

FUELS

In 1991, Florida ranked 20th nationally in petroleum and associated commodities production. The State's oil and gas industry produced 4,726,747 barrels of oil and 5,929,916 million cubic feet of casinghead gas. Approximately 62% of the oil and 86% of the gas came from the Jay Field.

Four dry holes, all in north Florida, were drilled, and a 130-mile gravity survey was permitted and conducted. At yearend, three seismic exploration permits for 13.5-line miles had been issued and one permit application for offshore gravity, magnetic, and seismic testing had been received.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

The State's mineral industry mined or manufactured 13 industrial minerals, and their sales accounted for more than 95% of Florida's mineral value. In 1991, the U.S. Mine Safety and Health Administration mine file for Florida contained a listing for 301 industrial mineral operations. The three leading commodities, in terms of tonnage, were stone, sand and gravel, and cement. The leaders, valuewise, were phosphate rock, stone, and cement.

Cement.—Estimated sales of portland and masonry cement fell from 14% to 11% of the State's total mineral value. Florida fell from first to sixth in masonry cement output and from sixth to seventh nationally in portland cement production. Masonry cement output fell from 442,000 short tons manufactured in 1990 to an estimated 214,000 short tons in 1991. Value declined about $14 million. Portland cement output fell 900,000 short tons, and value declined from $186 to $142 million.

Florida's six cement companies operated plants in Bradenton, Brooksville, Fort Pierce, Hialeah, Miami, and Tampa. Masonry cement was produced at three; all six manufactured portland cement. A total of eight kilns were in operation; five used the dry process and three used the wet. Both imported and domestically produced clinker were ground.

Clays.—Florida's clay industry consisted of seven firms operating eight pits. Three clay types, common, fuller's earth, and kaolin, were mined. Output and value for all three types declined below the 1990 level. The value of fuller's earth and kaolin declined from $39.6 million to $39.1 million, and tonnage fell from 391,000 metric tons to 363,000 metric tons. Common clay output and value, concealed because there were only two producers, declined 21% and 19%, respectively.

Common clay was produced by Solite Corp. in Clay County and Coddings Sand and Soil Inc. in Lake County. Sales were for the production of concrete block, structural concrete, and asphalt emulsions.

Fuller's earth was mined in three counties, Gadsden (Engelhard Corp.), Gadsden (Milwhite Co. Inc. and Floridin Co.), and Marion (Mid-Florida Manufacturing Co.). The four firms produced fuller's earth from five pits. Production totaled 332,000 metric tons valued at $35.6 million. Unit value was $97.14 per metric ton. The top three end uses were for pet waste adsorbents, pesticide carriers and related products, and oil and grease adsorbents. These three accounted for more than 60% of the tonnage produced.

Kaolin was mined by the Feldspar Corp. at an operation in Putnam County. Production declined from 38,400 metric tons to 30,800 metric tons; value fell slightly, but unit value rose from $84 to $105 per metric ton. Major sales, which accounted for almost 65% of the production, were to the electric porcelain, sanitaryware, and china manufacturers.

Magnesia.—Premier Refractories & Chemical Corp. operated a seawater magnesia extraction plant at Port St. Joe, about 40 miles southeast of Panama City on the northern Gulf of Mexico. The plant produced several magnesia products, including caustic calcined magnesia, magnesium hydroxide slurry, and a dead-burned magnesia.

Peat.—Florida maintained its second place ranking among the 19 peat-producing States. Output and value, 244,000 short tons and $4.0 million, respectively, were below the 252,000 short tons and $4.4 million reported in 1990. Ten firms harvested peat in Highlands, Hillsborough, Lake, Putnam, and Sumter Counties. The five firms in Lake County accounted for 43% of the output. Both reed-sedge and humus peat were harvested; the majority of the sales was for horticultural uses.

Phosphate Rock.—Florida continued as the major phosphate rock mining area in the world, producing about 30% of the world's phosphate rock. It was the leading mineral commodity mined in Florida, in terms of value, accounting for about 50% of the mineral value. In 1991, the demand for phosphate rock was affected by the usual factors: the economy, the weather, crop size and growth, etc. Although flooding in some areas of the Corn Belt delayed planting and fertilizer applications were delayed and reduced, the year ended with the State's phosphate industry producing 800,000 metric tons over the 1990 level, according to the Florida Phosphate Institute. Despite the increase in tonnage, total value of fertilizer, the end product of the majority of the phosphate rock produced, fell as its selling price slumped. Diamonium phosphate fertilizer prices slumped from $155 per ton in July

TABLE 2

FLORIDA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	100	274	2.74
Riprap and jetty stone	77	385	5.00
Filter stone	307	1,393	4.54
Coarse aggregate, graded:			
Concrete aggregate, coarse	12,583	68,567	5.45
Bituminous aggregate, coarse	3,902	21,181	5.43
Bituminous surface-treatment aggregate	613	2,646	4.32
Railroad ballast	W	W	3.30
Fine aggregate (-3/8 inch):			
Stone sand, concrete	5,706	27,690	4.85
Stone sand, bituminous mix or seal	2,008	8,111	4.04
Screening, undesignated	2,908	10,716	3.69
Other fine aggregate	W	W	1.25
Coarse and fine aggregate:			
Graded road base or subbase	14,636	47,609	3.25
Unpaved road surfacing	313	1,391	4.44
Crusher run or fill or waste	2,719	7,112	2.62
Other construction materials[2]	712	1,980	2.78
Agricultural: Agricultural limestone[3]	1,426	10,136	7.11
Chemical and metallurgical: Cement manufacture[4]	3,397	15,585	4.59
Special:			
Asphalt fillers or extenders	W	W	9.23
Other fillers or extenders	W	W	15.00
Other miscellaneous uses[5]	293	3,205	10.94
Unspecified:[6]			
Actual	2,920	15,400	5.27
Estimated	4,513	17,520	3.88
Total	[7]59,132	260,901	4.41

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes dolomite, limestone, and shell; excludes a minor amount of marl withheld to avoid disclosing company proprietary data.
[2]Includes withheld amounts for coarse aggregate, graded, and fine aggregate (-3/8 inch).
[3]Includes poultry grit and mineral food, and other agricultural uses.
[4]Includes glass manufacture and sulfur oxide removal.
[5]Includes withheld amounts for special, chemicals, and magnesia (dolomite).
[6]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[7]Data do not add to total shown because of independent rounding.

to $140 per ton in October.[5]

In 1991, there were nine phosphate rock mining-processing companies in operation, eight in central Florida and one in the northern part of the State. One of the central Florida operations closed in February.

Foreign ownership in the Florida phosphate industry increased as Farmland Industries Inc. sold one-half of its operations to Norsk Hydro, a Norwegian chemical manufacturer.[6] Norsk was also negotiating with Royster Phosphate Inc. for Royster's Tampa Bay facility. Royster filed for chapter 11 protection in April.[7] The phosphate fertilizer company name "Gardinier Inc." was changed to Cargill Fertilizer Inc. in March. Cargill purchased Gardinier in 1986.[8] Consolidated Minerals withdrew its application to build a powerplant at its proposed $1 billion phosphate rock mine and processing facility in De Soto County. Florida Power Co. declined to purchase any excess power generated by the proposed plant.[9] Tampa Port Authority officials reported cargo levels fell during the year because of reduced overseas phosphate demand.

Sand and Gravel.—Sales of sand and gravel, both construction and industrial, totaled $57 million, down from the $66 million reported in 1990. Production fell from 19 million short tons in 1990 to 16.6 million short tons in 1991. Despite the decline, Florida maintained its 16th place ranking among the 50 sand and gravel-producing States. Value was fourth among the mineral commodities produced instate, accounting for about 4% of the total value.

Construction.—The production of construction sand and gravel is surveyed by the U.S. Bureau of Mines for even numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimated data for 1989 and 1991 and actual data for 1990.

The estimated 1991 production and value, 16 million short tons valued at $51.4 million, fell below the 18.5 million short tons that sold for $59.1 million in 1990. In the last year that a complete industry canvass was received, 26 companies reported production from 43 pits. Historically, Hendry, Lake, Marion, Polk, and Putnam Counties have accounted for more than 75% of Florida's sand and gravel output.

Industrial.—Florida's ranking among the 37 industrial sand-producing States improved from 20th to 16th. Production increased 31,000 short tons. Unfortunately, the unit price per ton declined, and total value fell about $1 million. Production was reported by four companies with operations in six counties. These included Escambia (Clark Sand Co. Inc.), Glades and Lake (E. R. Janna Industries Inc.), Marion and Polk (Standard Sand and Silica Co.), and Putnam (Florida Rock Industries Inc., and the Feldspar Corp.) Counties.

TABLE 3

FLORIDA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Coarse aggregate (+1 1/2 inch)[2]	—	—	W	W	20	87	W	W
Coarse aggregate, graded[3]	W	W	W	W	6,144	39,433	10,475	48,685
Fine aggregate (-3/8 inch)[4]	W	W	W	W	3,126	11,453	7,274	34,148
Coarse and fine aggregate[5]	780	2,690	5,166	18,670	3,384	11,350	8,338	23,403
Other construction materials	648	3,360	561	3,693	131	589	2,522	10,854
Agricultural[6]	W	W	(7)	(7)	939	5,467	—	—
Chemical and metallurgical[8]	—	—	(7)	(7)	1,597	6,831	W	W
Special[9]	—	—	(7)	(7)	—	—	—	—
Other miscellaneous uses	—	—	594	7,269	—	—	—	—
Unspecified:[10]								
Actual	326	2,525	—	—	1,388	6,940	1,206	5,935
Estimated	840	3,892	851	2,835	392	1,570	2,430	9,223
Total[11]	2,593	12,467	7,172	32,467	17,121	83,720	32,244	132,247

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Excludes calcareous marl; withheld to avoid disclosing company proprietary data.
[2]Includes filter stone, macadam, and riprap and jetty stone.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[5]Includes graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[6]Includes agricultural limestone, poultry grit and mineral foods, and other agricultural uses.
[7]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[8]Includes cement manufacture, sulfur oxide removal, chemicals, glass manufacture, and magnesia (dolomite).
[9]Includes asphalt fillers or extenders, and other fillers or extenders.
[10]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[11]Data may not add to totals shown because of independent rounding.

Staurolite.—E. I. du Pont de Nemours & Co. Inc. produced a staurolite concentrate in Clay County as a byproduct of mineral sands processing. Output was up almost 30%, and value increased about 7%. The principal sales were to the foundry, sand blasting, and cement industries.

Stone.—The production of stone is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Crushed stone production (excluding marl) was 59 million short tons valued at $261. This was considerably lower than the 84 million short tons valued at $341 million produced by Florida's stone industry in 1989, the last year with a full industry canvass. Stone ranked second, valuewise, among the mineral commodities mined instate and accounted for almost 30% of Florida's 1991 mineral value. As noted elsewhere in this chapter, a construction "boom" and overbuilding in the first half of the 1980's coupled with a national recessions in the early 1990's has had a serious, negative impact on the construction industry and those mineral commodities, including stone, used in construction.

Stone production was reported by 71 companies operating 105 quarries in 25 counties. In 1989, there were 84 companies operating 130 mines in 29 counties. The Florida stone industry produced limestone and dolomite, shell, and marl. Limestone production accounted for more 95% of the tonnage. Limestone and dolomite were mined in 22 counties, shell in 4, and marl in 2. More than one stone type was produced in some counties. The five leading counties, in terms of tonnage, were: (1) Dade, (2) Broward, (3) Hernando, (4) Lee, and (5) Citrus. These five accounted for approximately 70% of the production. The five leading end uses reported included: (1) concrete aggregate, (2) poultry grit, (3) graded roadbase, (4) agricultural limestone, and (5) construction stone sand.

In September, Vulcan/ICA Distribution Co., part of an international joint venture between Vulcan Materials Co., Birmingham, AL, and Grupo, ICA of Mexico City, acquired construction aggregate businesses from Southdown Inc. in Hernando and Polk Counties. Vulcan/ICA will supply aggregate to Southdown's ready-mix concrete plants in Florida.[10]

Sulfur.—Exxon Corp. continued to operate the only facility in the State to remove sulfur from natural gas. Production at the Santa Rosa facility, 36,708 metric tons, was down from the 55,000 metric tons produced in 1990. The gas processed by the Santa Rosa plant came from the Jay and Blackjack Fields.

TABLE 4
FLORIDA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991[1]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	102	73,058	$305,920	$4.19	95	57,076	$250,740	$4.39
Dolomite	5	1,561	8,099	5.19	3	906	5,059	5.58
Calcareous marl	3	266	800	3.01	—	—	—	—
Shell	9	3,531	9,942	2.82	5	1,150	5,103	4.44
Miscellaneous stone	3	5,580	16,636	2.98	—	—	—	—
Total[2]	XX	83,995	341,397	4.06	XX	59,132	260,901	4.41

XX Not applicable.
[1]Excludes calcareous marl; withheld to avoid disclosing company proprietary data.
[2]Data may not add to totals shown because of independent rounding.

Other Industrial Minerals.—Several mineral commodities, not listed in table 1, were shipped into the State and used as an ingredient in a processing step or processed into a higher value product.

Fluosilicic acid was produced by six companies. The acid, a byproduct of wet-process acid production, was sold for water purification and other industrial applications.

Gypsum was imported by three companies, and byproduct gypsum was produced by all the major phosphate companies. The imported material was used in wallboard manufacture. Byproduct gypsum was stockpiled.

Nitrogen was recovered by Air Products and Chemical Inc. at a plant in Pace Junction and by Jones Chemical Inc. at a Fort Lauderdale facility. It was used in the manufacture of anhydrous ammonia and nitric acid.

Perlite was expanded at plants in Broward, Duval, Escambia, and Indian River Counties. The crude material was purchased from mines in the Western United States. Output, 23,791 short tons, was valued at $5.0 million. Unit value was $212.29, up from the $209.05 reported in 1990. Sales were to the horticultural, insulation, plaster aggregate, tile, oil-water absorbent, concrete aggregate, and filter aid industries.

Vermiculite was exfoliated by W.R. Grace and Schmeizer Sales Co. The two companies operated plants in Broward, Duval, and Hillsborough Counties. Sales were to the concrete aggregate, horticulture, and insulation industries.

Metals

Gold and Silver.—Orexana Corp. terminated operations at its precious-metals refinery. The 5-year-old refinery employed 15 workers and had the daily capacity to refine 2,400 troy ounces of gold and 11,200 troy ounces of silver.[11]

Iron and Steel.—Florida Steel Corp. operated two minimills at Jackson and Tampa. The two mills, housing three electric furnaces, had an aggregate annual capacity of 603,000 short tons. In the first quarter, the Tampa mill started up a new three-strand billet caster. The new caster replaced a two-strand unit.[12]

Mineral Sands.—RGC (USA) Mineral Sands Inc. and Du Pont recovered mineral sands by dredging from properties at Green Cove Springs and Trail Ridge. Both wet and dry milling were used to recover a monazite, titanium, and zirconium concentrate.

Rare Earths.—RGC recovered a monazite concentrate at its Green Cove Springs plant. The monazite was shipped to France for processing.

Titanium Concentrates.—RGC and Du Pont recovered concentrates containing rutile, ilmenite, and leucoxene. The concentrates were marketed to producers of titanium dioxide pigments and synthetic rutile. Du Pont planned to begin mining at its 7,200-acre Maxville site in northeastern Florida in 1992. The company will close portions of one of the two sites now in operation when production begins at the Maxville property.[13]

Uranium.—IMC Fertilizer Inc. operated a plant near Mulberry to extract uranium from phosphoric acid. The material was sold to a nuclear fuel manufacturing plant in Oklahoma. Late in the year, IMC and Florida Power & Light Co. were in arbitration in a multimillion dollar dispute over uranium contracts interrupted by the shutdown of two nuclear reactors. The power company argued that because two reactors at its Turkey Point plant were shut down last year, it was not liable for IMC uranium shipments during the shutdown period. IMC contended that the two companies were still bound by contracts, regardless of reactor problems. IMC's uranium sales accounted for $85.7 million in 1990.[14]

Zirconia Concentrates.—RGC and Du Pont recovered a zircon concentrate at their Green Cove Springs and Trail Ridge plants. The concentrate was sold to grinding plants and, after grinding, to the ceramic, refractory, and foundry industries.

[1]State Mineral Officer, U.S. Bureau of Mines, Tuscaloosa, AL. He has 32 years of mineral-related industry and government experience and has covered the mineral activities in Florida since 1989. Assistance in the preparation of the chapter was given by Maylene E. Hubbard, editorial assistant.

[2]State Geologist and Chief, Florida Geological Survey, Tallahassee, FL.

[3]The Ledger. As Protests Pile Up, EPA Reconsiders Gypsum Ban. June 30, 1991.

[4]The State Geologists Newsletter, Florida. Apr. 1991.

[5]The Tampa Tribune. Anhydrous Ammonia Futures To Be Traded. Oct. 31, 1991.

[6]Chemicalweek. Norsk Hydro To Make Phosphate in the U.S. Oct. 9, 1992.

[7]The Tampa Tribune. Royster Co. Files for Chapter 11. Apr. 11, 1991.

[8]East Bay Breeze (Brandon). Gardinier Gets New Name. Mar. 13, 1991.

[9]The Ledger. Plans Stall for Plant in De Soto. Jan. 25, 1991.

[10]Pit & Quarry. Vulcan/ICA Buys Florida Quarries. Nov. 1991, p. 10.

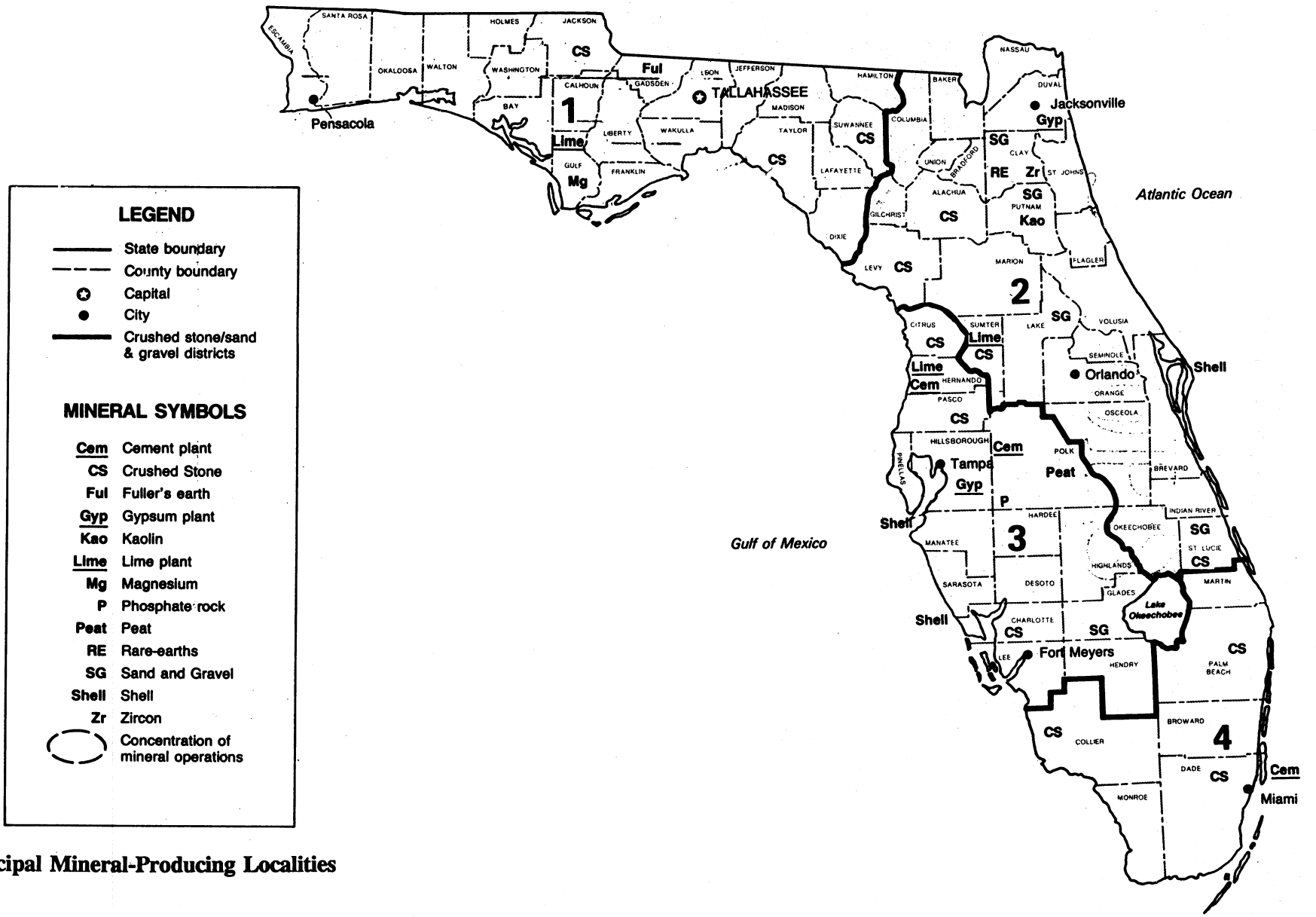
[11]American Metal Market. Precious Metals Refiner Declares Insolvency. V. 99, No. 62, Apr. 2, 1991.

[12]———. Florida Steel Has New Caster. V. 99, No. 62, Apr. 2, 1991.

[13]Engineering & Mining Journal. Du Pont Expands Titanium Operations. V. 191, No. 5, May, 1991, p. 16E.

[14]The Ledger. IMC, FP&L To Argue Uranium Contracts. Aug. 8, 1991.

FLORIDA



Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Lafarge Corp.	Box 223481 Tampa, FL 33622	Plants	Hillsborough.
Moore McCormack Resources Inc.	Box 23965 Tampa, FL 33630	Plant	Hernando.
National Portland Cement Co.	Route 1 Port Manatee Palmetto, FL 34221	do.	Manatee.
Rinker Portland Cement Corp.	Drawer K Palm Beach, FL 33416	do.	Dade.
Tarmac Florida Inc.	Box 122035 Hialeah, FL 33012	do.	Do.
Clays:			
Engelhard Corp. Specialty Chemicals Div.	Menlo Park Edison, NJ 08817	Mines and plant	Brevard.
The Feldspar Corp., EPK Div.[1]	Box 8 Edgar, FL 32049	do.	Putnam.
Florida Solite Corp.	Box 297 Green Cove Springs, FL 32043	do.	Clay.
Floridin Co.	5380 Capitol Cr., NW Tallahassee, FL 32303	do.	Gadsden.
Mid-Florida Mining Co.	3300 Southwest 34th Ave., Suite 152 Ocala, FL 32674	do.	Marion.
Gypsum (calcined):			
Jim Walter Corp.	Box 135 Jacksonville, FL 32226	Plant	Duval.
National Gypsum Co.	4100 First International Bldg. Dallas, TX 57270	do.	Hillsborough.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Duval.
Peat:			
Hyponex Corp.	14111 Scottslawn Rd. Marysville, OH 43041	do.	Lake.
Reliable Peat	Box 217 Winter Garden, FL 32787	do.	Do.
TU-CO Peat	9601 Bear Rd. Sebring, FL 33870	do.	Highlands.
Perlite (expanded):			
Airlite Processing Corp. of Florida	Route 2, Box 740 Vero Beach, FL 32960	Plant	Indian River.
Armstrong Cork Co.	Box 1991 Pensacola, FL 35289	do.	Escambia.
Chemrock Corp.	End of Osage St. Nashville, TN 37208	do.	Duval.
W. R. Grace & Co.[3]	62 Whittemore Ave. Cambridge, MA 02140	do.	Broward.
Phosphate rock:			
Agrico Mining Co.	Box 1110 Mulberry, FL 33860	Mine(s) and plant complex	Polk.
IMC Fertilizer Inc.	Box 867 Bartow, FL 33830	do.	Do.
Occidental Chemical Agricultural Products Inc.	White Springs, FL 32096	do.	Hamilton.

See footnotes at end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Construction:			
Florida Rock Industries Inc., Shands & Baker	Box 4667 Jacksonville, FL 32201	Pits and plant	Clay, Glades, Lake, Marion, Polk, Putnam.
General Development Corp.	1111 South Bayshore Dr. Miami, FL 33131	do.	Hendry, St. Lucie, Sarasota.
E. R. Jahna Industries Inc., Ortona Sand Co. Div.	102 East Tillman Ave. Lake Wales, FL 33853	do.	Glades, Lake, Polk.
Silver Sand Co. of Clermont Inc.	Route 1, Box US 1 Clermont, FL 32711	Pit and plant	Lake.
Industrial:			
The Feldspar Corp.	Box 8 Edgar, FL 32049	do.	Putnam.
E. R. Jahna Industries Inc., Ortona Sand Co. Div.	102 East Tillman Ave. Lake Wales, FL 33853	do.	Glades and Lake.
Standard Sand & Silica Co.	Box 35 Davenport, FL 33832	do.	Polk and Marion.
Stone:			
Florida Rock Industries Inc.	Box 4667 Jacksonville, FL 32201	Quarries and plant	Alachua, Collier, Dade, Hernando, Lee, St. Levy, St. Lucie.
Rinker Southeastern Materials Inc.	Box 5230 Hialeah, FL 33014	do.	Dade.
Tarmac Florida Inc.	Box 8648 Deerfield Beach, FL 33441	Quarry and plant	Dade and Monroe.
Vecellio & Grogan Inc.	Box 15065 West Palm Beach, FL 33416	do.	Dade.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	Quarries and plant	Broward and Dade.
Titanium concentrates:			
RGC (USA) Minerals Sand Inc.	Box 1307 Green Cove Springs, FL 32043	Mine and plant	Clay.
E. I. du Pont de Nemours & Co. Inc.[3]	Du Pont Bldg. D-10084 Wilmington, DE 19898	Mines and plants	Do.

[1]Also construction and industrial sand and gravel.
[2]Also exfoliated vermiculite.
[3]Also staurolite.

THE MINERAL INDUSTRY OF GEORGIA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Georgia Geologic Survey, Environmental Protection Division, Georgia Department of Natural Resources, for collecting information on all nonfuel minerals.

By Steve W. Sikich[1] and Bruce J. O'Connor[2]

Statistics released by the U.S. Bureau of Mines, Department of the Interior, indicate that the value of nonfuel minerals produced in Georgia in 1991 was $1.3 billion, a 13.1% decrease from that produced in 1990. This marked the first time since the recession year of 1982 that mineral production failed to increase to a record high. The State's two leading commodities, clays and crushed stone, accounted for more than 90% of the total worth of minerals produced and were responsible for almost all of the total decrease of $196.5 million. Clays decreased $110.8 million, and crushed stone decreased $94.4 million. These decreases were offset in part by a net increase of $8.7 million for all of the other mineral commodities produced.

As a result of the decrease, Georgia dropped from fifth in 1990 to sixth in the total worth of minerals produced but retained its ranking of third in industrial minerals. The State accounted for 4.3% of the total value of minerals produced in the country in 1991. Georgia continued to lead the Nation in the quantity and value of total clays mined, as well as two specific types of clays, kaolin and fuller's earth. The State also led in the quantity of granite dimension stone quarried, but it dropped to second in the value of barite and natural iron oxide pigments sold. No metals were mined in Georgia in 1991.

TRENDS AND DEVELOPMENTS

The reversal in the growth of Georgia's mineral economy after 8 consecutive years of record-high levels resulted primarily from a recession in the State's overall economy. For several years, Georgia, particularly the Atlanta area, appeared immune to the recession that was impacting much of the Nation. However, in 1990, the State's economy faltered and so did mineral activity. Those mineral commodities most dependent on a strong construction market, such as construction aggregate, cement, and clays, were particularly impacted.

TABLE 1
NONFUEL MINERAL PRODUCTION IN GEORGIA[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Clays	metric tons	9,768,312	$1,004,954	9,855,248	$1,060,539	9,518,026	$949,737
Gemstones		NA	21	NA	20	NA	10
Sand and gravel:							
Construction	thousand short tons	e6,100	e18,900	5,158	16,644	e4,700	e14,500
Industrial	do.	537	7,013	W	W	W	W
Stone:							
Crushed	do.	50,417	262,805	e53,000	e317,300	2 41,339	2 222,900
Dimension[2]	short tons	145,545	12,087	e147,068	e12,483	173,892	14,167
Combined value of barite, bauxite (1989, 1991), cement, feldspar, iron oxide pigments (crude), mica (scrap), peat (1989-90), stone [crushed marble (1991), dimension marble], talc and pyrophyllite, and values indicated by symbol W		XX	81,515	XX	88,138	XX	97,307
Total		XX	1,387,295	XX	1,495,124	XX	1,298,621

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain stones; kind and value included with "Combined value" data.

c Revenue at Georgia's ports appeared to be one of the few sectors of the State's economy not seriously affected by the recession.[3] The breakbulk handling terminal at Savannah handled 1.1 million short tons of cargo, led by kaolin and steel products, in fiscal 1991. Traffic through the Port of Savannah increased by 3.6% in 1991 and was projected to increase by an average of 4.2% annually from 1992 to the year 2000. Based on these projections, almost $400 million in improvements have been proposed for the State's two ports. Major projects include deepening of the Savannah River channel from 38 feet to 42 feet and lengthening Mayor's Point Terminal at Brunswick. The U.S. Army Corps of Engineers report on deepening the channel was under Federal review at yearend. Business at Georgia Port Authority's inland barge terminals at Bainbridge and Columbus also increased in 1991.

In May, the Governors of Georgia and Alabama announced an agreement on several issues in the legal battle over water allocations from rivers that run through both States. Under the agreement, Georgia agreed to withhold permit applications for a series of six regional reservoirs until a 3-year study of water use in the two-State area is completed by the Corps of Engineers. The mineral industry of both States could be impacted by restrictions on water withdrawals because of the large amounts of water required by many mineral processing operations.

Again in 1991, major corporate changes highlighted mineral industry activity. The Dry Branch Kaolin Co. was sold for a reported $180 million by its parent company, Asea Brown Boveri Inc. of Sweden, to a French holding company, Imetal. Hanson PLC purchased the American aggregate and cement operations of another English company, Beazer PLC, in October. Included in the sale were two subsidiaries of Beazer with extensive aggregate operations in Georgia, Davidson Mineral Properties and The Stoneman Inc. ECC America, headquartered in Atlanta, sold its Southern Clay Products Inc. subsidiary based in Gonzales, TX, to LaPorte PLC, also of the United Kingdom.

EMPLOYMENT

Based on statistics supplied by the U.S. Department of Labor,[4] employment in Georgia's mining sector decreased from 8,400 in 1990 to 7,600 in 1991, a drop of 9.5%. This was considerably higher than the State's overall employment rate, which decreased only 1.7%. U.S. Mine Safety and Health Administration (MSHA) statistics[5] ranked Georgia eighth in total employees engaged in nonfuel mineral employment and fourth in industrial mineral employment.

REGULATORY ISSUES

Plans to drill five test holes to evaluate phosphate deposits off the Georgia coast were delayed until an environmental assessment of the potential effects of mining activities was completed. A State-Federal task force was commissioned in April to conduct the assessment, which will be more limited than the full-scale environmental impact statement advocated by environmentalists.

The Georgia Geologic Survey initiated a test-drilling program to investigate a potential plume of radioactive ground water in eastern Burke County across the river from the Department of Energy's (DOE) Savannah River Site. The investigation was designed to determine the pathway by which tritium entered the ground water in Georgia. Funding for the $0.8 million, 1.5-year project was being provided by DOE.

The State denied Medusa Cement Co. and Blue Circle Cement Co. permits to burn hazardous wastes at their plants. Danger to public health was cited as the reason for denying the permits.

The Georgia Department of Natural Resources set a precedent when it denied Davidson Minerals Properties a permit to quarry granite because of the historic value of the adjacent ground.[6] The quarry would have been built within 1,500 feet of the 167-year-old Casulon Plantation, a national historic site.

EXPLORATION ACTIVITIES

The geology department of the University of Georgia, Athens, continued mapping a 1,300-square-mile area encompassing eight counties in northeast Georgia under a grant from the Georgia Geologic Survey. Gold exploration in the area by private companies has been hampered because of the lack of detailed geological mapping and the scarcity of large, individually owned tracts of land. This makes it difficult for a company to acquire a large enough block of land to justify the cost of a gold exploration program.

Exploration Resources Inc., Athens, reported[7] the discovery of an unexposed bright white marble deposit in Pickens County north of Atlanta. Test results indicated in excess of 40 million metric tons suitable for paper and other pigment and filler applications.

LEGISLATION AND GOVERNMENT PROGRAMS

The minerals industry was not directly affected by legislation enacted in 1991, although two bills had indirect impact. A supplemental budget approved during a special session to address the State's $415 million shortfall cut 2,189 positions. This resulted in the loss of 14 out of 40 positions in the Georgia Geologic Survey. Persons affected by the decisions either resigned or were transferred to federally funded regulatory positions in the Department of Natural Resources and other State agencies. The cuts also curtailed economic mineral studies being conducted by the Survey.

The second bill mandated environmental impact reports for projects receiving State financing. This bill was partly responsible for delaying proposed offshore test drilling until an environmental assessment was completed. The U.S. Geological Survey issued an open file report[8] related to previous drilling on the project.

In a related study, the Marine Minerals Technology Center at the University of Mississippi issued a report[9] outlining a

TABLE 2
GEORGIA: FULLER'S EARTH SOLD OR USED BY PRODUCERS, BY KIND

(Thousand tons and thousand dollars)

Kind	1988		1989		1990		1991	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Attapulgite	393	26,931	894	85,052	745	95,171	461	59,243
Montmorillonite	191	12,472	988	80,643	1,563	128,475	187	13,487
Total	584	39,403	1,882	165,695	2,308	223,646	648	72,730

commercial use for the phosphate and related manganese nodule found by the offshore drilling. The study suggested that the minerals could be simultaneously mined and barged directly to onshore utility powerplants. With minor mineral processing using existing technology, the manganese nodules would be used to produce filter packs for cleaning sulfur dioxide from the effluents produced by the powerplants. Completely sulfated filter packs would then be treated for the extraction of byproduct metals such as cobalt, copper, and nickel. The resulting sulfuric acid from this treatment would be used to react with the phosphate rock to produce a low cost superphosphate fertilizer. The project was funded by the U.S. Bureau of Mines through its Mineral Research Institute program at the University of Mississippi.

In other Bureau-related research, Extract Inc., a subsidiary of Ashtabula Trading Co. of Ashtabula, OH, plans to use Bureau-developed technology to recover salable titanium minerals and carbon from pond-solids waste. The work will be done at Kemira Inc's. titanium dioxide pigment plant in Savannah.

The Georgia Environmental Protection Division (EPD) reported that there were 543 active mining permits as of yearend 1991. In addition, there were 94 archived permits on which mining and reclamation had been completed and the bonds released. Another 26 permits were inactive, and 7 applications for permits had been denied by EPD. Since Georgia's mine reclamation law became effective in 1969, 48,934 acres has been permitted. Of these, 21,531 acres or 44% of the permitted acreage has been reclaimed.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Georgia ranked third nationally both in the value of industrial mineral production and in the variety of industrial mineral commodities mined. Fourteen industrial mineral commodities were mined in 1990; eight others were produced from raw materials mined within the State or shipped in. All of the nonfuel mineral commodities produced in Georgia were industrial minerals.

Barite.—Georgia ranked second nationally in both the value and quantity of barite produced. Barite was produced by two companies, Cyprus Industrial Minerals Corp. and New Riverside Ochre Co., near Cartersville. All of the barite mined in 1991 was used by the chemical and the industrial filler and pigments industries.

The barite occurs in residuum developed from dolomitic units of the Cambrian Shady and Rome Formations. The residuum is mined using conventional open pit methods that usually require no blasting. The ore is processed using a combination of screening, crushing (if needed), log washing, jigging, grinding, flotation, and drying.

Bauxite.—A relatively small amount of bauxite was mined by Mulcoa, a subsidiary of France's Imetal, in Sumter County. The bauxite was blended with bauxitic kaolin to manufacture Mulcoa's highest grade of synthetic mullite, "Mulcoa 70," which has an alumina content of 70%.

Cement.—Georgia ranked 11th in quantity and 10th in value of masonry cement, which was produced in 33 States, and 19th in quantity and 20th in value of portland cement, which was produced in 38 States. Blue Circle Inc. in Atlanta and Medusa Corp. in Clinchfield, Houston County, produced both masonry and portland cement.

Clays.—Clay production in Georgia totaled 9.5 million metric tons, a decrease of 3.4% from that of 1990. The value of clays produced showed an even greater reduction of 10.4% to $950 million. The year 1991 was the first since 1988 that the State failed to realize $1 billion from clay production. Nevertheless, Georgia once again led the Nation in both the volume and the value of clays produced. Three types of clays, common clay, fuller's earth, and kaolin, were mined in 17 of Georgia's 159 counties.

Common Clay and/or Shale.—The value of common clays reported to the Bureau increased by $3.4 million, although production decreased from 1.5 million metric tons in 1990 to 1.4 million tons in 1991. As a result of the changes, Georgia's national ranking rose from fourth to third in value but dropped from fourth to eighth in volume.

Common clay production was reported by 9 companies from 13 operations and 14 pits in 8 counties. It was used in common and face brick; portland cement; flue linings; floor, wall, and ceramic tile;

TABLE 3
GEORGIA: KAOLIN SOLD OR USED BY PRODUCERS, BY COUNTY

County	1991		
	No. of mines	Quantity (thousand)	Value (thousand)
Richmond[1]	4	343	$8,506
Twiggs	19	1,846	250,873
Washington	11	1,313	179,914
Wilkinson	8	821	119,485
Other[2]	31	3,196	304,088
Total	73	7,519	862,866

[1]Includes Jefferson County.
[2]Includes Columbia, Houston, Sumter, Various, and Warren County.

TABLE 4
GEORGIA: KAOLIN SOLD OR USED BY PRODUCERS, BY USE

(Thousand metric tons)

Use	1990	1991
Domestic:		
Adhesives	42	26
Fiberglass and mineral wool	244	223
Firebrick, blocks and shapes	7	W
Floor, wall tile, and ceramics	W	W
Paint	226	200
Paper coating	2,753	2,604
Paper filling	1,453	1,052
Plastics	55	50
Rubber	59	55
Sanitaryware	39	33
Other	1,194	1,398
Exports	1,591	1,880
Total	7,661	7,519

W Withheld to avoid disclosing company proprietary data; included in "Other."

and quarry tile. The leading producers, in order of volume, were Blue Circle Inc., Douglas and Fulton Counties; Boral Bricks Inc., Richmond County; Bickerstaff Clay Products Co., Columbus and Floyd Counties; General Shale Products Corp., Floyd and Fulton Counties; and Cherokee Brick and Tile Co., Bibb County.

Fuller's Earth.—Clays included in the fuller's earth category included attapulgite mined by Engelhard Corp. and Milwhite Co. Inc. in Decatur County, Medusa Cement Co. in Houston County, and Oil Dri Corp. of America and Waverly Minerals Products Co. in Thomas County. Clays classified as montmorillonite were mined by the Georgia-Tennessee Mining and Chemical Co. in Jefferson County and by Floridan Co. and Waverly in Thomas County.

The volume of fuller's earth produced decreased from 648,009 metric tons in 1990 to 616,534 tons in 1991, although the value increased from $72.7 million to $76.4 million. Georgia produced 22.5% of the volume and 28.3% of the value of all the fuller's earth produced in the United States during the year.

Principal uses of fuller's earth, which accounted for more than 80% of the volume produced, were in the manufacturing of pet waste absorbents, oil and grease absorbents, and pesticide carriers. Other uses included fertilizers; drilling mud; cement; paint; filtering, clarifying, and decolorizing agents; and as a catalyst in oil refining.

Kaolin.—Georgia continued to rank as the principal producer of high-grade kaolin products both domestically and worldwide. In 1991, the State accounted for 78.5% of national production and more than 30% of the world's estimated production. The State's kaolin production dropped to 7.5 million metric tons, 1.8% lower than the record-high level achieved in 1990. Kaolin's value showed a greater decrease of 12% to $862.9 million in 1991.

Kaolin was mined by 17 companies at 73 pits in 9 counties. Table 3 summarizes Georgia kaolin sold or used by producers by county. Table 4 contains an abbreviated listing of kaolin sold or used by producers by use. A more complete listing is given in the Bureau's 1991 Clays Annual Report, which also contains a breakdown of kaolin exports. Kinds of kaolin sold or used by producers with their quantities produced in metric tons and values in thousand dollars were as follows: water washed, 4,144 tons, $442,032; calcined, 1,500 tons, $269,457; delaminated, 996 tons, $110,997; air-float, 702 tons, $34,790; and unprocessed, 178 tons, $34,790. Both low-temperature filler and high-temperature refractory grades were included in the calcined kaolin.

ECC America Inc. replaced Engelhard Corp. as Georgia's leading kaolin producer in 1991. This was primarily the result of ECC's first full year of production after acquiring a majority of Georgia Kaolin Co.'s (GK) assets. In 1990, ECC endeavored to purchase all of GK, but the U.S. Justice Department ruled that part of the transaction violated fair trade laws and allowed ECC only part of the purchase. Excluded from the sale were GK's operations at Dry Branch, which were retained by GK's parent company, Asea, Brown, Boveri Ltd. (ABB) and reorganized as the Dry Branch Kaolin Co. (DBK). In 1991, ABB sold

DBK to the French holding company Imetal for a reported $180 million.[10]

In a related move, ECC sold its Southern Clay Products Inc. subsidiary, based in Gonzales, TX, to Laporte PLC of the United Kingdom for $30 million.[11] Laporte owns another Georgia clay producer, Waverly Mineral Products Co. of Meigs, Thomas County.

J. M. Huber Clay Div. installed its third High-Gradient Magnetic Separator. Huber has modified the original design so that the new 250-ton separator removes both Fe_2O_3 and TiO_2. Huber introduced a new family of kaolin-based structured pigments manufactured at its plant in Wrens. The pigments, which serve as a replacement or extender for titanium dioxide, are referred to as SAMS (sodium alumina metal silicates) and reportedly can be custom engineered to meet specific customer applications.[12]

Nord Kaolin also reported the manufacture and shipment to domestic paper companies of a new high-bulking composite pigment, Norplex 604.

Feldspar.—Georgia dropped from fourth in 1990 to fifth in the tonnage of feldspar produced nationally, while retaining its ranking of fourth in value. The State's only feldspar producer, The Feldspar Corp., a wholly owned subsidiary of the Zemex Co., operated a high-sodium feldspar mine near Monticello, Jasper County, and a high-potassium feldspar mine near Siloam, Greene County. Ore from the two mines was blended at a froth-flotation plant in Monticello to produce a concentrate used in the manufacture of glass and ceramic products.

Iron Oxide Pigments.—Nationally, Georgia ranked third in the volume and second in the value of natural iron oxide pigments, which were produced in five States in 1991. New Riverside Ochre Co., the State's only producer, mined ochre and umber near Cartersville in Bartow County. Ochre is an orange-yellow mixture of limonite and clay averaging 55% to 65% Fe_2O_3 with less than 2% MnO_2 oxide. The most valuable ochres average 0.5% MnO_2 and have the brightest yellow color. Umber has a chocolate-brown color and may contain up to 5% MnO_2. The deposits occur in residuum developed in the basal part of the Lower Cambrian Shady Dolomite.

Mica.—Nationally, Georgia ranked third out of seven States in which mica was mined in 1991. Franklin Mineral Products Div. of the Mearl Corp. produced flake muscovite from micaceous granite saprolite. It had a mine and wet-grinding plant 1/2 mile west of Hartwell and a second mine 5 miles south of Hartwell. Much of the plant's production was used by the parent company to manufacture pearlescent pigments used in plastic coatings and cosmetics.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Based on estimated construction sand and gravel production, the volume and the value decreased 8.9% and 12.9%, respectively, from data reported in 1990. The volume, 4.7 million short tons, was the smallest reported since an estimated 3.8 million tons was produced in the recession year of 1983. The value, $14.5 million, was the lowest since an estimated $13.4 million was sold in 1985.

Although data on the companies producing construction sand and gravel and the number of active operations were not collected by the U.S. Bureau of Mines for 1991, MSHA reported[13] it had inspected 41 pits in 23 counties operated by 34 companies.

Industrial.—Nationally, Georgia ranked 18th in both quantity and value when compared with the 37 States producing industrial sand and gravel. Although the production of industrial sand and gravel decreased more than 8% from that of 1990, the State's ranking improved two places in value and three places in quantity.

Atlanta Sand and Supply Co., operating under the name of Crawford County Mining Co., produced sand for blasting, ground fillers, roofing granules, filtration, traction, and golf courses. It mined from three pits south and southeast of Gaillard, Crawford County. The company also produced construction sand and gravel at the same location. Approximately 6% of its total production was industrial sand and gravel.

The Morie Co. Inc., the Nation's third largest industrial sand and gravel producer, mined sand near Junction City, Marion County. It operated one pit and a plant producing sand for glass containers, blasting, filtration, traction, molding, and core facing.

The Granite Panelwall Co., a division of Florida Crushed Stone Co., produced sand for blasting, golf courses, and traction from a Quaternary alluvial sand deposit 1 mile west of Mount Vernon, Montgomery County. The company, under the name Montgomery Sand Co., also produced construction sand and gravel at the same location.

Major uses of industrial sand and gravel in 1991 were flat glass and glass containers, blasting sand, ground fillers, and filtration sand. The four products accounted for the end use of more than 95% of the sand produced in Georgia. Flat glass was manufactured using industrial sand as the principal ingredient by PPG Industries at Perry. Glass containers were manufactured by Anchor Glass Co. Inc., Warner Robbins; and Owens-Brockway Inc. and Smith Container Corp., both in Atlanta. Industrial sand was also used in the manufacture of fiber-optic cable by the Fitel Corp., a joint venture of Penn Central Corp. and Furukawa Electric of Japan, at its plant in Carrollton.

Fused silica was produced by Harbison-Walker Refractories Co., a subsidiary of Dresser Industries Inc., at Calhoun and by Leco Corp. at Lawrenceville. Fused or vitreous silica is manufactured by the fusion of very high-grade silica sand in various electric arc and electrical resistance furnace

TABLE 5

GEORGIA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Riprap and jetty stone	392	3,162	$8.07
Filter stone	24	166	6.92
Coarse aggregate, graded:			
Concrete aggregate, coarse	6,064	34,063	5.62
Bituminous aggregate, coarse	3,497	20,196	5.78
Bituminous surface-treatment aggregate	489	3,046	6.23
Railroad ballast	844	4,076	4.83
Fine aggregate (-3/8 inch):			
Stone sand, concrete	1,832	10,487	5.72
Stone sand, bituminous mix or seal	1,638	7,961	4.86
Screening, undesignated	2,327	11,931	5.13
Coarse and fine aggregate:			
Graded road base or subbase	4,180	18,739	4.48
Unpaved road surfacing	46	266	5.78
Crusher run or fill or waste	4,031	19,423	4.82
Other construction materials[2]	568	2,743	4.83
Special: Other fillers or extenders[3]	473	7,635	16.14
Unspecified:[4]			
Actual	14,703	77,826	5.29
Estimated	230	1,176	5.11
Total[5]	41,339	222,900	5.39

[1]Includes dolomite, granite, limestone, and quartzite; excludes a minor amount of marble, marl, and miscellaneous stone withheld to avoid disclosing company proprietary data.
[2]Includes dam construction, drainfields, and roofing granules.
[3]Includes other specified uses not listed.
[4]Includes production reported without a breakdown by use and estimates for nonrespondents.
[5]Data may not add to totals shown because of independent rounding.

configurations.

Stone.—**Crushed.**—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Georgia crushed stone statistics are compiled by geographic districts as depicted on the State map. These data are summarized by major-use category in table 5, by use and district in table 6, and by kind in table 7.

Georgia ranked eighth out of 49 States in the value of crushed stone, although 11 States produced a greater quantity. These rankings were significantly lower than those of 1990 when the State ranked fourth in value and eighth in quantity because of a 29.8% drop in value and a 22% decrease in volume quarried. The 41.4 million short tons quarried in 1991 was the lowest output since 41.1 million tons was quarried during the recession year of 1983. Likewise, the value of $222.9 million was the lowest since $220 million of crushed stone was quarried in 1984.

Of the total production, more than 36 million tons (87.2%) valued at $189.4 million (85%) was granite. Other rock types quarried, in descending order of tonnage, were limestone (11.7%) and quartzite and dolomite, which together accounted for less than 1%. Not included in the aforementioned were marble, marl, and a minor amount classified as "other." Data on these rock types were withheld to protect proprietary company data.

Crushed stone production was reported by 23 companies with 79 operations in 47 of Georgia's 159 counties. Six companies, each producing more than 1 million short tons of crushed stone, accounted for more than 90% of the State's production. These companies, listed in order of stone quarried, were as follows: Vulcan Materials Co. with 14 quarries in 13 counties; Blue Circle Inc., 8 quarries in 7 counties; Martin-Marietta Aggregates Inc., 9 quarries in 8 counties; Hanson PLC (Davidson Mineral Properties and Stoneman Inc.), 14 quarries in 11 counties; Florida Rock Industries Inc., 5 quarries in 5 counties; and Southern Aggregates Co., 2 quarries in 2 counties.

Dimension.—Dimension stone was the State's only mineral commodity that increased significantly in both volume and value in 1991. Georgia continued to lead the Nation in the value of marble dimension stone and volume of granite dimension stone quarried. Overall, it ranked second in the volume and third in the value of all dimension stone produced. Although production of granite dimension stone reached a new high for recent years, both the quantity, 174,000 short tons, and value, $14,167, were considerably lower than the record highs established in the early- to mid-1980's.

The Elberton granite district retained its position as the world's leading producer of granite monuments. In 1990, 95 firms, 25 of which operated quarries, were members of the Elberton Granite Association (EGA). The EGA Museum and Exhibit celebrated its 10th anniversary in March. More than 36,800 visitors from 48 States and 25 foreign countries have toured the museum in Elberton since it opened.

Granite dimension stone production was reported from 30 quarries in De Kalb, Elbert, Greene, Madison, Oglethorpe, and Wilkes Counties. All of the marble dimension stone was produced by Georgia Marble Co. from its Tate

TABLE 6

GEORGIA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[2]	80	537	W	W	W	W
Coarse aggregates, graded[3]	2,042	12,224	W	W	W	W
Fine aggregates (-3/8 inch)[4]	1,139	6,689	W	W	W	W
Coarse and fine aggregates[5]	1,936	9,832	W	W	W	W
Other construction materials	238	1,316	19,090	99,286	1,407	6,376
Special[6]	473	7,635	—	—	—	—
Other miscellaneous uses	(7)	5	—	—	—	—
Unspecified:[8]						
Actual	4,680	24,174	2,371	11,853	7,501	41,003
Estimated	382	1,972	—	—	—	—
Total[9]	10,969	64,383	21,461	111,139	8,908	47,379

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Excludes calcareous marl, marble, and miscellaneous stone; withheld to avoid disclosing company proprietary data.
[2]Includes riprap and jetty stone, and filter stone.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[5]Includes for graded road base or subbase, unpaved road surfacing, crusher run (select material or fill), roofing granules, drainfields, and dam construction.
[6]Includes other fillers or extenders.
[7]Less than 1/2 unit.
[8]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[9]Data may not add to totals shown because of independent rounding.

TABLE 7

GEORGIA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991[1]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	16	7,796	$38,814	$4.98	15	4,848	$30,939	$6.38
Dolomite	—	—	—	—	1	180	1,040	5.78
Marble	15	W	W	5.42	—	—	—	—
Calcareous marl	1	W	W	3.01	—	—	—	—
Granite	43	32,554	169,196	5.20	52	36,027	189,388	5.26
Quartzite	1	W	W	5.47	3	284	1,533	5.40
Slate	1	W	4,300	W	—	—	—	—
Total[2]	XX	50,417	262,805	5.21	XX	41,339	222,900	5.39

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Excludes marble, calcareous marl, and miscellaneous stone; withheld to avoid disclosing company proprietary data.
[2]Data may not add to totals shown because of independent rounding.

quarry in Pickens County.

Talc.—Georgia's lone talc operation closed permanently in March. Southern Talc Co., a subsidiary of United Catalysts Inc., suspended mining operations at the company's underground mines near Chatsworth in December 1990, but continued to operate its dry-grinding and froth-flotation plant using stockpiled local talc blended with ore shipped in from Montana until the mid-March closing. United Catalyst's endeavors to sell the operation were unsuccessful as of yearend.

Other Industrial Minerals.—The only other industrial mineral commodity mined in Georgia in 1991 was gemstones. The State remained a minor gemstone producer, retaining its ranking of 32d nationally in the value of gemstones produced despite a 50% reduction in reported sales. Amethyst was the

principal variety produced, with most of the production coming from a mine operated by Dan Quillan Co. in Greene County. Peat was produced by one company, the Hyponex Corp. in Cook County, in 1990, but the company did not report production in 1991.

Several industrial mineral commodities were processed into added-value products from raw materials not mined by the processing company. Although these commodities are not included in table 1, they play a significant role in the overall mineral industry in Georgia.

Kemira Inc. used several industrial minerals at its titanium dioxide pigment plant in Savannah. The plant is one of two in the United States that uses both the chloride and the sulfate processes to produce TiO_2. In the chloride process, rutile is converted to $TiCl_4$ by chlorination at 850° to 950° C in the presence of petroleum coke. To produce TiO_2 pigment, the $TiCl_4$ is oxidized with air, forming TiO_2 particles that are calcined at 500° to 600° C to remove residual chloride and any hydrochloric acid that may have formed during the reaction. Aluminum chloride is added to the $TiCl_4$ to ensure complete oxidation of the titanium in the rutile. In the sulfate process, ilmenite or titanium slag is reacted with sulfuric acid and titanium hydroxide is precipitated by hydrolysis, filtered, and calcined. Among the industrial minerals used in the process were aragonite imported from the Bahamas for acid neutralization, rutile and ilmenite from Florida and foreign sources, titanium-rich slag from Canada, and aluminum chloride. In addition to the TiO_2 pigments, gypsum was produced as a byproduct. The byproduct gypsum, along with imported crude gypsum, was used by Domtar Inc. to manufacture wallboard at its plant in Savannah. Wallboard was also manufactured by the Building Products Div. of Georgia-Pacific Corp. near Brunswick in Glynn County and Gold Bond Building Products Div. of National Gypsum Corp. in Garden City, Chatham County. Georgia-Pacific also operated a gypsum-plaster plant in Marietta, Cobb County. All four plants calcined crude gypsum imported principally from Nova Scotia.

The Specialty Products Div. of Franklin Industrial Minerals Co. ground calcined gypsum for use in flame and smoke suppressants at its Dalton plant. Alumina trihydrates (ATH), brucite, calcium carbonate, and calcium sulfate were also ground and blended at the plant for use in fire retardant materials and reinforced plastics. Other companies grinding similar materials and producing comparable products were Custom Grinders Sales Inc. and Filler Products Co., Chatsworth, Murray County; Dalton Alumina Chemical Co., Dalton; and Solem Div., J. M. Huber Corp., Fairmount, Gordon County.

Bentonite from Wyoming was used by Clem Environmental Corp. to manufacture geocomposite clay liners for the water, waste, mining, and petrochemical industries.

Celestite was imported from Mexico by Chemical Products Co. of Cartersville to be manufactured into strontium chemicals. The major product was strontium carbonate used in the manufacture of color television and video screens.

Various iodine chemicals valued at almost $390,000 were produced by Ajay Chemicals Inc. at Powder Springs, Cobb County; Diversey Wyanndotte Corp. at Tucker, De Kalb County; and Natrochem Inc. at Savannah, Chatham County.

Georgia ranked fifth in quantity and sixth in value of expanded perlite, which was produced in 33 States. Both the quantity and value of expanded perlite produced in Georgia increased in 1991. Armstrong World Industries Inc. was Georgia's lone producer of expanded perlite, which was imported from Greece and used in the manufacture of acoustic tile at its plant in Macon, Bibb County.

Salt was used to produce chlorine by Brunswick Pulp and Paper Co., Brunswick, Glynn County, and Olin Corp., Augusta, Richmond County. Brunswick was one of several companies that used a variety of industrial minerals to manufacture paper products. The others included Augusta Newsprint Co., Augusta; Federal Paper and Board Co., Augusta; Fort Howard Corp., Rincon, Effingham County; Gilman Paper Co., St. Marys, Camden County; and Southeast Paper Manufacturing Co., Dublin, Laurens County.

Slag from Atlantic Steel Co. plants in Atlanta and Cartersville was sold as construction aggregate by International Mill Service Corp.

Georgia's national ranking in the production of exfoliated vermiculite improved from 15th in 1990 to 8th in 1991. Its value showed a less dramatic increase from 13th to 10th. Exfoliated vermiculite was produced by Anitox Corp. at Buford, Gwinnett County. It was sold primarily to the agriculture market as a horticultural medium and fertilizer carrier. A minor amount was sold for fireproofing purposes.

Metals

Numerous metals such as copper, corundum, gold, iron ore (limonite and hematite), lead, manganese, pyrite, and silver have been mined in Georgia but are not viable under present economic conditions. However, metal products are commonly manufactured in the State from metallic ore or concentrates shipped into the State or from recycled metals.

Southwire Co., Carrollton, Carroll County, is one of the Nation's leading producers of aluminum and copper cable, rods, and castings. Aluminum ingots were produced by Alcan Recycling from aluminum scrap at Greensboro, Greene County. A variety of extruded aluminum products were produced by Alcan Extrusions USA, Rome, Floyd County; William L. Bonnell Co. Inc., Newnan, Coweta County; General Extrusions, Union City, Fulton County; Hoover Group Inc., Franklin, Heard County; Indal Extrusion and Macklanburg-Duncan Co., Gainesville, Hall County; and Tifton Aluminum Co. Inc., Tift County.

Atlantic Steel Co. produced hot-rolled steel bars, rods, shapes, and wire from electric arc minimills in Atlanta and Cartersville. The Atlanta plant continued to operate pending completion of work to consolidate operations in Cartersville.

Southern Zinc Co., Atlanta, produced zinc dust, zinc oxide, and zinc slabs from its smelter and refining operation at East Point, Fulton County.

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[1]State Mineral Officer, U.S. Bureau of Mines, Tuscaloosa, AL. He has 33 years of mineral-related industry and government experience and has covered the mineral activities in Georgia since 1989. Assistance in the preparation of the chapter was given by Maylene E. Hubbard, editorial assistant.

[2]Principal geologist, Georgia Geologic Survey, Environmental Protection Div., Georgia Department of Natural Resources.

[3]Georgia Ports Authority (Savannah, GA). Update 1991, 14 pp.

[4]U.S. Department of Labor. Employment and Earnings. V. 39, No. 5, May 1992, p. 135.

[5]———. Mine Injuries and Worktime Quarterly. Jan.-Dec. 1991, pp. 7-17.

[6]Tifton (GA) Gazette. Mining Denied To Preserve Historic Land. July 17, 1991.

[7]Mining Journal (London, United Kingdom). World Class White Marble Deposit. V. 316, No. 8116, Apr. 5, 1991, p. 259.

[8]J. R. Herring, et al. Size Analysis, Visual Estimation of Phosphate and Other Minerals, and Preliminary Estimation of Recoverable Phosphate in Size Fractions of Sediment Samples From Drillholes GAT-90, Tybee Island, and GAS-90-2, Skidaway Island, GA. U.S. Geol. Surv. OFR 91-0586, 1991, 35 pp.

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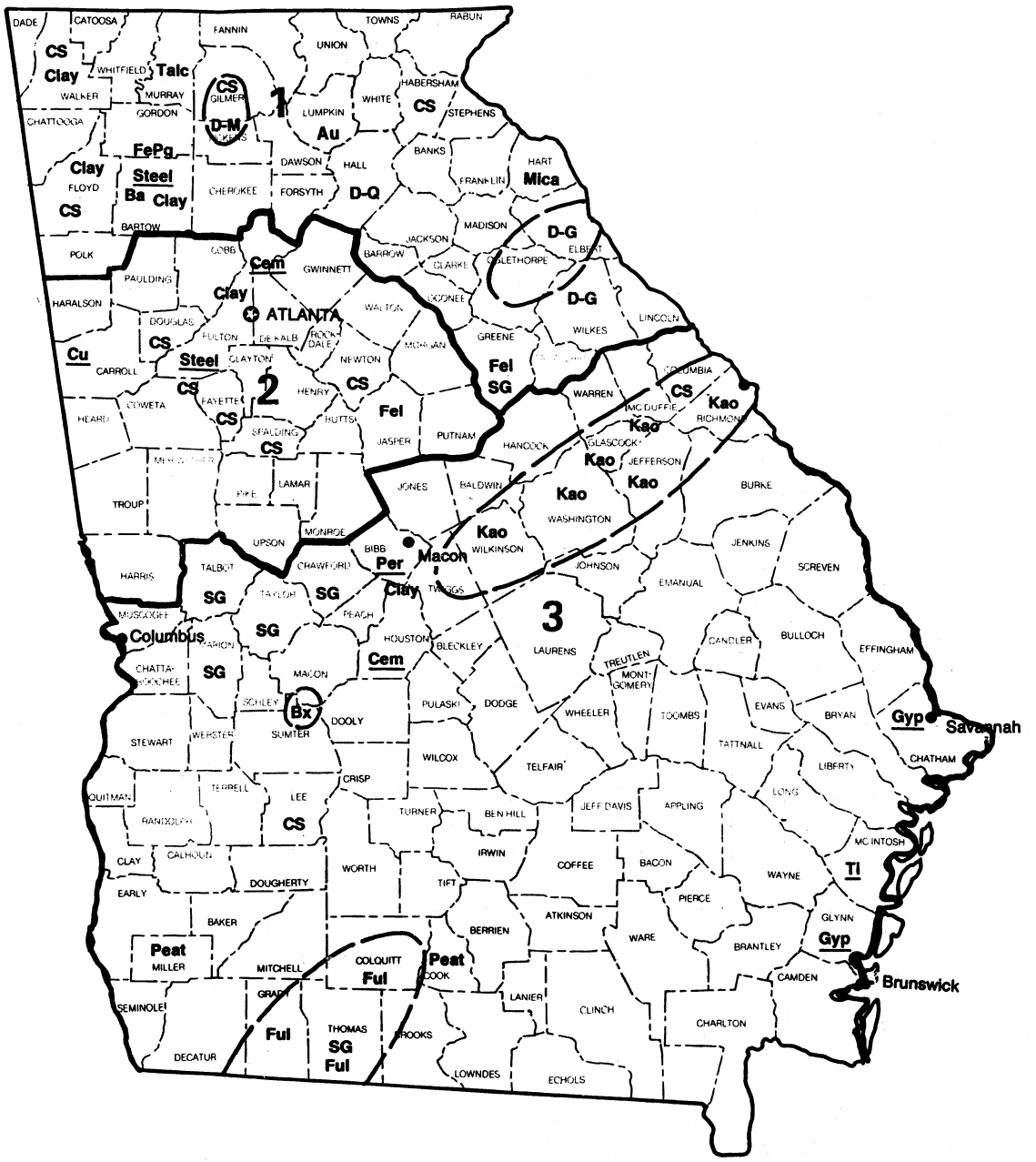
[10]The Macon (GA) Telegraph. Kaolin Company Rebuilds After Turmoil of International M&A. Apr. 29, 1991, p. B-3.

[11]Industrial Minerals (London, United Kingdom). Laporte Acquires Southern Clay. No. 287, Aug. 1991, p. 12.

[12]———. Huber Introduces New Kaolin Pigment. No. 284, Apr. 1991, p. 17.

[13]U.S. Department of Labor, Mine Safety and Health Administration. Metal/Nonmetal Mine Safety and Health. Jan. 8, 1992.

GEORGIA



LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Au	Gold
Ba	Barite
Bx	Bauxite
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper smelter
D-G	Dimension Granite
D-M	Dimension Marble
D-Q	Dimension Quartzite
Fel	Feldspar
FePg	Iron Oxide pigments
Ful	Fuller's earth
Gyp	Gypsum plant
Kao	Kaolin
Mica	Mica
Peat	Peat
Per	Perlite plant
SG	Sand and Gravel
Steel	Iron and Steel plant
Talc	Talc
Tl	Titanium plant
	Concentration of mineral operations

Principal Mineral-Producing Localities

TABLE 8
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Barite:			
Cyprus Industrial Minerals Co.	Box 130 Cartersville, GA 30120	Open pit mine and mill	Bartow.
New Riverside Ochre Co.[1]	Box 387 Cartersville, GA 30120	do.	Do.
Bauxite:			
Mullite Co. of America	Box 37 Andersonville, GA 31711	Open pit mines and mill	Macon and Sumter.
Cement:			
Blue Circle Inc.[2]	2520 Paul Ave., NW Atlanta, GA 30318	Plant	Fulton.
Medusa Cement Co.[2]	Box 120 Clinchfield, OH 31013	do.	Houston.
Clays:			
Common:			
Bickerstaff Clay Products Co.	Box 1178 Columbus, GA 31993	Open pit mines	Floyd and Muscogee.
Boral Bricks Inc.	Box 1957 Augusta, GA 30903	Open pit mines and plants	Bibb and Richmond.
Chattahoochee Brick Co., a subsidiary of General Shale Products Corp.	Box 813250 Smyrna, GA 30081	do.	Floyd and Fulton.
Fuller's earth:			
Englehard Corp.	Box 222 Attapulgus, GA 31715	do.	Decatur.
Oil Dri Corp. of America	Box 200A Ochlocknee, GA 31773	do.	Thomas.
Waverly Mineral Products Co.	Box 106 Meigs, GA 31765	do.	Do.
Kaolin:			
ECC International	Box 471 Sandersville, GA 31082	do.	Various.
Engelhard Corp.	Box 37 Gordon, GA 31031	do.	Decatur, Washington Wilkinson.
J. M. Huber Corp.	Route 4 Huber, GA 31298	do.	Various.
Feldspar:			
The Feldspar Corp.	Mine Rd. Monticello, GA 31064	Open pit mines and plant.	Greene and Jasper.
Gypsum:			
Byproduct:			
Kemira Inc.	Box 368 Savannah, GA 31402	Plant	Chatham.
Calcined:			
Georgia-Pacific Corp., Gypsum Div.	Box 1397 Brunswick, GA 31520	do.	Glynn.
Gold Bond Building Products, a subsidiary of National Gypsum	Box 7016 Garden City, GA 31408	do.	Chatham.
Domtar Gypsum, division of Domtar Inc.	Box 1526 Savannah, GA 31498	do.	Do.
Mica:			
Franklin Mineral Products Co. Inc., division of The Mearl Corp.	Drawer 390 Hartwell, GA 30643	do.	Hart.

See footnotes at end of table.

TABLE 8—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Construction:			
Atlas Sand and Gravel Co.	Box 249 Eden, GA 31307	Open pit mines	Effingham.
Brown Brothers Sand Co.	Route 1 Roberta, GA 31087	do.	Talbot.
Southern Aggregates Co.	Box 4510 Augusta, GA 30907	do.	Richmond.
Industrial:			
Atlanta Sand & Supply Co.[3]	Route 1 Roberta, GA 31078	Open pit mine and plant	Crawford.
Montgomery Sand Co., a subsidiary of Florida Crushed Stone Co.[3]	Box 255 Mount Vernon, GA 39445	do.	Montgomery.
The Morie Co. Inc., Georgia Silica Div.[3]	1201 North High St. Millville, NJ 08332	do.	Marion.
Stone:			
Crushed:			
Davidson Minerals Properties Inc. and The Stoneman Inc., subsidiaries of Hanson PLC	Box 486 Lithonia, GA 30058	Quarries and plants	Various
Martin Marietta Aggregates Co.	Box 4380 Augusta, GA 30917	do.	Do.
Vulcan Materials Co.	Box 80730 Atlanta, GA 30366	do.	Do.
Dimension:			
Granite:			
Coggins Granite Inc.	Box 250 Elberton, GA 30635	Quarries	Madison and Oglethorpe.
Keystone Granite Co.	Box 516 Elberton, GA 30635	do.	Oglethorpe.
T & C Quarries Inc.	Box 119 Elberton, GA 30635	do.	Elbert and Oglethorpe.
Marble:			
Georgia Marble Co.	Building 100 1201 Roberts Blvd. Kennesaw, GA 30144	do.	Pickens.

[1]Also produced crude iron oxide pigments.
[2]Also produced common clay and limestone.
[3]Also construction sand and gravel.

THE MINERAL INDUSTRY OF HAWAII

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Department of Land and Natural Resources of the State of Hawaii for collecting information on all nonfuel minerals.

By Fred V. Carrillo[1]

Hawaii's nonfuel mineral production value in 1991 was more than $141 million. The 33% increase in production from that of 1990 reflected Hawaii's continuing rise in construction spending and rising prices of the materials used, as growth continued strong through 1991. According to the Bank of Hawaii, gross State product (GSP) for Hawaii has increased more than 63% since 1983, with the most rapid real growth occurring in the past 3 years. Hawaii ranked 39th nationally in the value of 1991 nonfuel mineral production.

TRENDS AND DEVELOPMENTS

The U.S. Labor Department reported that despite a decline, the mining industry remains the highest paid industrial sector in Hawaii with average annual pay of slightly more than $39,000. The Bank of Hawaii reported 1991 construction completed (construction put in place) was up 9% from that of 1990 to $4.5 billion. Mineral production in Hawaii was used principally for local construction. (Most mining in Hawaii is for sand and gravel and stone.)

According to the U.S. Labor Department, the greatest percentage gain in growth was in construction and mining (12.8%).

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Hawaiian finished portland cement production was estimated to increase to 547,000 short tons and was valued at more than $47 million during 1991, up 18% and 17%, respectively, from that of 1990. Masonry cement production decreased 17% to 10,000 short tons, valued at $600,000.

The principal producer of finished portland cement in Hawaii was the Lone Star plant at Barbers Point, Oahu. Portland cement was used by building material dealers, concrete product manufacturers, ready-mix companies, and highway and building contractors. Raw materials consumed at the plant included limestone, sand, gypsum, and volcanic ash.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1990 and estimates for 1989 and 1991. Construction uses of sand and gravel were partially supplemented by crushed stone and were estimated to decrease about 9% (from 1990's production) to 400,000 short tons. However, higher prices limited the

TABLE 1
NONFUEL MINERAL PRODUCTION IN HAWAII[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	10	$1,566	12	$1,870	e10	e$600
Portland	do.	493	40,495	532	46,311	e547	e47,589
Gemstones		NA	44	NA	55	NA	60
Sand and gravel (construction)	thousand short tons	e600	e13,200	438	2,459	e400	e2,300
Stone (crushed)	do.	6,205	46,746	e7,000	e55,400	[2]10,486	[2]90,563
Total[3]		XX	92,051	XX	106,095	XX	141,112

eEstimated. NA Not available. XX Not applicable
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain stones; value excluded to avoid disclosing company proprietary data.
[3]Partial total, excludes values that must be concealed to avoid disclosing company proprietary data.

TABLE 2

HAWAII: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	36	379	$10.53
Riprap and jetty stone	3	34	11.33
Filter stone	442	2,013	4.55
Coarse aggregate, graded:			
Concrete aggregate, coarse	1,981	18,688	9.43
Bituminous aggregate, coarse	110	845	7.68
Bituminous surface-treatment aggregate	7	88	12.57
Fine aggregate (-3/8 inch):			
Stone sand, concrete	1,729	21,025	12.16
Stone sand, bituminous mix or seal	352	2,350	6.68
Screening, undesignated	83	544	6.55
Coarse and fine aggregates:			
Graded road base or subbase	1,952	16,213	8.31
Unpaved road surfacing	170	825	4.85
Crusher run or fill or waste	900	6,031	6.70
Other construction materials[2]	1,666	11,615	6.97
Roofing granules	(3)	(3)	14.55
Agricultural:			
Agricultural limestone	W	W	11.11
Other agricultural uses	W	W	8.66
Chemical and metallurgical: Cement manufacture[4]	360	2,966	8.24
Unspecified:[5]			
Actual	263	2,357	8.96
Estimated	431	4,592	10.65
Total[6]	10,486	90,563	8.64

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes granite, limestone, and traprock, excludes a minor amount of miscellaneous stone withheld to avoid disclosing company proprietary data.
[2]Includes other coarse and fine aggregates.
[3]Less than 1/2 unit.
[4]Includes withheld amounts for agricultural.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.
[6]Data may not add to totals shown because of independent rounding.

decrease in the estimated value of the sand and gravel to 6%, resulting in an estimated total value of $2,300,000.

Grove Farm Rock Co. completed expansion of its aggregate facility on the Island of Kauai. Additional screening and conveyor capacity was installed to complement the increased crusher capacity expansion begun in 1989 at its basalt quarry.

Stone (Crushed).—Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1990 and actual data for 1989 and 1991.

The crushed stone production of 10 million short tons in 1991 was about 70% higher than that reported in 1989.

[1]State Mineral Officer, U.S. Bureau of Mines, Reno, NV. He has 25 years of mineral-related government experience and has covered the mineral activities in Hawaii for 9 years. Assistance in the preparation of the chapter was given by Marguerite Roberto, program assistant.

TABLE 3
HAWAII: CRUSHED STONE SOLD OR USED, BY KIND

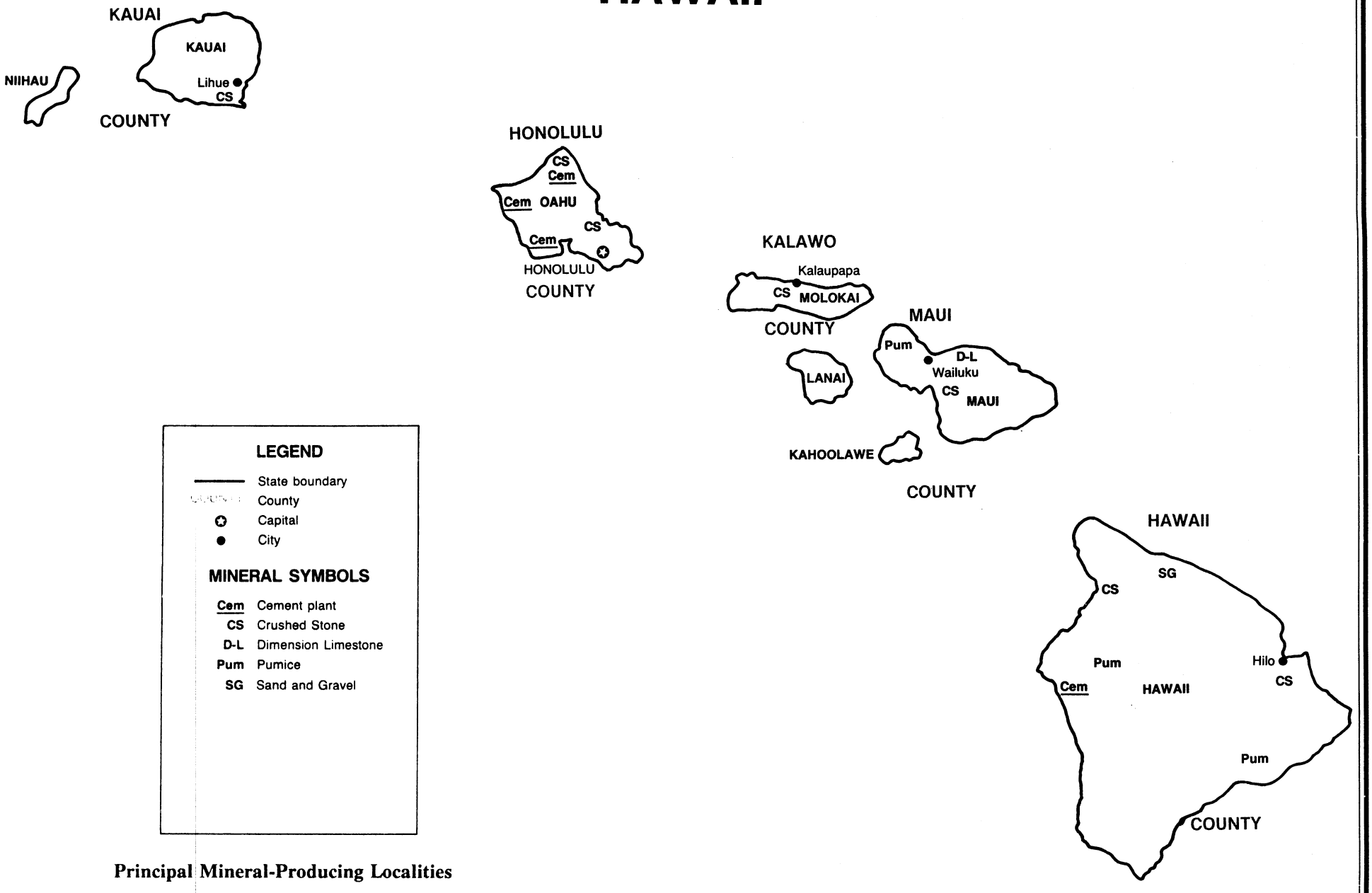
Kind	1989				1991[1]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	6	650	$3,600	$5.54	7	2,804	$24,471	$8.73
Granite	—	—	—	—	1	W	W	10.53
Traprock	14	5,475	42,965	7.85	13	7,269	62,534	8.60
Volcanic cinder and scoria	2	W	W	2.18	7	W	W	4.43
Miscellaneous stone	1	W	W	3.00	—	—	—	—
Total[2]	XX	6,205	46,746	7.53	XX	10,486	90,563	8.64

W Withheld to avoid disclosing company proprietary data, included in "Total." XX Not applicable.
[1]Excludes miscellaneous stone; withheld to avoid disclosing company proprietary data.
[2]Data may not add to totals shown because of independent rounding.

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Hawaii Cement	Barbers Point Plant 91-044 Kaomi Loop Ewa Beach, HI 96706	Cement plant	Oahu.
Sand and gravel (construction):			
Amelco Corp., Maui Concrete	Box 488 Kuhului, HI 96732	Plant and pit	Maui.
Kauai Sand & Gravel Inc.	4247 Kapaia Rd. Lihue, HI 96766	do.	Kauai.
Stone (crushed):			
Allied Aggregates Corp.	761 Keaa St. Hilo, HI 96720	Quarries	Hawaii.
Ameron Honolulu Construction & Drayage Ltd.	Box 29968 Honolulu, HI 96820	do.	Oahu and Maui.
Grace Pacific Corp., Concrete & Rock Div.	91-220 Farrington Hwy. Ewa Beach, HI 96707	do.	Do.
Grove Farm Rock Co., Inc.	Puhi Rural Station Lihue, HI 96776	do.	Kauai.
Herbert Tanaka Co.	87-1748 Farrington Hwy. Waianae, HI 96792	Quarry	Oahu.
Kuwaye Bros Inc.	160 Keaa St. Hilo, HI 96720	do.	Hawaii.
Lone Star Hawaii Rock Products	11555 Dublin Canyon Rd. Pleasanton, CA 94566	do.	Oahu.

HAWAII



Principal Mineral-Producing Localities

THE MINERAL INDUSTRY OF IDAHO

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Idaho Geological Survey for collecting information on all nonfuel minerals.

By R. J. Minarik[1] and V. S. Gillerman[2]

Nonfuel mineral production for Idaho in 1991 was valued at $297 million, a decrease of more than 21% from that of 1990, according to the U.S. Bureau of Mines. A drop in the production values for molybdenum, silver, and zinc accounted for the bulk of the decrease.

Phosphate rock continued to be the leading mineral commodity in terms of value, followed in order by silver, gold, construction sand and gravel, lead, and crushed stone. The aggregate value of the metallic minerals—antimony, copper, gold, lead, molybdenum, silver, vanadium, and zinc—dropped 46% from that reported in 1990. The drop in the value of metallic minerals and an almost 23% increase in the value of industrial minerals resulted in industrial minerals accounting for more than one-half of the State's nonfuel mineral production value, compared with 36% in 1990 and 38% in 1989.

Idaho ranked 33d nationally for total mineral production value compared with 26th in 1990. The State was the Nation's sole producer of antimony and vanadium, ranked first in garnet production, second in silver and the quantity of phosphate produced, third in lead, and fourth in perlite.

TRENDS AND DEVELOPMENTS

Idaho's mining industry was hit hard by the continuation of depressed prices for many base metals, precious metals, and ferroalloys. Aggregated value for the

TABLE 1
NONFUEL MINERAL PRODUCTION IN IDAHO[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	metric tons	W	W	W	W	967	W
Copper[3]	do.	2,950	$8,516	W	W	W	W
Feldspar	do.	11,612	720	W	W	W	W
Gemstones		NA	500	NA	$320	NA	$426
Gold[3]	kilograms	3,057	37,602	W	W	3,348	39,107
Lime	thousand short tons	W	W	W	W	150	9,124
Phosphate rock	thousand metric tons	W	W	4,380	r67,978	5,921	86,328
Pumice	metric tons	W	W	31,333	220	36,868	267
Sand and gravel:							
Construction	thousand short tons	e5,800	e18,900	9,222	25,590	e11,600	e31,300
Industrial	do.	459	5,037	552	6,234	W	W
Silver[3]	metric tons	439	77,651	r442	r68,418	337	43,807
Stone:							
Crushed	thousand short tons	3,298	12,609	e4,300	e12,900	3,230	15,057
Dimension	short tons	W	W	—	—	3,596	W
Combined value of antimony, cement, clays, [bentonite (1989), common, kaolin], garnet (abrasive), lead, molybdenum, perlite, vanadium ore, zinc, and values indicated by symbol W		XX	203,075	XX	r195,977	XX	71,632
Total		XX	364,610	XX	r377,637	XX	297,048

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.
[3]Recoverable content of ores, etc.

State's metals production dropped 46%, with a decline in value reported for all metals. Low silver and base metal prices exacted a heavy toll on mines in the Coeur d'Alene Mining District; two metal mines were closed and two others cut back exploration and development and reduced production. Workers were laid off at the State's only molybdenum mine, and production was pared.

On the plus side, total production value for Idaho's industrial minerals increased by almost 23%, with an increase in production value reported for many of the industrial minerals. Phosphate rock, the State's highest valued mineral commodity, and lime had the largest absolute value increases in 1991. Although the price of phosphate rock decreased slightly, companies continued expansion and renovation work on their plants, resulting in an increase in the quantity produced. The rise in the value of lime production reflected both an increase in output and product value.

EMPLOYMENT

After 3 consecutive years of increases, employment in Idaho's mining sector dropped. According to the Research and Analysis Bureau of the Idaho Department of Employment, overall mining employment averaged 3,076 employees, a decrease of more than 21% from that of 1990. The average number of metal mining employees declined by almost 29% to 1,983.

The average hourly wage for mining in 1991, which included premium pay for overtime and late shift work as well as changes in basic hourly and incentive wages, was $14.17. Average weekly earnings were $561, an increase of $27 from that of 1990; the average length of the workweek declined from 40 hours in 1990 to 39.6. In its December 1991 monthly report, commenting on the drop of employment in the State's mining industry, the Idaho Department of Employment stated, "Not only has this decline had significant effects on local economies, the poor prospects for mining to ever recover its former glory means that hundreds of relatively high wage jobs have disappeared and most likely will be replaced by lower wage jobs in the trade and services sector."

REGULATORY ISSUES

Cleanup continued within the 54-square-kilometer Bunker Hill Superfund site in the Coeur d'Alene Mining District, Shoshone County. Work included removing soil from residential yards, planting trees, building erosion control terraces and rock dams, and mitigating dust. Public hearings and the establishment of long-term plans occupied a large part of the year. Eight companies, designated by the Environmental Protection Agency (EPA) as potentially responsible parties, submitted a 7-year plan to clean up the site. The proposal, estimated to cost about $120 million, called for removing contaminated soil from residential yards, cleaning interiors of homes, treating contaminated ground and surface waters, demolishing the closed smelter, covering surface impoundments and waste piles, improving water systems, controlling fugitive dust, replanting hillsides, and providing health screening for residents. Using the plan as a starting point, officials from the EPA, the Idaho Department of Health and Welfare, and the mining companies will work together to shape the proposal into a solid plan of action. The eight companies are ASARCO Incorporated, Callahan Mining Corp., Coeur d'Alene Mines Corp., Gulf Resources and Chemical Corp., Hecla Mining Co., Stauffer Chemical Co., Sunshine Precious Metals Inc., and the Union Pacific Railroad. Bunker Hill Mining Co. also was considered a "potentially responsible party" by the EPA but filed for bankruptcy protection.

The EPA held public hearings to determine whether FMC Corp., at its Pocatello elemental phosphorus plant, could receive a waiver that would allow the company to exceed EPA's current radionuclide emissions standards imposed on the Nation's phosphorus producers. After the EPA reduced the federally allowable level of radioactive emissions from 21 to 2 curies in December 1989, FMC installed new state-of-the-art scrubbers, estimated to cost $14 to $21 million, on its four calcining furnaces, but still may not be able to meet the new standards at all times. With the waiver, the company would like the standard set for its plant at 4.5 curies. FMC's elemental phosphorus plant is the world's largest.

The EPA announced that the J. R. Simplot Co.'s fertilizer complex and FMC's elemental phosphorous plant in Pocatello were formally added to the East Michaud Superfund site. Heavy metals detected in soil and water at the site prompted the listing. Both companies agreed to conduct remedial investigation and feasibility studies, to pay for the studies and cleanup, and according to the Idaho Geological Survey (IGS), were cooperating fully with State and Federal agencies.

Coeur d'Alene Mines received the DuPont-Conoco Environmental Leadership Award for reclamation efforts at its Thunder Mountain gold mine and other properties. The company was specifically recognized for its corporate management philosophy and organizationwide commitment to environmental excellence. Thunder Mountain, sited in rugged country east of McCall, Valley County, was mined out in 1990. Reclamation work included neutralizing leach pads, ripping out asphalt pads, backfilling solution holding ponds with clay, removing buildings and foundations, and recontouring, seeding, and mulching surrounding grounds. The $50,000 prize was to be distributed with $20,000 each to the College of Environmental Science of the University of Alaska Southeast, Juneau, AK, and the University of Nevada Mackay School of Mines, Reno, NV, and $10,000 to the Nature Conservancy in Idaho.

Hecla received the State's top award for surface mining from the Governor and the State Land Board for outstanding mining practices and reclamation at the Yellow Pine heap-leach gold mine east of McCall.

EXPLORATION ACTIVITIES

Exploration activity in Idaho was down about 50% from that of 1990, according to the IGS. The principal target of 42 advanced projects was gold, although a few projects for base metals were underway and a number of firms explored for industrial minerals. Four projects under development were delayed in part by low gold prices and lack of wetland permits. These were FMC Gold's Beartrack project at Leesburg, Idaho Gold Corp.'s Buffalo Gulch Mine near Elk City, Hecla's Grouse Creek project in Custer County, and Nerco Minerals Co.'s proposed Stone Cabin Mine in Owyhee County. A new gold discovery near Shale Mountain in the Kelly-Cayuse Roadless Area, north of Lolo Pass in Clearwater County, was announced by a team of scientists from the U.S. Bureau of Mines, U.S. Geological Survey, and the IGS, which mapped and sampled the breccia-hosted occurrence.

Exploration activity in northern Idaho, especially in the Coeur d'Alene Mining District, was down considerably. A number of the silver and lead mines either closed or reduced production, and normal exploration work surrounding the properties was dropped, including the well-known Caladay project recently acquired by Coeur d'Alene Mines. Shoshone Silver Co. continued to drive an exploration drift at the Keep Cool Mine in the Lakeview district, Bonner County. The company stockpiled lead and silver ore while waiting for more favorable prices. Golden Chest Inc., a subsidiary of Viking Investment Corp., continued exploration and development of the Golden Chest Mine 2 kilometers east of Murray. Newmont Mining Co. had drilled and returned the property to Golden Chest in 1990.

Kennecott Exploration drilled, mapped, and sampled three polymetallic projects in Latah and Clearwater Counties. Results continued to be evaluated by Kennecott on the LBC prospect on Little Bear Creek near Troy; Kennecott's property at the old King David polymetallic mine above Ruby Creek east of Bovill was dropped, along with the Lad project on Laguna Creek north of Bovill.

In Idaho County, Newmont Exploration Ltd. drilled for the second year at Leggett Creek near Golden and Cominco drilled in the Red River/Big Creek area near Dixie. A small operator, NJB Mines Inc., test milled ore from an open pit gold mine on the Ko-Dan claims north of the Red River Ranger Station. According to the IGS, a 23-metric-ton-per-day gravity mill was built at the Johnson Ranch, about 11 kilometers from the mine. Unity Gold Mines Inc. retimbered a section of the old Unity gold mine in Warren and leased the nearby Cochran property. Also in Warren, at the Rescue Mine, Jim Striker was putting in a new decline to access the Rescue vein.

In Lemhi County, exploration activity continued to center around FMC's Beartrack property, albeit less than that in the past couple of years. FMC returned the Arnett Creek property, a gold prospect on 69 square kilometers adjacent to and west of Beartrack, to owner American Gold Resources Corp. Also near Beartrack, Formation Capital Corp. controlled more than 155 square kilometers, including the northern extension of the Panther Creek Fault. Formation Capital continued surface exploration, some with joint-venture partners, on several projects, including the Bobcat, King Solomon, Moose Creek, Morning Glory, and Redrock properties. The company did surface mapping, geophysical surveys, and soil sampling, particularly on the Bobcat and Redrock land packages. New targets were identified in the Moose Creek area, north of Beartrack, and at Comet Creek Ridge, also in the district. Gold Fields Mining Corp. completed reclamation work after drilling at the joint ventures with Formation Capital, Teck Exploration Ltd. drilled at the Morning Glory property and did some reclamation work in the King Solomon Mine area, and Hecla continued assessment of the Bowman claims near Williams Pass.

Also in Lemhi County, FMC had disappointing results from its exploration at the headwaters of Fourth of July Creek east of North Fork; and near Shoup, West Fork Gold Co. analyzed drill data from its property on the West Fork of Indian Creek and Noranda Exploration Inc. worked at McConn Creek. In addition to mapping and sampling, Atlas Precious Metals Corp. had a late season drilling program at Musgrove Creek; Panther Gold Co. drilled Rabbitsfoot; and Cominco did mapping, geochemistry, and geophysics at the Iron Creek property south of Salmon.

In south-central Idaho, in the Yellow Pine area of Valley County, Placer Dome Ltd. drilled at the Red Mountain project near Quartz Creek; Cambior USA Inc. mapped and sampled on a ridge west of Johnson Creek south of Yellow Pine; Kennecott continued its drilling and mapping program at the Moscow Mine in the Moore Creek drainage near Big Creek; and the joint partnership of Great Basin Exploration Co. and Nerco explored for gold at the old McCrae tungsten mine about 13 kilometers northwest of Edwardsburg on a tributary of Big Creek. To the west, Cominco staked claims and explored for massive sulfides near Peck Mountain, northwest of Council, Adams County.

Umont Mining Inc. and Western Mining Co. USA worked in the Bayhorse district in Custer County. The companies were cooperating with the Idaho Parks and Recreation Department to preserve historic buildings and sites in the district. Sunshine Mining Co., with partner N. A. Degerstrom Co., resumed drilling on a gold skarn in the Washington Basin of the Sawtooth National Recreational Area. The project was dropped, with Sunshine citing corporate financial difficulties and Degerstrom citing environmental sensitivity. Cyprus Minerals Co. explored for gold on claims near its molybdenum mine at Thompson Creek. Westmont Mining Inc. continued work in the Boulder Mountains at the head of the North Fork of the Big Lost River, but Westmont's parent company, Costain Minerals, later sold all its base metal assets to Cambior. Plexus Resources Corp. worked, then put on hold, two properties at Navarre Creek west of Mackay, and North Lily Mining Co.

acquired the Copper Basin property. The approximately 3-square-kilometer deposit is a possible open pit and/or underground gold-copper project. Biomyne Inc. continued gold exploration, including drilling, sampling, and trenching, in hills along the West Fork of Warm Springs Creek about 10 kilometers west of Ketchum, Blaine County. Precious Metals Technology Inc. planned to move its cyanide mill from the Princess Blue Ribbon Mine, 23 kilometers northeast of Fairfield in Camas County, to the Doniphen Mine, 19 kilometers west of Hailey. The gold mine was closed when a tailings dam collapsed in 1990, sending water and sediments into Beaver and Willow Creeks.

In the Weiser area of southwest Idaho, Noranda drilled and returned the Blue Dog hot-springs gold property to Gold Canyon Resources Inc.; adjacent to the Blue Dog, the joint venture of Silver Standard Resources, Carlin Resources, and Bradner Resources explored the Chandler property. AMAX Exploration Inc. leased the Idaho-Almaden gold property from ICAN Minerals Ltd., then sampled, mapped, and drilled a number of holes at the old mercury mine. Atlas Corp. explored at Thirsty Mountain; Manville Corp. ran geophysics at its Indianhead claims; and Western Epithermal and the J. L. Carroll Mineral Exploration Office drilled on the WD-VAR claims near the mouth of Crane Creek.

In the Boise Basin area, Cactus West Exploration Ltd. sampled for gold on its Centerville project near Placerville; the property was previously considered for its copper and molybdenum. Approximately 13 kilometers to the southwest, Pegasus Gold Inc. drilled on Cactus' Century claims by the Gold Hill Mine, near Quartzburg. Equinox Resources Ltd. worked at the Boise Queen Mine, including sampling of the Boise Queen, West, and Celtic shear zones. Cominco worked on the Elk Horn project north of Idaho City, while Independence Mining Co. maintained its claims at the Mineral Mountain project near Alder Creek Summit.

Newmont drilled for the final year on claims leased from GEXA Gold Corp. in the Rocky Bar district, Elmore County. Mineralization was found along a northeast trend from Red Warrior Gulch to Spanish Town, including the area drilled at the Ophir Mine near Hardscrabble Gulch. The property was dropped and returned to GEXA. Cactus West sampled for gold on claims near the Bonaparte Mine and Cayuse Creek southeast of the town of Rocky Bar. Also northeast of Boise in Elmore County, Newmont completed a deep-drilling program to test the high-grade gold veins below known low-grade deposits on top of Atlanta Hill. The company returned the metallurgically complex property to Atlanta Gold Corp., which continued with its own drill program.

In the Owyhee Mountains north of the DeLamar Mine, Nerco drilled its Twin Peaks project, and Placer Dome drilled at the Black Sheep prospect in Slaughterhouse Gulch. War Eagle Mining Co. leased its epithermal targets on War Eagle Mountain above Silver City, Owyhee County, to Great Basin Exploration Corp.

In southeast Idaho, Atlas mapped in the Magpie Basin and Rock Creek areas south of Twin Falls; Gold Fields mapped and sampled the Cherry Creek property near Malad; Newmont returned to drill the Caribou Mountain property in Bonneville County; and Placer Dome continued a drilling program at its gold prospect northwest of Kilgore near Dubois.

LEGISLATION AND GOVERNMENT PROGRAMS

Construction began on the Idaho Department of Parks and Recreation's mining interpretive center near Challis, on an 81,000-square-meter site at the junction of U.S. 93 and State Highway 75. The center will include interpretive displays and audiovisual programs on Idaho's mining history in the region. A circle road tour was also being developed; included in a number of posted stops would be the historic Yankee Fork gold dredge.

The Mining and Mineral Resources Institute of the University of Idaho, at Moscow, received an allotment of $148,000 from the U.S. Bureau of Mines. The school has received a total of $3.65 million since inception of the Mineral Institute Program in 1978.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Both the quantity and value of Idaho's cement production remained essentially unchanged from those of 1990. The State's only cement producer was Ash Grove Cement West Inc. at Inkom in Bannock County. Most of the cement produced was general-use, moderate-heat Types I and II gray portland cement. Lesser quantities of Type III high-early-strength portland cement and masonry cement were also produced. Users of the finished portland cement included ready-mix concrete companies, highway and other contractors, concrete product manufacturers, and building material dealers. Limestone and quartzite used in the cement production were quarried from nearby.

Clays.—Idaho's reported clay production dropped in quantity and value from that of 1990. Common clay for brick production was mined by Interpace Corp. Clayburn Industries operated a kiln at the old Simplot clay plant near Deary in Latah County. The calcined clay was shipped to Clayburn's refractory brick plant in British Columbia, Canada. Applied Industrial Minerals Corp. (AIMCOR) operated the Ben-Jel bentonite pit near Oreana, Owyhee County. The company processed the white clay for use in papermaking at a plant in Caldwell. E. J. Wilson and Sons produced bentonite from the Morning Glory property for the sealing of fish ponds, basements, and water hazards on golf courses.

Diatomite.—Grefco Inc. continued assessment and development work at its Deep Creek diatomite property in Owyhee County. According to the IGS, the deposit is one of the highest grade diatomite deposits in North America. Work included reclamation of areas disturbed by exploration efforts in 1990.

Feldspar.—Feldspar production rose slightly in quantity and more than 6% in value from that of 1990. Unimin Corp. in Emmett, Gem County, was the State's sole producer. The company produced a feldspar-silica sand mixture used mainly in glass production, but also for sandblasting and golf courses.

Garnet.—Garnet production rose more than 4% in quantity and value from that of 1990. Emerald Creek Garnet Milling Co. Inc., which operated the State's only commercial garnet mine near Fernwood, Benewah County, and was the Nation's largest garnet producer, was sold to Hawkeye Development Ltd. of Canada. In addition to gem-quality stones, including star garnets, the mine was one of the world's largest producers of garnets used for industrial abrasives. Using five washing plants, the company mined garnet year-round from two sites on Carpenter Creek and three locations on Emerald Creek. Each of the washing plants can support about 16,000 square meters of placer mining per year. The mine site included a shop, jig plant, and a sizing and bagging plant. The recovered garnet was milled to varying coarseness for use in water filtration, sandblasting, and polishing.

Gemstones.—The value of gemstone production increased 33% from that of 1990. Many of the active gemstone collection areas continued to be in Benewah, Boise, Clark, Clearwater, and Latah Counties. Aquamarine, garnet (including star garnet), jasper, smoky quartz, precious opal, topaz, and turquoise were among the gem materials recovered during the year. The U.S. Forest Service closed the Sawtooth National Recreational Area to mineral and crystal collecting. Officials said it was not a new law, just a 19-year-old law being enforced. A special permit may be granted by the Forest Service for collecting minerals for scientific research.

Lime.—Lime production in Idaho increased significantly in both quantity and value from that of 1990. Three lime plants operated by Amalgamated Sugar Co. in Canyon, Minidoka, and Twin Falls Counties accounted for all of the State's 1991 reported lime production. The raw material was shipped by rail from Ash Grove Cement's limestone quarry in Durkee, OR. The quicklime was used in the manufacture of sugar.

Chemstar Lime Co. began construction on its new Tenmile lime plant and quarry near Bancroft, Caribou County. The lime will be mined from a Mississippian algal-reef limestone deposit, and the plant was expected to produce up to 600 tons of high-calcium lime daily. Steel plants, soda ash operators, and heap-leach gold operations are targeted markets. A new high-efficiency Maerz gas-fired vertical kiln was being installed, along with fabric dust filters and automated controls. The plant was expected to be very efficient and environmentally clean. Plans called for the construction of a new railroad terminal complex in Bancroft.

West One Minerals continued negotiations with Amalgamated Sugar to supply lime for its sugar beet factory in Nampa. A sample was shipped to the plant for testing. The limestone was mined from a quarry near Leslie Butte, about 32 kilometers north of Arco, Butte County.

Perlite.—Perlite production decreased more than 16% in quantity and almost 11% in value from that of 1990. National Perlite Products Co., a division of Oglebay Norton Co., mined perlite from the Oneida Mine in the Wrights Creek drainage of the Caribou National Forest about 40 kilometers north of Malad City, Oneida County. The perlite was processed and expanded at the company's plant in Malad City. Late in 1991, the plant was closed because of air quality violations. As a result, the company was testing the use of harder perlite ore and new dust abatement equipment. The expanded product was used for industrial filters, in fireproofing, and as a filter medium.

Phosphate Rock.—The quantity of phosphate rock production increased more than 35% and, based on the 1990 revised figure, value increased by more than 10%. Idaho rose from the third to the second ranking State in marketable phosphate output. None of the Idaho phosphate producers marketed phosphate rock as a salable commodity. Monsanto Co. and FMC produced elemental phosphorus, Simplot and the Conda Partnership made various grades of phosphoric acid, and Rhone-Poulenc Basic Chemicals Co. shipped ore to its elemental phosphorus plant in Montana.

With two operating mines, one with the largest output in the State, Simplot was Idaho's top ranked phosphate rock producer in 1991. Simplot mined phosphate at the Smoky Canyon Mine, near the Idaho-Wyoming border in Caribou County, and at the Gay Mine, about 48 kilometers northeast of Pocatello on the Fort Hall Indian Reservation in Bingham County. Simplot completed an 140-kilometer slurry pipeline from the Smoky Canyon Mine near Afton, WY, to the company's phosphoric acid and fertilizer complex at Pocatello. With the pipeline, ore can be pumped directly from the mine to the Pocatello plant, bypassing the company's calcining plant at Conda. Simplot developed a proprietary filter and digestion process that uses uncalcined, organic-bearing ore in the manufacture of agricultural fertilizers, thus enabling the company to shut down its three calciners, making the Conda plant obsolete. One direct result was a reduction of particulate emissions. At the fertilizer plant, the new process technology was expected to significantly reduce air emissions and energy consumption. With the ore being used directly, it eliminates the need for ore stockpiles, thus reducing dust pollution. At the Smoky Canyon mine site, Simplot began work on a new tailings impoundment early in 1991. To

ensure no net loss of wetlands and to receive its 404 (wetlands) permit from the EPA and the U.S. Army Corps of Engineers, the company will restore up to 790,000 square meters of former wetlands lost to livestock and other uses.

Owing to dwindling reserves, the Gay Mine has been tentatively scheduled for closure in 1994. Mine production was processed by Simplot into phosphoric acid and by FMC into elemental phosphorus at their Pocatello plants. The Gay Mine has been a large contributor to the Shoshone-Bannock Tribes' tax base, a major employer on the reservation. Simplot received an award from the State Land Board for its reclamation work at the mine.

To replace the production of high-grade ore from the Gay Mine, FMC started development and will be the operator of a new phosphate mine in Dry Valley about 40 kilometers northeast of Soda Springs, Carbon County. With an estimated mine life of 20 years, plans were for the mine to be in full production by early 1995. The company began construction of a railroad siding at the mine site in order to rail-ship the ore to its Pocatello plant.

Simplot and EG&G Idaho Inc. signed a research agreement to study the possible use of biotechnology in the extraction of phosphate from ore. The process, developed by EG&G, uses microorganisms at the mine site to separate the phosphate from waste rock. Plans were to build a small pilot plant at Simplot's Pocatello facilities to test the process.

Monsanto was Idaho's second largest phosphate rock producer. In 1991, the company began processing ore from its new Enoch Valley Mine in Caribou County. Enoch Valley replaced the company's Henry Mine about 6 kilometers to the west, which closed in 1990. The new mine has an estimated 14 years of reserves. The ore is hauled by truck to Monsanto's elemental phosphorus plant at Soda Springs.

Rhone-Poulenc was the State's third ranked phosphate rock producer. With reserves at the company's Wooley Valley Mine exhausted, Rhone-Poulenc began mining phosphate on its lease at the southern end of Rasmussen Ridge, about 29 kilometers northeast of Soda Springs. Ore was transported on a 6-kilometer haulage road to its mill at the Wooley Valley mine site, washed, then shipped by rail to the company's elemental phosphorus plant in Silver Bow, MT.

The fourth ranked phosphate rock producer was the Conda Partnership, a joint venture of NuWest Industries Inc. and Western Cooperative Fertilizer Ltd. of Calgary, Alberta, Canada. The partnership contracted to have phosphate rock mined at the Mountain Fuels Lease in Dry Valley, Caribou County. The ore was beneficiated at the venture's calcining plant, and the calcined product was moved by conveyor to NuWest's adjacent Conda phosphate fertilizer complex. The fertilizer plant manufactures super phosphoric acid and five different dry products.

Pumice.—Output of pumice in Idaho increased almost 18% in quantity and more than 21% in value from that of 1990. Pumice was produced by two operations in Bonneville County and by one in Oneida County. Hess Pumice Products operated a mine on Wrights Creek, north of Malad City in Oneida County, and an automated pumice processing plant at Malad City. The very pure fine-grained pumice had a variety of uses as an abrasive, lightweight aggregate, and filler.

Amcor Inc. quarried pumice from its Sunnyside pit along the west flank of the Blackfoot Mountains, near Ammon in Bonneville County. The material was trucked to Idaho Falls where it was crushed, screened, and used for lightweight concrete aggregate. Also near Ammon, Producers Pumice, a subsidiary of Builders Masonry Products, operated the Rock Hollow Mine. The pumice was shipped by rail to Meridian, where it was crushed, screened, and used for lightweight concrete aggregate.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

The estimated 1991 output of construction sand and gravel in Idaho increased almost 26% in quantity and more than 22% in value from that reported in 1990.

Industrial.—Industrial sand and gravel production dropped in both quantity and value from that of 1990. Output came from three pits in three counties: FMC in Power County; Monsanto near Soda Springs, Caribou County; and by Unimin Corp. at the top of Freeze Out Hill east of Emmett, Gem County. Uses of the industrial sand and gravel included glass containers, sandblasting sand, specialty sands, and nonmetallurgical flux (slag) in electric furnaces at elemental phosphorus plants.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Crushed.—The quantity of crushed stone produced in 1991 dropped 25% from that estimated in 1990 but remained essentially the same as that reported in 1989. The value increased almost 17% from that of 1990 and more than 19% from the reported 1989 figure.

Crushed stone production was reported by 33 companies and governmental agencies in 22 counties. The top three counties in the production of Idaho's crushed stone, in order of value, were Idaho, Caribou, and Bannock. Combined with Benewah and Nez Perce Counties, the top five producing counties accounted for more than 60% of the State's total crushed stone production value.

Eight companies and government agencies accounted for two-thirds of the quantity produced and 70% of the value. The bulk of the crushed stone produced was limestone and traprock, which

TABLE 2

IDAHO: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Riprap and jetty stone	24	91	$3.79
Filter stone	1	2	2.00
Coarse aggregate, graded:			
Concrete aggregate, coarse	15	101	6.73
Bituminous aggregate, coarse	288	1,525	5.30
Bituminous surface-treatment aggregate	105	377	3.59
Fine aggregate (-3/8 inch):			
Stone sand, concrete	10	80	8.00
Stone sand, bituminous mix or seal	8	20	2.50
Screening, undesignated	44	168	3.82
Coarse and fine aggregates:			
Graded road base or subbase	705	2,143	3.04
Unpaved road surfacing	414	1,893	4.57
Terrazzo and exposed aggregate	W	W	4.22
Crusher run or fill or waste	14	50	3.57
Other construction materials:[2]	21	248	11.81
Roofing granules	(3)	(3)	3.00
Agricultural:			
Agricultural limestone	25	77	3.08
Poultry grit and mineral food	16	109	6.81
Chemical and metallurgical: Flux stone[4]	718	5,355	7.46
Special: Mine dusting or acid water treatment	1	11	11.00
Unspecified:[5]			
Actual	814	2,787	3.42
Estimated	5	20	4.00
Total	[6]3,230	15,057	4.66

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes granite, limestone, miscellaneous stone, quartzite, shell, traprock, and volcanic cinder and scoria.
[2]Includes withheld amounts for coarse and fine aggregates.
[3]Less than 1/2 unit.
[4]Includes cement manufacture and sulfur oxide removal.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.
[6]Data do not add to total shown because of independent rounding.

accounted for almost 69% of the total in 1991. The top four uses of crushed stone specified in the survey—flux stone, graded roadbase, unpaved road surface, and bituminous aggregate—accounted for more than 68% of the crushed stone sold or used in the State.

Dimension.—Idaho Travertine Corp. operated a stone-cutting plant at Idaho Falls, Bonneville County, and a travertine quarry east of the city. Some of the travertine quarried in 1991 was used to finish the interior of the Idaho Power building in Boise. Decorative sandstone was quarried at the Table Rock property in Ada County by Table Rock Sandstone Inc. Part of the stone production was shipped to Idaho Travertine's plant for processing, then used as facing for public buildings and private homes.

A number of companies marketed Oakley Stone from quarries south of Oakley, Cassia County. Northern Stone Supply Co. operated the Rocky Mountain Quartzite quarry, selling slab quartzite for paving and facing applications. Oakley Valley Stone Co. mined and sold quartzite from the Valley View Mine. Idaho Quartzite Corp. purchased quartzite from other contractors and shipped flagstone to markets in the United States and overseas. The Rocktile Co. of Boise bought slabbed, roughed quartzite, cut the stone to tile, and sold most of it as a facing stone.

Zeolites.—Teague Mineral Products Co. mined clinoptilolite from a quarry near the old townsite of Sheaville on the Idaho-Oregon border just north of U.S. Highway 95 in Owyhee County. The company trucked the ore to its processing plant at Adrian, OR. Along with mine output from deposits in southeastern Oregon, the zeolite was sold for ammonia absorbent in aquarium systems, animal feed supplement, anticaking agents, fungicide carriers, odor control, and wastewater treatments.

Metals

Antimony.—Idaho was the only State in the Nation reporting antimony production in 1991. Production decreased about 56% in quantity and value from that of 1990. Sunshine Mining recovered antimony as a byproduct from the electrolytic treatment of tetrahedrite, a complex silver-copper-antimony sulfide that is the principal ore mined at the Sunshine Mine near Kellogg, Shoshone County. The antimony output dropped as a result of an overall reduction in ore production at the mine.

Copper.—Idaho's copper production dropped by almost 35% in quantity and 42% in value from that of 1990. The major copper-producing region in the State continued to be the Coeur d'Alene Mining District where copper was produced as a byproduct at the following mines: the Coeur, Galena, Lucky Friday, and Sunshine. Three of the four mines reduced output; only the Galena Mine continued a normal production schedule.

Gallium.—In February, N. A. Degerstrom began extracting gallium and silver from "treater dust," a waste

TABLE 3
IDAHO: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	8	960	$4,575	$4.77	11	1,027	$5,274	$5.14
Shell	—	—	—	—	2	53	200	3.78
Granite	8	167	425	2.54	5	322	1,702	5.29
Traprock	23	2,083	7,428	3.57	22	1,190	4,324	3.63
Quartzite	5	88	182	2.07	3	338	2,830	8.37
Volcanic and scoria	—	—	—	—	2	W	W	4.18
Miscellaneous stone	—	—	—	—	2	W	W	1.23
Total[1]	XX	3,298	12,609	3.82	XX	3,230	15,057	4.66

W Withheld to avoid disclosing company proprietary data, included in "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

product from Monsanto's elemental phosphorus plant near Soda Springs. In August, malfunctioning equipment forced a temporary shutdown of the $2.25 million chemical processing plant. In the extraction operation, still in the testing stage, gallium was recovered by solvent extraction and silver by a cyanide leach. Phosphate and zinc were also removed. Gallium was sold to the electronics industry where it was used to make gallium arsenide computer chips.

Gold.—Gold production decreased by more than 9% in quantity and more than 14% in value from that of 1990. The State ranked eighth nationally in gold production in 1991.

Nerco's DeLamar gold-silver mine, 32 kilometers east of Jordan Valley, OR, in Owyhee County, continued at its full operating level during the year and was the State's largest gold producer in 1991. The property includes an open pit, a countercurrent decant mill, a vat-leach plant, and a heap-leach facility; the heap-leach facility was closed all year. A mill expansion was completed, increasing the average throughput to about 3,100 tons per day; the company hopes to increase that to 3,500 tons per day. Gold and silver ore was mined from the Sommercamp, Glensilver, and South Wahl pits. The company was constructing an acid volatilization plant that will allow Nerco to recover and reuse cyanide and prevent it from entering the mine's pond water. In ongoing exploration efforts, Nerco drilled north of the mine on the Ohio property where it intersected mineralization.

The Stibnite Mine, owned and operated by MinVen Gold Corp., was Idaho's second ranked gold producer in 1991. MinVen Gold became the sole owner of the Stibnite Mine after purchasing the remaining 50% interest from Pegasus, which had earlier acquired its holdings from Pioneer Metals Corp. as a result of a lawsuit. The suit involved default on a loan from Pegasus to Pioneer that was secured by the mine. The seasonal open pit, heap-leach operation is 24 kilometers southeast of Yellow Pine, Valley County. Mining was concentrated in the West End pit; other reserves include the Midnight, Northeast, Stibnite, and Garnet Creek pits. Exploration, including soil and rock sampling, geophysics, and drilling, was ongoing throughout 1991.

Hecla operated the Yellow Pine heap-leach gold mine adjacent to the Stibnite property, about 72 air-kilometers east of McCall. During 1991, Hecla completed mining the low-grade ore out of the Homestake pit and processed oxide ore that was stockpiled from the old Bradley pit. Hecla's operations included an on-site leach pad and gold recovery plant. The mine was closed and reclamation began. According to Hecla's 1991 annual report, the mine produced 546 kilograms (kg) of gold. Hecla was looking for a partner to mine and process refractory gold from the larger sulfide ore body that has been identified under the Bradley pit.

Idaho Gold Corp. produced gold and silver at the Champagne Mine, 32 kilometers west of Arco, Butte County. The open pit, heap-leach mine is on Idaho Gold's Lava Creek property. The company mined the South Zone pit, with additional work being done on a leach pad to accommodate the South Zone ore. To protect the environment, the on-site plant used a Merrill-Crowe process in a closed system with zero discharge. Including the higher grade ore remaining in the main Champagne pit, Idaho Gold expected to complete mining the Champagne property in the spring of 1992, with secondary leaching and reclamation continuing into 1993. The company is 85% owned by BEMA Gold Inc. and 15% owned by Glamis Gold Ltd.

The Yellowjacket Mine, owned and operated by U.S. Antimony Corp. (USAC), is about 24 kilometers southwest of Cobalt, Lehmi County. The surface mine was constructed and the mill opened in a joint venture with BumbleBee Inc. Sited on almost 49,000 square meters of Forest Service land and more than 49,000 square meters of private land, the property was drilled out by Westgold in 1989. The new 250-ton-per-day mill averaged about 150 tons per day of actual output. The concentrates were further processed at USAC's custom mill at Preachers Cove on the Yankee Fork. As

a result of a lawsuit, the plant was closed to custom milling late in the year. Plans called for restarting the mill in November to process ore from the Lost Packer Mine on Loon Creek, Custer County, and the Black Mine near Custer.

Pegasus continued development at the Black Pine Mine in Cassia County. Work focused on construction of the leach pad; all other surface facilities were completed. The open pit, heap-leach mine may have to operate on a seasonal basis (8 to 9 months per year), but leaching was expected to continue uninterrupted throughout the year. Pegasus purchased 51% of the Cassia County property from Noranda in 1990 and retained an option to buy the remaining 49%. The 42-square-kilometer property, which contains reserves at three identified pit sites, is centered around the old Tolman Mine in the Black Pine Mountains of the Sawtooth National Forest, southeast of Burley.

Other gold producers included NJB Inc., which started a small open pit gold mine and gravity mill northeast of the Red River Ranger Station near Elk City; the Coeur and Galena silver mines, operated by Asarco; the Sunshine silver mine, owned and operated by Sunshine; and Hecla's Lucky Friday lead mine.

A number of gold placer mines continued to be worked in the State. A and T Mining Co. placer mined the old bed of the Salmon River along Highway 95, south of Lucile, Idaho County, and on John Day Creek. At both locations, the company sold gravel for construction to supplement gold recoveries. Other placer operations included Yellow Eagle Mining Inc. on Orofino Creek near Pierce; several small placers near Dixie; Calumet Placer Mine on claims adjacent to Franklin Creek near Pony Meadows Road in the Florence Basin; and Ted Schaff near Centerville. Also included were a 16,000-square-meter project operated by Coyote Resources and Development in the Boise Basin; the Twin Springs placer on the Middle Fork of the Boise River; and the Golden Chariot Placer operated by Roeder Mining in Elmore County. Others were a placer on South Boone Creek in the Targhee National Forest operated by Mace Riddle of Rexburg, and many recreational suction dredges throughout Idaho.

Important gold projects being developed included FMC's Beartrack property, Hecla's Grouse Creek deposit, Idaho Gold's Buffalo Gulch and Ericson Reef deposits, and Nerco's Stone Cabin project.

Although owner FMC put the project on hold, development drilling and geologic mapping continued at the Beartrack project, approximately 16 kilometers west of Salmon in Lemhi County. The proposed open pit, heap-leach mine, reportedly one of the largest gold discoveries in Idaho's history, is sited near the historic placer mining town of Leesburg in the Mackinaw Mining District. Two large gold deposits have been identified. The deposits, Gold Ridge and North, are situated on the Panther Creek Fault Zone within the Trans-Challis belt. The proposed 3-square-kilometer mine would include two open pits, a cyanide heap-leach pad, waste rock dumps, and other facilities. A negotiated settlement regarding the wetlands issue was reached at yearend, and the company received approval of its environmental impact statement (EIS) from the U.S. Forest Service. Production is estimated at 18,700 kg over a 7-year life. Additional sulfide tonnage underneath the shallow leachable oxide reserves has been identified. FMC owns 71% of the property, Canyon Resources, 15%, and Mirex Partners, 14%.

Development continued on the Grouse Creek gold and silver project, sited 43 kilometers southwest of Challis in Custer County. Hecla became owner and operator of the property when it acquired CoCa Mines Inc. in a stock-exchange merger. CoCa had acquired the property, on Jordan Creek in the historic Yankee Fork Mining District, when it purchased Geodome Resources Ltd., the parent of Sunbeam Mining Co. As a result of extensive drilling, two mineral targets have been identified—the Grouse Creek deposit and the old Sunbeam Mine. In the past, the project was hampered by environmental concerns involving the Pinyon Basin wetland. Wetland and riparian mitigation has been thoroughly addressed by Hecla, and a supplemental EIS was being finalized. Plans called for a 3,000-ton-per-day mill and a carbon-in-pulp circuit.

The Buffalo Gulch open pit, heap-leach property and the Ericson Reef prospect, both owned by Idaho Gold, are part of the Elk City Gold Belt. Final U.S. Bureau of Land Management (BLM) and State permits have been issued for Buffalo Gulch, 5 kilometers northwest of Elk City, and startup was dependent upon financing and gold prices. Reportedly, there were some delays in obtaining the environmental permits, especially the 404 (wetlands) permit, because of the cyanide used in the heap-leaching process. The U.S. Army Corps of Engineers wanted more research done on the possible effect on wetlands. Final permitting was underway for the Ericson Reef deposit, approximately 13 kilometers north-northwest of Elk City. Plans were to mine Buffalo Gulch and Ericson Reef as one unit.

Nerco continued the permitting process to bring its Stone Cabin project into production. The new property, sited on Florida Mountain, is about 8 kilometers east of the DeLamar Mine and would become a satellite operation. The proposed gold and silver operation would include three open pits, with ore processing via conventional milling at DeLamar or on a new heap-leach pad to be constructed on the west slope of Jacob's Gulch.

Lead.—Idaho ranked third nationally in the quantity of lead produced, unchanged from 1990. Although lead production increased by 18% in quantity, value dropped 14% from that of 1990. Lead production was concentrated in the Coeur d'Alene Mining District in Shoshone County, the location of the State's only primary lead mine.

Hecla's Lucky Friday Mine near Mullan, Shoshone County, was the State's leading lead producer. According to Hecla's 1991 annual report, the Lucky Friday Mine produced 18,857 metric tons of lead, 57,600 kgs of silver, 3,164

metric tons of zinc, plus small amounts of copper and gold. In its annual report, Hecla said the mine "... did not operate at a profit," but it "... kept the Lucky Friday open because it is less expensive to operate the mine than it would be to place it on a care-and-maintenance status." The unique Lucky Friday Underhand Longwall Method (LFUL) continued to be used at the mine, particularly in stopes on lower levels, along with a conventional crushing and grinding milling circuit. The LFUL system was designed to enhance safety and improve efficiency by employing more mechanized equipment, including rubber-tired vehicles, a ramp system, and cement sandfill.

Other mines reporting lead production included the Galena Mine, operated by Asarco, and Sunshine's Sunshine Mine. Both mines produced lead as a byproduct of silver.

Molybdenum.—Molybdenum production dropped by nearly two-thirds in quantity and 70% in value from that of 1990. As a result of low prices, a reflection of the continued depressed market worldwide for molybdenum, Cyprus Minerals Inc. laid off more than 100 workers, about 25% of its work force, and reduced production at its Thompson Creek open pit mine west of Challis. Reportedly, the laid off workers were equally divided among mining, milling, and administrative departments. During the year, a considerable amount of development work was completed, especially on the north and east side of the pit. Cyprus continued to operate its high-purity, lubricant-grade molysulfide circuit, newly installed in 1990.

Silver.—Silver production dropped almost 24% in quantity and 36% in value from that of 1990. The State ranked second in the Nation after Nevada in silver production. Sunshine Precious Metals Inc., a subsidiary of Sunshine Mining, was the State's largest producer and the Nation's only vertically integrated silver mining company, operating a silver mine and refinery on Big Creek and a mint near Coeur d'Alene, all in Shoshone County. Sunshine cut employment by more than 60% in June. Reportedly, mine production was to cease in all but a few stopes containing high-grade ore; output for the year was forecasted to be halved. Sunshine laid off most of its exploration staff and moved some employees from Boise to its office on Big Creek. According to Sunshine's 1991 annual report, the mine produced 108,740 kg of silver. The mint produced silver and gold coins and bars, and the company had a contract with the U.S. Government to produce coin blanks.

Callahan Mining Corp. became a wholly owned subsidiary of Coeur d'Alene Mines Corp. when it merged, by stock transfer, with the company. As a result of the merger, Coeur d'Alene Mines acquired Callahan's interest in the Galena Mine, the State's second largest silver producer. The Shoshone County underground mine was operated by Asarco, which holds a 50% joint-venture interest. The mine utilized horizontal cut-and-fill mining and track haulage with battery-powered locomotives. The Galena produced both silver-copper and silver-lead concentrates. According to Coeur d'Alene Mines' 1991 annual report, the Galena Mine continued to operate throughout the year and produced 102,000 kg of silver and 10 kg of gold. Miners at Galena rejected a $4 per hour pay cut that was coupled with a promise/guarantee that the mine would remain open until the current labor contract expires in January 1993.

On April 3, as a result of low silver prices, Asarco temporarily suspended mining at the Coeur Mine and placed the property on care-and-maintenance status. Miners laid off at the Shoshone County mine were eligible for assistance under the Trade Adjustment Assistance program, which provides training and job counseling for workers whose jobs have been lost to foreign competition. The U.S. Department of Labor program was administered by the Idaho State Department of Employment. With its acquisition of Callahan, Coeur d'Alene Mines received Callahan's 5% interest in the Coeur Mine and now owns a 50% operating interest in the property; Asarco, the mine's operator, holds the other 50% interest. According to Coeur d'Alene Mines' 1991 annual report, the Coeur Mine produced 11,800 kg of silver and 2,500 grams of gold.

With the Callahan merger, Coeur d'Alene Mines also acquired the Caladay silver exploration project, an ore body immediately east and connected by a tunnel to the Galena Mine. Over the life of the project, development work at the Caladay has included the sinking of a 1,550-meter shaft and considerable underground drilling. Callahan wrote off almost $1 million of project cost. Underground maintenance was being done by Asarco, who uses the Caladay shaft for ventilation in the Galena Mine.

Other mines reporting silver production included Hecla's Lucky Friday lead mine in Shoshone County and its Yellow Pine gold mine, Valley County; Nerco's DeLamar gold mine, Owyhee County; Bema Gold's Champagne gold mine in Idaho County; and USAC's Yellowjacket gold mine, Custer County.

Vanadium.—Although the quantity of vanadium produced increased by more than 9%, value dropped 47% from that of 1990. Kerr-McGee Chemical Corp. operated a vanadium recovery plant at Soda Springs, Caribou County. The operation recovered vanadium from ferrophosphorus slag, a waste product generated by Monsanto's elemental phosphorus plant across the road from Kerr-McGee. During the year, Kerr-McGee installed a new ammonia scrubber at the plant, which was expected to capture more than 90% of the ammonia and recycle the gas back into the plant process. The plant produced ammonium metavanadate, potassium vanadate, sodium vanadate, and vanadium pentoxide. These products were used to make industrial catalysts and specialty steel.

Zinc.—The amount of zinc produced dropped significantly; production was only about 5% of that in 1990. In January, Bunker Hill Mining Co., owner

and operator of the Bunker Hill Mine, filed for bankruptcy, then closed the Shoshone County zinc mine 1 week later. The company cited depressed metal prices, high operating costs, and burdensome debt as reasons for the closure. According to IGS, 16,323 tons grading 1.76% lead, 28 grams-per-ton silver, and 5.26% Zn was mined prior to closure. Unsuccessful in raising needed capital, the company announced in April that it would be liquidated to pay creditors. An auction was held in August and much of the equipment, including four mine hoists, was sold at very low prices. In September, fire destroyed the mine's rockhouse. Many of the historical records of the company that extended back to its beginning in 1885 were donated to the University of Idaho Library in Moscow and to the Kellogg Mining Museum. The mine maps and records were removed and stored by the IGS.

The only other reported zinc production was as a byproduct of Hecla's Lucky Friday lead and silver production.

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[1]State Mineral Officer, U.S. Bureau of Mines, Spokane, WA. He has 17 years of mineral-related experience in industry and government and has covered the mineral activities in Idaho since 1989. Assistance in preparation of the chapter was given by W. A. Lyons, editorial assistant.

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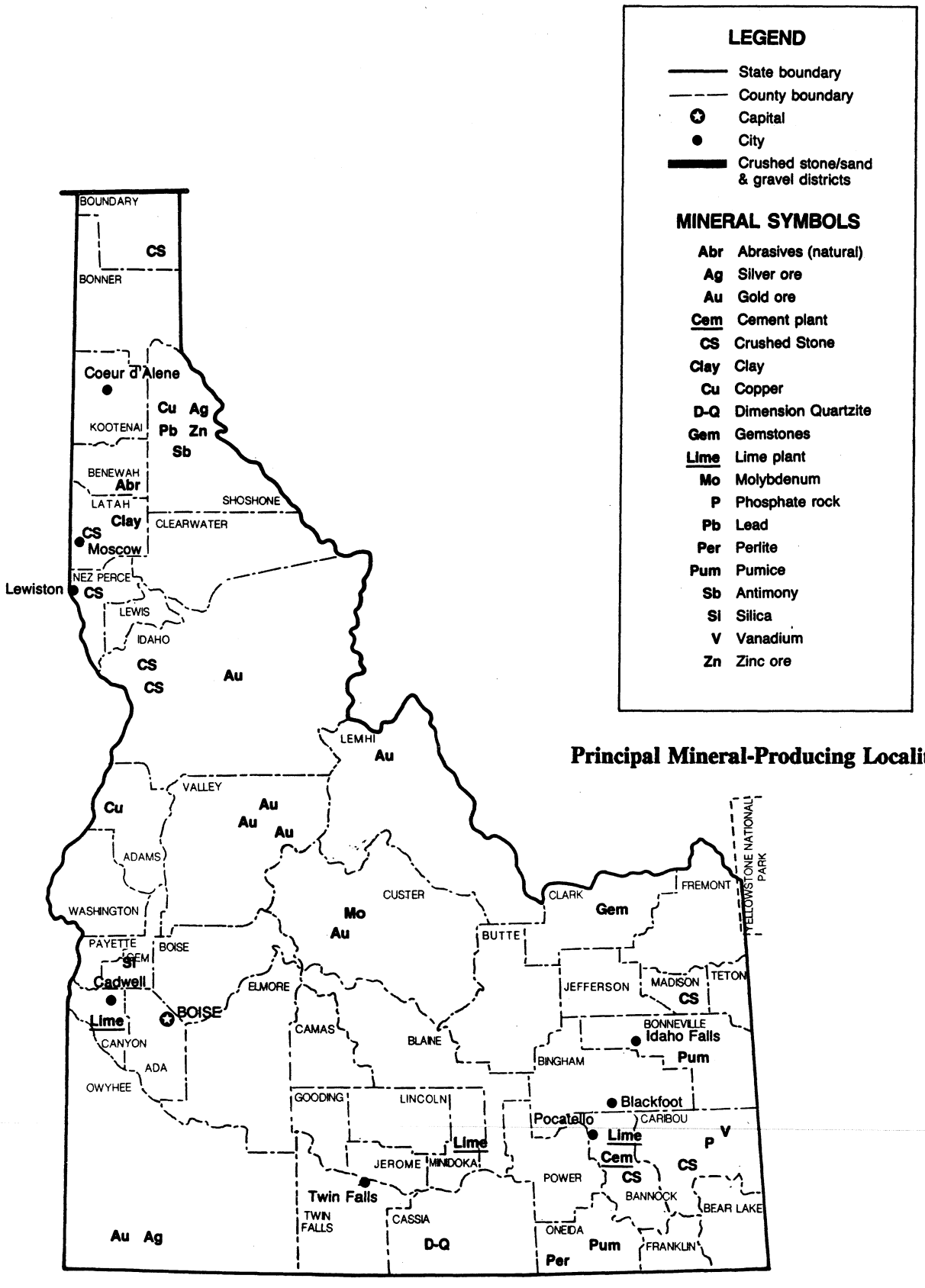
LEGEND
State boundary
County boundary
Capital
City
Crushed stone/sand & gravel districts
MINERAL SYMBOLS
Abr Abrasives (natural)
Ag Silver ore
Au Gold ore
Cem Cement plant
CS Crushed Stone
Clay Clay
Cu Copper
D-Q Dimension Quartzite
Gem Gemstones
Lime Lime plant
Mo Molybdenum
P Phosphate rock
Pb Lead
Per Perlite
Pum Pumice
Sb Antimony
Sl Silica
V Vanadium
Zn Zinc ore
Principal Mineral-Producing Localities
BOUNDARY
BONNER
KOOTENAI
BENEWAH
LATAH
CLEARWATER
NEZ PERCE
LEWIS
IDAHO
SHOSHONE
Coeur d'Alene
Moscow
Lewiston
LEMHI
VALLEY
ADAMS
WASHINGTON
PAYETTE
BOISE
GEM
CUSTER
ELMORE
CAMAS
BLAINE
BUTTE
CLARK
FREMONT
YELLOWSTONE NATIONAL PARK
JEFFERSON
MADISON
TETON
BONNEVILLE
Idaho Falls
BINGHAM
Blackfoot
Pocatello
CARIBOU
POWER
BANNOCK
BEAR LAKE
ONEIDA
FRANKLIN
CANYON
ADA
OWYHEE
GOODING
LINCOLN
JEROME
MINIDOKA
TWIN FALLS
CASSIA
Twin Falls
Cadwell
Cu Ag
Pb Zn
Sb
Abr
Clay
CS
Au
Cu
Mo
Gem
Lime
Cem
P
V
Pum
Per
D-Q
Au Ag

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Antimony:			
Sunshine Mining Co.	815 Park Blvd. Suite 100 Boise, ID 83712	Mine, mill, plant	Shoshone.
Cement:			
Ash Grove Cement West Inc.	6720 SW Macadam Ave. Suite 300 Portland, OR 97219	Surface mine and plant	Bannock.
Clays:			
Applied Industrial Minerals Corp. (AIMCOR)	520 Blomquist Ave. Caldwell, ID 83605	Pit	Owyhee.
E.J. Wilson & Sons	HC 61 Box 1190 Dubois, ID 83423	Pit	Clark.
Interpace Corp.	3502 Breakwater Ct. Hayward, CA 94545	Pit	Benewah.
Copper:			
ASARCO Incorporated	Box 440 Wallace, ID 83873	Mines and mills	Shoshone.
Sunshine Mining Co.	815 Park Blvd. Suite 100 Boise, ID 83702	Mine, mill, refinery	Do.
Garnet:			
Emerald Creek Garnet Milling Co. Inc.	Route 4, Box 190 Fernwood, ID 83830	Pits and plant	Benewah.
Gold:			
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d'Alene, ID 83814	Surface mine and leach plant	Valley.
Idaho Gold Corp.	Box 195 Arco, ID 83213	do.	Butte.
MinVen Gold Corp.	7596 West Jewell Ave. Suite 303 Lakewood, CO 80232	do.	Valley.
NERCO Minerals Co.	111 SW Columbia Suite 800 Portland, OR 97201	Surface mine, mill, leach plant	Owyhee.
Lead:			
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d'Alene, ID 83814	do.	Do.
Lime:			
Amalgamated Sugar Co.	First Security Bank Bldg. Ogden, UT 84402	Plants	Various.
Molybdenum:			
Cyprus Minerals Co.	7200 South Alton Way Englewood, CO 80110	Surface mine and mill	Custer.
Perlite:			
National Perlite Products, a div. of Oglebay Norton Co.	520 North Michigan Ave. Chicago, IL 60611	Surface mine and plant	Oneida.
Phosphate rock:			
Conda Partnership	Box 37 Conda, ID 83230	do.	Caribou.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Phosphate rock—Continued:			
Monsanto Co.	Box 816 Soda Springs, ID 83276	Surface mine and plant	Caribou.
Rhone-Polenc Basic Chemical Co.	Box 160 Montpelier, ID 83254	Surface mine	Do.
J. R. Simplot Co.	Box 912 Pocatello, ID 83201	Surface mine and plant	Bingham and Caribou.
Pumice:			
Amcor Inc.	Box 1411 Idaho Falls, ID 83401	Quarry and plant	Bonneville.
Hess Pumice Products	Box 209 Malad City, ID 83252	do.	Oneida.
Producers Pumice	6001 Fairview Ave. Boise, ID 83704	Quarry	Bonneville.
Sand and gravel:			
Industrial:			
Unimin Corp.	258 Elm St. New Canaan, CT 06840	Pit	Gem.
Silver:			
ASARCO Incorporated	Box 440 Wallace, ID 83873	Mines and mills	Shoshone.
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d'Alene, ID 83814	Mine and mill	Do.
NERCO Minerals Co.	111 SW Columbia Suite 800 Portland, OR 97201	Surface mine, mill, leach plant	Owyhee.
Sunshine Mining Co.	815 Park Blvd. Suite 100 Boise, ID 83712	Mine, mill, refinery	Shoshone.
Stone:			
Crushed:			
Ash Grove Cement West Inc.	6720 SW Macadam Ave. Suite 300 Portland, OR 97219	Quarry	Bannock.
Conda Mining Co.	Box 536 Soda Spring, ID 83276	do.	Caribou.
Monsanto Co.	Box 816 Soda Spring, ID 83276	do.	Do.
Seubert Excavators Inc.	Box 57 Cottonwood, ID 83522	Quarries	Idaho.
Dimension:			
Idaho Travertime Corp.	3935 North Yellowstone Hwy. Idaho Falls, ID 83401	Quarry, plant	Bonneville.
Northern Stone Supply Inc.	Box 249 Oakley, ID 83346	Quarry	Cassia.
Oakley Valley Stone Inc.	Box 28 Oakley, ID 83346	do.	Do.
Vanadium:			
Kerr-McGee Chemical Corp.	Box 478 Soda Springs, ID 83276	Plant	Caribou.
Zinc:			
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d'Alene 83814	Mine and mill	Shoshone.

THE MINERAL INDUSTRY OF ILLINOIS

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the State Geological Survey, Illinois Department of Energy and Natural Resources, for collecting information on all nonfuel minerals.

By Robert H. Wood II[1]

In 1991, for the fifth consecutive year, the value of Illinois nonfuel mineral production increased to a record high. The total value gained about 1% over that of 1990 to $673 million. Crushed stone, portland cement, and construction sand and gravel, all utilized heavily in the construction industry, were the three leading commodities, although cement and sand and gravel production decreased moderately. These three commodities alone accounted for 73% of the State's nonfuel mineral value, illustrating the mineral industry's relationship to a strong construction industry. Nonfuel mineral commodities that increased in value include barite, clays, crushed stone, tripoli, and zinc. Illinois continued to lead the Nation in both the quantity produced and the value of fluorspar, industrial sand and gravel, and tripoli. The State continued to rank 16th in total mineral value, accounting for more than 2% of the Nation's nonfuel mineral value in 1991.

TRENDS AND DEVELOPMENTS

Industrial minerals comprised most of the State's nonfuel mineral production value. Crushed stone production, the State's leading nonfuel mineral commodity in value, continued to increase and was largely responsible for the growth in Illinois' mineral production in 1991. Increased highway construction, financed by a 1989 increase of 6 cents per gallon in the State's gasoline tax, was largely responsible for the increased demand for crushed stone. Crushed stone is readily available and heavily utilized in the northeastern part of the State, including the Chicago metropolitan area. Production of other construction materials such as cement and sand and gravel decreased, however.

The site selection process for a new airport in the Chicago region continued through the year. Final selection is expected early next year from five alternative sites. Four of the sites are in Illinois or along the Illinois/Indiana border, and the other site is in Indiana.

TABLE 1
NONFUEL MINERAL PRODUCTION IN ILLINOIS[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	2,776	$117,224	2,842	$116,781	e2,654	e$108,814
Clays[2]	metric tons	142,207	641	598,479	2,516	935,154	38,877
Gemstones		NA	W	NA	W	NA	547
Sand and gravel:							
Construction	thousand short tons	e33,000	e108,900	32,380	104,728	e26,300	e90,400
Industrial	do.	4,582	52,935	4,486	62,531	4,146	57,210
Stone (crushed)[3]	do.	60,829	256,832	e62,700	e283,100	68,586	295,362
Combined value of barite, cement (masonry), clays (fuller's earth, 1989-90), copper (1989-90), fluorspar, lead (1989-90), lime, peat, silver (1989-90), stone [crushed sandstone (1989-90), crushed sandstone and limestones (1991), dimension], tripoli, zinc, and values indicated by symbol W		XX	96,829	XX	95,478	XX	82,081
Total		XX	633,361	XX	665,134	XX	673,291

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" data.
[3]Excludes certain stones; kind and value included with "Combined value" data.

A new airport would relieve congestion at O'Hare Airport. Included were two suburban locations, one an expansion of the regional airport in Gary, IN, and the other a southeast Chicago location. The southeast location could displace about 75 manufacturing companies, 53 service-related businesses, and 6,700 housing units. Included could be LTV Steel Co.'s coke plant, Acme Steel Co.'s blast furnace and coke plant, the Republic Engineered Steels Inc. plant, and Ford Motor's Chicago Assembly Plant. More than 10,000 jobs could be displaced by the new airport facility if the southeast Chicago location is chosen.

Illinois faces the additional prospect of having thousands of coal miners unemployed as utility companies switch from locally mined high-sulfur coal to low-sulfur western coal to comply with the 1990 Clean Air Act standards. Major provisions of the act would require the reduction of sulfur dioxide emissions by about 50% to 2.5 pounds per million British thermal units (Btu) by 1995 and to 1.2 pounds per million Btu by the year 2000. Congressional estimates put national annual cleanup costs at a minimum of $25 billion.[2]

EMPLOYMENT

According to the Bureau of Labor Statistics, the number of Illinois workers employed in mining and quarrying, including coal mining and oil and gas extraction, dropped by 600 to 19,200, a decrease of more than 3% from the number employed in 1990. Average hourly wages were $16.93, 12 cents less than those in 1990. Average weekly hours worked dropped from 41.8 in 1990 to 41.4 in 1991.

The number of basic steel industry workers declined from 24,500 in 1990 to 24,000 in 1991. Wages decreased from $14.07 to $13.96, while average weekly hours worked fell from 43.7 to 42.2 between 1990 and 1991, respectively.

During the 8 million employee-hours worked in 1991 at surface mining operations, there were no fatalities; 198 injuries resulting in lost workdays and 77 injuries resulting in no workdays lost were reported by the U.S. Department of Labor. At underground mines, 6,828 employees worked a collective total of about 14.7 million hours with 2 fatalities, 1,232 injuries resulting in lost workdays, and 155 injuries with no workdays lost. At mills and preparation plants associated with mining operations, an additional 157 injuries to workers resulted in lost workdays and 78 injuries resulted in no lost workdays. A total of 6.4 million employee-hours were worked at the mills and plants during the year.

There were eight strikes in mineral-related industries in Illinois during 1991. The longest, affecting a concrete manufacturing company, lasted 71 days. Strikes in the steel industry involved three companies and affected the most workers (231). Other strikes involved a sand and gravel and crushed stone company, a crushed stone and brick company, a concrete company, and a glass manufacturing company.

The United Mine Workers of America lobbied the Illinois Legislature in an attempt to head off potential job loss in the State's coal industry as a result of the 1990 Clean Air Act. The union wanted the Illinois Commerce Commission to be required to consider the economic impact of utilities switching to low-sulfur western coal, tax incentives for plants that use clean-coal technology, State financing for clean-coal research, and creation of a State board with control over credits earned by utilities that reduce sulfur emissions.

The Illinois Department of Mines and Minerals reported a reduction of 462 employees in the State's coal mining industry from that of 1990. All of the job losses were at surface mining operations.

Lower demand for coal from existing customers and cutbacks in seasonal reclamation activities caused some coal companies to reduce their work force at year's end. The Delta Mine in Marion reduced its work force by 90 people. A 30% reduction in coal production from the Delta Mine was forecast for 1992.

REGULATORY ISSUES

After a 20-month investigation, the U.S. Labor Department announced plans to prosecute 20 Illinois mining firms (504 mining companies nationally) for violating mine air quality regulations. Some Illinois mining firms allegedly have tampered with coal dust sampling systems designed to protect miners from black lung disease. Fines of $1,000 for each violation and criminal charges could be levied against some of the companies. Legally, coal miners cannot be exposed to a coal dust concentration greater than 2 milligrams per cubic meter of air. After farming, coal mining is the State's second largest industry.[3]

Concern over ground water contamination prompted the Illinois Pollution Control Board to consider stricter regulations under the 1987 Ground Water Protection Act. State officials were concerned over possible ground water contamination from different sources, including sand and gravel mining. Because Illinois' shallowest aquifers are sand and gravel deposits, it was feared that sand and gravel mining could provide a relatively quick, direct route for pollutants to enter the water table. The Illinois Environmental Protection Agency required some sand and gravel pits used for land fills to be cleaned up. The Wauconda Sand and Gravel Co. dump, which was used to dump sludge from its wastewater treatment system, was one requiring cleanup.

The State's proposed low-level radioactive waste disposal site at Martinsville may need to be split in half if the Vandalia sand facies underlie the untested portion of the proposed site. Illinois, one of the Nation's largest producers of low-level radioactive waste, formed a compact on waste disposal with Kentucky in 1990 to comply with terms of 1985 amendments to the Low-Level Radioactive Waste (LLRW) Policy Act. LLRW requires States or groups of States to have LLRW sites by 1993.

Acme Steel Co., the Chicago area's largest steelmaker, was urged by the U.S.

Environmental Protection Agency (EPA) to voluntarily cut its hazardous chemical emissions in half by 1995. EPA made similar appeals to more than 600 companies across the country that emit the largest volumes of the most threatening chemicals targeted for reduction. Acme had no plans to move more quickly than required by the Clean Air Act in reducing targeted chemicals. A $9 million gas capture system was being installed in the company's South East Side plant to reduce benzene emissions.

North Chicago Refiners & Smelters Inc. was granted a 1-year extension by the State to complete a stormwater treatment facility. Boron, copper, iron, lead, and zinc allegedly were being discharged through stormwater runoff into a tributary of Pittibone Creek. Pittibone Creek flows into Lake Michigan. The company made custom brass and bronze ingots from scrap metals.

Du Page County officials continued debating the purchase of the Elmhurst stone quarry for use as a flood-control reservoir. County officials agreed to start work on a flood control plan that included the transformation of the Elmhurst-Chicago Stone Co. quarry into a retention area capable of holding up to 9,500 acre-feet of stormwater from Salt Creek. The project was expected to cost between $70 million and $1 billion.

After operating for 70 years, the Mines and Minerals Rescue Station at Saline closed on October 31. Four rescue stations in the State (Benton, Du Quoin, Springfield, and Elizabethtown) remained open. The Benton station assumed the functions of the Saline station. Federal law requires that a rescue station be located within 2 hours of any potential mine disaster.

EXPLORATION ACTIVITIES

The Illinois Department of Energy and Natural Resources prepares an annual report on statewide exploration and leasing activities.[4]

Test hole record and plugging affidavits for 680 holes were filed by coal mining companies in 1991. This was only six more than were filed in 1990. Approximately 103 of the holes drilled in 1991 were drilled far enough from active mines to be considered exploration tests, a significant decrease from the 222 holes drilled for exploration in 1990. Exploration holes drilled in 1991 were in Clark, Hamilton, Perry, Randolph, White, and Vermilion Counties. Companies actively exploring for new mining sites were Consolidation Coal, Kerr McGee Coal, Amax Coal, Mapco/White County Coal, and Vermilion Energy.

The Illinois State Geological Survey (ISGS) received Test Hole Record and Plugging Affidavits from 69 mineral exploration or structure test holes in 1991, less than one-half of the 171 received in 1990. Exploration activities by Ozark-Mahoning for fluorspar and other minerals in Hardin County accounted for 65 of the holes. The remaining four holes were mineral tests drilled by Noranda Exploration in Carroll County.

Leasing activity, with interest in rare-earth and specialty minerals, was reported in the Illinois-Kentucky fluorspar district. New leasing activity was also reported in the Upper Mississippi Valley zinc-lead district. One fluorspar prospecting permit was issued in 1991 by the U.S. Forest Service for the Shawnee National Forest. Acquisition of new reserves, particularly for the aggregate and sand producers, was mainly limited to properties adjacent to existing operations and purchase of small companies by larger ones.

High-purity limestone was sought statewide for the industrial filler, chemical, and coal desulfurization markets. Quincy Carbonates Inc. was preparing for an early entry into the mineral filler market.

LEGISLATION AND GOVERNMENT PROGRAMS

Three bills indirectly affecting the mining industry were enacted into law in 1991. Public Act 87-0744 amended the Illinois Oil and Gas Act by (1) requiring the filing of geophysical logs and drilling reports within 90 days after drilling ceases on any well; (2) requiring a permit for deepening or conversion of a well; (3) changing the surety bond requirements; (4) imposing requirements on the transfer of wells; (5) authorizing the Illinois Department of Mines and Minerals (IDMM) to order plugging of certain wells; (6) imposing annual permit fees; (7) establishing standards for core samples; (8) imposing deadlines and confidentiality requirements for various logs and reports; and (9) requiring a permit for disposal, transportation, or handling of liquid oilfield waste.

Public Act 87-0379 amended the Abandoned Mined Lands and Water Reclamation Act by requiring the Abandoned Mined Lands Reclamation Council to file a Notice of Reclamation with the county. The notice must identify land reclaimed, describe adverse effects of past mining, and describe the reclamation performed.

Public Act 87-800 extended the moratorium on the issuance of permits for new hazardous waste incinerators. The law prevents Lone Star Cement Co. and Illinois Cement Co. from using waste oil as fuel for their kilns.

The U.S. Bureau of Mines Intermountain Field Operations Center, in Denver, CO, continued its mineral resource evaluation of the Shawnee National Forest. Deposits or occurrences of barite, beryllium, clays, coal, columbium, fluorspar, limestone and dolomite, oil and gas, rare-earth minerals, sand and gravel, silver, tripoli, and zinc have been reported within the area being evaluated. In 1991, fluorspar was mined by Ozark-Mahoning, coal by Peabody Coal Co., and tripoli by Unimin Corp. and Lone Star Industries. Crushed stone and sand and gravel were produced by numerous local operators. The Bureau study was intended to assist the U.S. Forest Service in incorporating mineral resource data into its forest plans, to augment the Bureau's mineral resource data base, and to determine the location and types of mineral deposits that could be mined economically.

The U.S. Geological Survey (USGS) completed geological mapping of the Waltersburg, Glendale, and Goreville 7.5 minute Quadrangles. Coalbeds of Pennsylvanian age occur within all three of the mapped areas. Geologic mapping was started on the Mill Creek and Jonesboro Quadrangles that include the Illinois tripoli district. USGS also completed the Continuous U.S. Mineral Assessment Program (CUSMAP) on the Paducah 1° x 2° quadrangle. The Paducah map will be released in January 1992.

Reclamation work at four abandoned mine sites in southern Illinois was approved and scheduled to commence in early 1992. Cleanup was estimated to cost the State more than $3 million. Reclamation projects included the Zeigler Coal Co. No. 1 Mine in Franklin County, the Fluorspar Group II mine sites in Pope and Hardin Counties, the Madison Coal Co. No. 12 Mine Group in Williamson County, and the St. Ellen Mine in St. Clair County.

With support from a U.S. Department of Energy grant and matching State funds, the ISGS was able to intensify its research in the fields of petroleum geology, chemistry, and engineering in attempts to discover ways of recovering more oil from the Illinois Basin. About two-thirds of the oil in mature basins, like the Illinois Basin, is not economically recoverable using today's methods. This amounts to about 6 billion barrels of oil in the Illinois Basin alone. Into its third year of research, ISGS studies indicated that recoverable oil is still available by using proper strategies and techniques. Based on engineering and geologic interpretations, ISGS may recommend that the IDMM relax its regulations on well spacing in some oilfields, particularly where multiple producing horizons occur. Studies also indicated that injecting water into a well may not necessarily force oil out of nearby wells, especially where different or unconnected reservoirs are involved.

Federal clean-air legislation has given targeted utilities a deadline of 1995 to cut substantially SO_2 emissions. At the request of ISGS personnel, Illinois high-sulfur coal was tested at Destec Energy's Louisiana powerplant. The plant was the largest powerplant that used an integrated gasification combined cycle. Illinois coal was found to work more efficiently than low-sulfur coal currently obtained from Western States, and byproduct elemental sulfur recovered was valued at about $115 per ton. Another advantage in using Illinois coal was that it contains about 2,000 more Btu per pound than western coal.

A high-surface-area hydrated lime product utilizing Illinois limestone and a lime-water slurry process was developed by ISGS personnel to make the State's high-sulfur coal more environmentally acceptable. Under most conditions, ISGS's hydrated lime product removed more SO_2 emissions and utilized calcium more effectively than the best hydrated lime available on the market. Six of the nine utility plants targeted in the State for SO_2 reduction by 1995 were expected to be able to continue operations using the process and hydrated lime product developed by ISGS personnel. Plants from other States that use Illinois coal also will benefit. Through a $677,000 award from the Illinois Department of Commerce and Community Affairs, ISGS planned to build and operate a process optimization unit to process larger quantities of the hydrated lime.

An $18 million small-scale mild coal gasification plant was approved for construction at the coal development park near Carterville. The new plant will test a new coal gasification technique to convert high-sulfur and low-grade coals into premium fuels. The high-temperature, moderate-pressure system would turn 22 metric tons per day (24 short tons per day) of coal into a premium solid fuel (char, used to make coke that fires steel furnaces, foundries, and cupolas), and liquid byproducts (used to manufacture plastics and gasoline). The system also would produce enough natural gas to fire the plant. The new process was developed by the Institute of Gas Technology in Chicago, which will be in charge of the technical end of the project. Kerr-McGee will oversee the project and supply the test coal; Southern Illinois University will operate the facility and test the char as a fuel for fluidized-bed powerplants; and LTV Steel, Armco Inc., and General Motors Research Laboratories Pellet Technology Corp. will test the form coke. The coal development park also was used as a training ground to improve mining processes.

FUELS

According to IDMM, 44 mines (29 underground and 15 surface), operating in 18 counties, reported coal production in 1991. Total coal production amounted to 60,035,515 short tons, a decrease of nearly 3% from the 61,657,068 short tons reported in 1990. Mines in Franklin, Perry, Randolph, and Saline Counties accounted for about one-half of the coal produced in the State in 1991. Overall, Illinois ranked sixth in the Nation among the 27 States reporting coal production and accounted for nearly 6% of the total U.S. production of nearly 1 billion short tons.

Surface mining, down 14.7% from that of 1990, has declined steadily since peaking in 1969 and accounted for only about 26% of the coal mined in 1991. Continuous mining accounted for 74%, longwall for 22%, and conventional methods accounted for the remaining 4% of the State's underground coal production.

According to the National Coal Association, Illinois ranked second to Wyoming in the total amount of demonstrated coal reserves in the United States. The State's coal reserves were estimated at 78 billion short tons (63 using underground mining methods and 15 using surface methods).

Two coalbed methane gas discoveries were made in Saline County, 6 miles south of Galatia, by DI Energy Inc. Coal gas at the two wells flowed at rates of 278,000 cubic feet per second and 212,000 cubic feet per second. The two producers reportedly were drilled into abandoned coal mines. Five other test wells are planned by DI in the Saline County area.

Illinois continued to rank 15th among the 32 oil-producing States in 1991. Estimated oil production was 19 million barrels, a decline of about 4% from that of 1990, and marked the sixth continuous year of declining production. Natural gas production was 366 million cubic feet in 1991, down about 39% from the previous year's production. Well completions were down more than 25% in Illinois from 1990 levels. Of the 542 wells drilled, 292 were oil producers and 5 had natural gas production, indicating a success rate of about 45%. Only 1 of the 45 wildcat wells discovered a new producing area. Budmark Oil Co. completed three oil producers in the newly discovered area near Herrin and Energy, Williamson County. The State apparently incorporated the new area into the Energy field (Aux Vases oil pool) 1 mile to the south.[5]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Industrial mineral sales accounted for more than 99% of the value of all nonfuel mineral production in Illinois. The value of industrial minerals produced increased slightly over the value produced in 1990.

Cement.—Illinois ranked eighth of 38 portland cement-producing States. The estimated quantity and value of portland cement produced decreased by 7% from that of 1990. Estimated quantity and value of masonry cement produced in the State decreased more than 80% from that reported in 1990. Masonry cement production continued to remain comparatively unimportant as the State ranked last along with Washington among the 33 States reporting masonry cement production.

Following nearly 2 months of controversy, the Woodford County Board approved a special use permit for Peoria Concrete Construction to build a cement plant in Spring Bay Township. Property owners near the site opposed the plant because of increased noise and dust as well as possible decreases in property values. A proposed ready-mix concrete plant in Montgomery Village and a permit request for continuation of an 8-year-old concrete business in unincorporated Cook County were rejected.

Lafarge Corp. (formerly the Davenport Cement Co.) has recycled 15,000 tons of solid waste annually from the Blackhawk Foundry and Machine Co. in addition to solid waste received from eight or nine other foundries. Within 5 years, waste products could make up 30% of raw materials used by Lafarge in cement manufacture.

Clays.—Illinois ranked 14th in clay and shale output among the 43 producing States. Production and attendant value increased about 6% and 45%, respectively, compared with 1990 figures. Clay and shale production was reported from only 5 of the State's 102 counties. Livingston and Pulaski Counties accounted for more than 90% of the total volume of clay and shale produced in the State.

An ISGS geologist discovered a deposit of kaolin (ball clay) near Sterling in Whiteside County. The kaolin is possibly within the Ordovician age Neda Formation. The purity variations and extent of the deposit have not been determined.

Common Clay.—Common clay production decreased 14% in quantity and 3% in value from a record high of more than 598,000 metric tons reported in 1990. The average value of common clay produced in Illinois was $4.31 per ton, an 11-cent-per-ton gain over 1990's average value. Common clay was produced by six companies in four counties. Major uses included the manufacture of common brick, cement, and drain tile.

Fuller's Earth.—Fuller's earth production increased significantly in both quantity and value. Illinois ranked second among the 10 States with reported fuller's earth production in 1991. Two companies in Pulaski County, Golden Cat Corp. and Absorbent Clay Products Div. of American Colloid Co., produced montmorillonite, a variety of fuller's earth. Pet-waste absorbents accounted for the end use of 84% of the fuller's earth mined in Illinois. Other end uses included use as oil and gas absorbents and as an ingredient in animal feed and fertilizer.

The Granite City operation of American Colloid Co. added about 30 employees to its staff of 7. This was in response to higher demand for its new form of cat litter. Its product consisted of specific-size particles of sodium montmorillonite and contained no additives. The litter reacts to liquid and solid wastes by expanding and hardening into easily removable clumps. The raw material was mined and processed at the company's operation in Wyoming.

Fluorspar.—Illinois was the only State with reported fluorspar production in the United States in 1991. The quantity of fluorspar mined in Illinois declined about 32% in 1991 over that of 1990, while its reported value increased 7%. A combination of increased competition from foreign imports, especially from Chinese sources, and a decrease in the use of chlorofluorocarbons (because of environmental concerns) was mostly responsible for the decline in domestic production. Illinois Fluorspar continued to be in demand because of its high purity and absence of toxic trace elements often found in imported fluorite. Fluorspar is used in making steel, enamels, aluminum, toothpaste, specialty glass, and a variety of chemicals.

Ozark-Mahoning Co. (O-M), the country's only fluorspar producer, was owned by Pennwalt Corp. of Philadelphia. The company operated three mines in Hardin County in 1990: the Annabel Lee and Denton Mines in the Harris Creek district and the Minerva No. 1 Mine in the Cave-in-Rock district. Mining in the company's No. 1 Mine (formerly Minerva No. 1) was reportedly below 400 meters, and drilling indicated ore levels were at least 40 meters deeper. In response to the importation of acid-grade filter cake from China, O-M

reduced operating costs by reducing the number of core drilling rigs used for exploration from five to two. During the year, O-M's mill at Rosiclare was undergoing modernization.[6]

Lime.—Illinois continued to rank seventh among the 32 States with reported lime production in 1991. Both quantity and value of the State's lime production decreased moderately from those of the previous year. Firms producing lime were Vulcan Materials Co. in McCook and Marblehead Lime Co., a subsidiary of General Dynamics, with plants at Thornton and South Chicago. Marblehead was 1 of the top 10 lime producers in the Nation in 1991.

Peat.—Increased peat production in New Jersey in 1991 dropped Illinois into seventh rank among the 19 reporting States. Peat production in Illinois was virtually unchanged from that of 1989 and 1990. Peat was produced in Lake County by Dahl Enterprises Inc. and Roots Peat Farm, and in Whiteside County by Hyponex Corp. and Markman Peat Co. Most of the peat produced in Illinois was used for general soil improvement; only minor amounts were used for earthworm cultivation and by golf courses.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990. A decrease of 19% in quantity and 14% in sales of construction sand and gravel was estimated in 1991. Average estimated unit value of the material mined in the State increased about $0.21 per short ton, to $3.44 per short ton during the year.

Local opposition to sand and gravel operations, especially in and near populated areas, continued in 1991. McHenry County Board proposed creating a board to evaluate the taxing of the county's 31 working gravel pits. Information obtained from American Environmental Sciences and Technology, hired to evaluate the gravel pits, will be used to update their taxable value. County officials estimated that local taxing districts would gain at least $200,000 annually from increased taxes. Ruling on a State law that might allow the gravel reserves to be assessed at their fair market value could allow the county to tax gravel operations even more. Such a ruling could force some operations out of business.

Industrial.—Illinois continued to rank first in both quantity and value over the 37 States with reported production of industrial sand and gravel in 1991. The quantity and value of industrial sand and gravel produced in Illinois in 1991 decreased by 8% and 9%, respectively, compared with 1990 figures. Major uses were in the manufacture of glass containers, flat glass, and chemicals; for molding and core facing; and as hydraulic frac sand.

Unimin Corp., U.S. Silica Co., Manley Brothers of Indiana Inc., and Fairmont Minerals Ltd. mined the high-purity St. Peter's sandstone in La Salle County. Manito Investment Co. mined a Quaternary quartz-feldspar dune sand in Mason County for the foundry sand market. Unimin, U.S. Silica, and Fairmont Minerals were the top three industrial sand and gravel producers in the United States, and Manley Brothers ranked seventh nationally. Crystal Products Co., formed to develop high-purity limestone and silica sand deposits in southern Illinois, did not report any production during the year.

Hepworth Minerals and Chemicals Ltd. of the United Kingdom apparently reached an agreement with Best Sand Corp./Wedron Silica Corp. (the silica sand operators held by Fairmont Minerals) to purchase the Troy Grove operation and two other silica plants operated by Manley Brothers. Wedron produced foundry, glass, proppant, abrasive, and blasting sand at Wedron. The Federal Government held up the final sale to review the effect on the silica sand market in the Midwestern United States.

Fairmont Minerals, formed in 1986 by the merger of Wedron Silica and Best Sand Co., sold principally to the glass industry, foundries, hydraulic fracturing, and abrasives industries, with additional sales to the construction, filtration, and specialty markets.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Crushed.—Crushed stone was the principal mineral commodity produced in the State, accounting for nearly 44% of the total value of all nonenergy mineral commodities produced in Illinois in 1991. Illinois increased to second rank in the quantity and value of crushed stone production reported by 49 producing States; only Pennsylvania reported more crushed stone production during the year. Crushed stone production was reported from 177 quarries by 96 companies with operations in 52 of Illinois' 102 counties. Major uses for crushed stone included graded road base or subbase, coarse concrete aggregate, coarse bituminous aggregate, agricultural limestone, cement manufacture, and unpaved road surfacing.

Local opposition to quarry operations, especially in and near populated areas, continued in 1991. Effects of blasting, dust, noise, and increased traffic were the main complaints. Residents fought quarry expansion in Boone and Ogle Counties, as well as quarries proposed in Kankakee and Kendall Counties. Proposed quarrying expansion operations near Leaf River in Ogle County were finally approved. Operators, however, were required to transport their material by a private haul road or by rail to eliminate truck traffic on Lightsville and Leaf River Roads.

Dimension.—Dimension stone production continued to remain comparatively unimportant as the State ranked last among the 34 States with

TABLE 2
ILLINOIS: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	778	3,357	4.31
Riprap and jetty stone	629	2,765	4.40
Filter stone	315	1,138	3.61
Other coarse aggregate	W	W	4.00
Coarse aggregate, graded:			
Concrete aggregate, coarse	9,216	38,179	4.14
Bituminous aggregate, coarse	8,146	35,426	4.35
Bituminous surface-treatment aggregate	5,056	19,587	3.87
Railroad ballast	285	1,077	3.78
Fine aggregate (-3/8 inch):			
Stone sand, concrete	979	2,454	2.51
Stone sand, bituminous mix or seal	2,372	8,803	3.71
Screening, undesignated	1,257	4,783	3.81
Coarse and fine aggregates:			
Graded road base or subbase	16,653	65,274	3.92
Unpaved road surfacing	2,420	8,980	3.71
Crusher run or fill or waste	249	991	3.98
Other construction materials[2]	467	2,773	5.94
Agricultural:			
Agricultural limestone	3,610	13,320	3.69
Poultry grit and mineral food	4	50	12.50
Other agricultural uses	2	4	2.00
Chemical and metallurgical:			
Cement manufacture	3,023	11,642	3.85
Lime manufacture	W	W	3.12
Dead-burned dolomite manufacture	548	2,602	4.75
Flux stone	W	W	4.30
Chemical stone	148	805	5.44
Glass manufacture	200	W	4.61
Special:			
Mine dusting or acid water treatment	256	1,057	4.13
Asphalt fillers or extenders	W	W	8.35
Other fillers or extenders	489	19,422	39.72
Other miscellaneous uses[3]	1,235	4,610	3.73
Unspecified:[4]			
Actual	3,759	17,078	4.54
Estimated	6,491	29,182	4.50
Total[5]	68,586	295,362	4.31

W Withheld to avoid disclosing company proprietary data; included with "Other construction material" and "Other miscellaneous uses."
[1]Includes limestone, dolomite, and sandstone; excludes value amounts of limestone and dolomite, and sandstone withheld to
[2]Includes withheld amounts for coarse aggregate (+1 inch) and roofing granules.
[3]Includes withheld amounts for chemical and metallurgical, and special.
[4]Includes production reported without a breakdown by use and estimates for nonrespondents.
[5]Data may not add to totals shown because of independent rounding.

reported building stone production. The State's only producer, Rein, Schultz & Dahl Inc., finished quarry-run dolomite for veneer and flagstone at its Fox River crushed stone quarry southwest of South Elgin in Kane County.

Tripoli.—Illinois continued to lead the Nation in the production of tripoli with more than 70% of the tripoli mined in the United States in 1991 coming from Illinois' mines. Reported quantity and value of tripoli mined in Illinois in 1991 increased slightly over 1990 levels. Tripoli was mined in only three other States. Unimin Corp. was Illinois' sole tripoli producer. Tripoli, a microcrystalline silicate, was used as an abrasive and as fillers and extenders.

Other Industrial Minerals.—Small quantities of barite and gem materials were produced in Illinois during 1991. Barite was recovered by Ozark-Mahoning as a byproduct during flotation of fluorspar at the plant near Rosiclare. The percentage of the State's barite production increased considerably over production reported in 1990. Gem materials found in Illinois included a variety of mineral specimens such as calcite, chalcopyrite, dolomite, fluorite, galena, and sphalerite, in addition to various fossil specimens. Reported value of Illinois gemstone production in 1991 was about the same as that in 1990.

Raw materials, obtained from out-of-State sources, were used in Illinois for producing iron oxide pigments, expanded perlite, exfoliated vermiculite, gypsum, iodine, slag, and sulfur.

Illinois ranked second among the 12 States with reported production of finished iron oxide pigments. Production was down slightly compared with that of 1990. Illinois producers of iron oxide pigments from natural and/or synthetic sources included AST Co., Granite City; Harcros Pigments Inc., East St. Louis; Prince Manufacturing Co., Quincy; and Solomon Grind-Chem Services Inc., Springfield. Harcros Pigments, a subsidiary of Harrison & Crosfield PLC of the United Kingdom, announced the sale of its magnetic iron oxide pigments business to Ishihara Sangyo Kaisha. Included in the sale were the East St. Louis operations that Harcros acquired from Pfizer Inc. in 1990.

Lower reported production of expanded perlite slid Illinois from second

TABLE 3

ILLINOIS: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Coarse aggregate (+1 1/2 inch)[2]	821	3,245	320	1,372	184	1,010	398	1,641
Coarse aggregate, graded[3]	13,414	51,436	2,889	13,238	3,307	15,889	3,093	13,705
Fine aggregate (-3/8 inch)[4]	3,887	12,905	116	582	182	744	423	1,810
Coarse and fine aggregate[5]	11,321	43,020	2,753	11,592	2,995	12,073	2,252	8,561
Other construction materials	27	93	49	889	178	977	211	807
Agricultural[6]	435	1,323	W	W	W	W	1,627	5,151
Chemical and metallurgical[7]	1,870	6,837	—	—	W	W	W	W
Special[8]	208	967	W	W	W	W	W	W
Other miscellaneous uses	—	—	1,159	21,904	2,493	9,467	1,724	7,864
Unspecified:[9]								
Actual	1,633	7,588	189	1,123	254	106	1,682	8,261
Estimated	3,958	18,255	865	3,155	590	2,822	1,077	4,950
Total[10]	37,574	145,669	8,341	53,856	10,184	43,088	12,487	52,750

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[1]Excludes limestone/dolomite and sandstone value only; withheld to avoid disclosing company proprietary data.
[2]Includes filter stone, macadam, riprap and jetty stone, and other coarse aggregate.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[5]Includes graded road base or subbase, unpaved road surfacing, crusher run or fill or waste, and roofing granules.
[6]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[7]Includes cement manufacture, glass manufacture, lime manufacture, dead-burned dolomite, flux stone, and chemical stone for alkali works.
[8]Includes asphalt fillers or extenders, mine dusting or acid water treatment, and other fillers or extenders.
[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[10]Data may not add to totals shown due to independent rounding.

to fourth nationally in the quantity sold or used in 1991. Manville Corp. manufactured roofing insulation using expanded perlite at its Rockdale plant in Will County near Joliet. Silbrico Corp. expanded perlite primarily for the filler market at its Hodgkins plant in Cook County. Strong-Lite Products Corp. expanded perlite for use in the manufacture of acoustical tile, horticultural aggregate, insulation, and concrete aggregate.

Lower reported production of expanded vermiculite sold or used in 1991 caused the national ranking of Illinois to move from fifth to seventh place. Exfoliated vermiculite was produced for use in insulation, aggregates, horticulture and soil conditioners, and fireproofing by Strong-Lite Products Co. at its Seneca plant in La Salle County.

National Gypsum continued production of calcined gypsum at its wallboard plant in Waukegan. The gypsum was shipped from mines in Michigan. Slightly lower levels of production were reported in 1991 compared with 1990 figures.

Crude iodine was processed into inorganic iodine chemicals by Allied Signal Corp. at Metropolis and by West Argo Inc. at Des Plaines. Organic iodine chemicals were manufactured by Echolab Inc. at Joliet, Will County. Iodine production increased slightly in 1991 compared with that of the previous year.

Illinois ranked seventh in the quantity of iron and steel slag sold or used in 1991 among the 28 States with reported production. Iron and steel slag was used primarily as road base, fill, and aggregate. The slag was distributed in Illinois by five companies with operations in Clay, Cook, Kankakee, Madison, and Whiteside Counties.

Elemental sulfur was recovered from oil refinery operations by Marathon Oil Co. at Robinson, Shell Oil Co. at Wood River, Uno-Ven Co. at Chicago, and by Mobil Oil Corp. at Joliet. In 1991, reported production of elemental sulfur in Illinois was down in both quantity and value compared with those of 1990.

Crosfield Chemicals announced plans to build a detergent zeolite plant in Joliet. Expected to be completed early in 1992, the plant would produce a 4A detergent zeolite product intended to replace phosphates in detergents.

Metals

Illinois was a minor producer of metals. All metals produced from ores mined in the State were recovered as byproducts of fluorspar beneficiation.

Copper, Lead, Silver, and Zinc.—Zinc was the only metallic mineral commodity reportedly recovered in 1991 as a byproduct of Ozark-Mahoning's fluorspar mining operations in southern Illinois. In previous years, copper, lead, and silver were recovered along with zinc. The quantity of zinc produced increased substantially over that produced in 1990.

TABLE 4
ILLINOIS: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989[1]				1991[2]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone[3]	160	57,293	$242,461	$4.23	165	59,243	$255,999	$4.32
Dolomite	18	3,536	14,371	4.06	11	8,923	39,363	4.41
Sandstone	—	—	-	—	1	420	W	W
Total	XX	60,829	256,832	4.22	XX	68,586	295,362	4.31

W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]Excludes sandstone; withheld to avoid disclosing company proprietary data.
[2]Excludes sandstone, value only; withheld to avoid disclosing company proprietary data.
[3]Includes "Limestone/dolomite," reported with no distinction between the two.

Iron and Steel.—According to the American Iron and Steel Institute, Illinois mills produced 7.2 million short tons of raw steel in 1991, about 8% less than the 7.8 million short tons reported for 1990. The Illinois steel mills provided more than 8% of the nearly 88 million tons produced nationwide. Nationally, the State ranked fourth in production, following Indiana, Ohio, and Pennsylvania.

Acme Steel Co. was reorganizing its business into a parent company with four operating subsidiaries to reduce impacts of steel industry cycles on the company. Acme Metals Inc. would provide direction, planning, and purchasing for its subsidiaries utilizing a centralized staff. The subsidiaries include Acme Steel Co. (producer of iron and steel); Acme Packaging Corp. (manufacturer of steel strapping); Alpha Tube Corp. (producer of welded steel pipe and tube); and Universal Tool & Stamping (manufacturer of automobile jacks).

National Components, a Houston-based steel company, planned to open a new manufacturing plant near Mattoon. The company manufactured steel used in building construction. About 50 jobs would be created in the area.

Tax-exempt revenue bonds were expected to help finance Robinson Steel Co.'s proposed construction of a multimillion dollar steel processing plant in the Granite City area. Company officials expected to employ 30 to 40 people initially and to have a production capacity of more than 240,000 tons per year. The plant was expected to be fully operational by the second quarter of 1992.

The Granite Foundry moved its operation from Tennessee to a newly constructed building just north of Augusta. Fired by an electric furnace, the foundry will make boat anchors, stove parts, and other cast-iron items. In addition to 6 or 7 employees from the Tennessee plant, 20 to 25 workers were expected to be employed from the Augusta area.

American Steel Foundries in Granite City laid off more than 500 workers in July because of the reduced demand for railroad cars. The auto industry was one of the major users of rail shipping. American's workers could expect their "temporary layoffs" to last at least until sometime in 1992.

U.S. Steel Corp. planned to permanently close its South Works steel plant in Chicago after determining that an employee buyout was not feasible. Bethleham Steel Corp. was the only major integrated producer left that made structural beam, primarily used for the high-rise construction market. Depressed prices, lower construction activity, and increased competition from lower cost minimills prompted the U.S. Steel closure.

In October, Galva Foundry announced plans for closure. Company owners cited complaints about air pollution, lower product orders, and the high costs of machinery and pollution-abatement equipment as reasons. The company produced gray iron castings for Deere & Co., Case International Harvester, and other equipment companies. Galva's 90 employees were given opportunities to apply for work in the company's Berlin Foundry in Wisconsin.

Valley Industries announced plans to close its Valley Steel facility in Centralia early next year. The facility stored and processed steel pipe used in oil and gas drilling and produced large-diameter pipe used for casing, culverts, and other construction projects.

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[1]State Mineral Officer, U.S. Bureau of Mines, Denver, CO. He has 15 years of mineral-related work with the Government. Assistance in the preparation of the chapter was given by Pat LaTour, editorial assistant.
[2]Stone Review. Clean Air Act Amendments of 1990. June 1991, p. 27.
[3]Springfield State Journal Register. Coal Dust Cheating Alleged. Apr. 5, 1991.
[4]Frankie, W. T., J. M. Masters, and R. E. Hughes. State Activities 1991-Illinois. Min. Eng., v. 44, No. 5, May 1992, pp. 433-434.
[5]Petroleum Information Corp. Resume 1991.
[6]Work cited in footnote 4.

ILLINOIS

LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper
D-L	Dimension Limestone
F	Fluorspar
Ful	Fuller's earth
IS	Industrial Sand
Lime	Lime plant
Pb	Lead
Peat	Peat
SG	Sand and Gravel
Steel	Iron and Steel plant
Trip	Tripoli
Zn	Zinc

Principal Mineral-Producing Localities

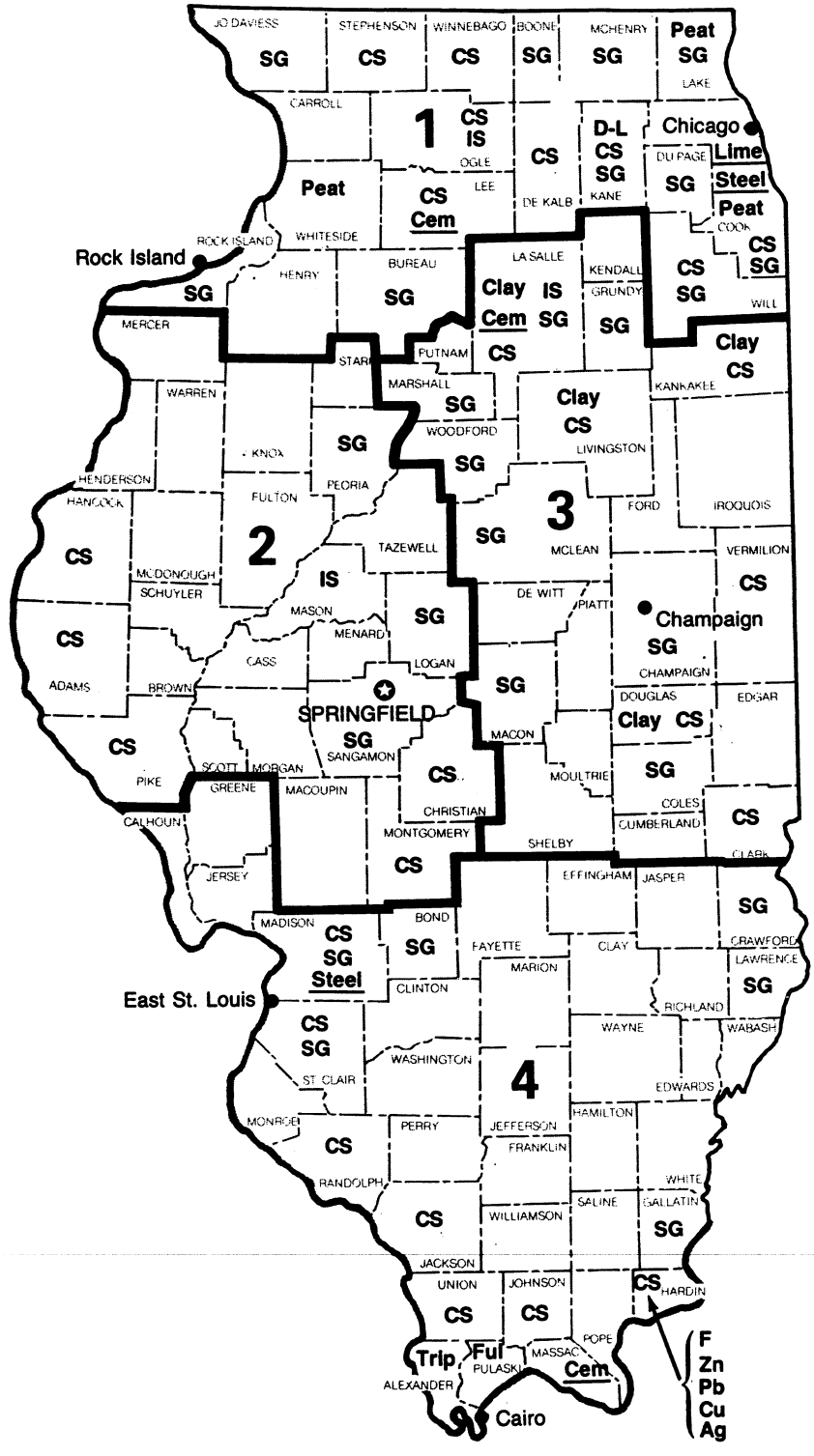

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Dixon-Marquette Cement Inc., a subsidiary of Prairie Materials Sales Inc.	12152 South Plainfield Naperville Rd. Plainfield, IL 60544	Quarry and plant	Lee.
Illinois Cement Co. Inc., a subsidiary of Centex Corp.	Box 442 La Salle, IL 61301	Quarry, clay pit, plant	La Salle.
Lone Star Industries Inc., Cement & Construction Materials Group	1 Greenwich Plaza Box 5050 Greenwich, CT 06836	do.	Do.
Missouri Portland Cement Co., a division of Cementia Holdings AG	Box 4288 Davenport, IA 52801	Plant Quarry	Massac. Hardin.
Clays:			
American Colloid Co.	1500 West Shore Dr. Arlington Heights, IL 60004	Pit and plant	Pulaski.
Lowe's Southern Clay Inc.	P.O. Box 1086 Cape Girardeau, MO 63702	do.	Do.
Richards Brick Co.	234 Springer Ave., Box 407 Edwardsville, IL 62025	do.	Bond.
Streator Brick Systems Inc.	West 9th St. Streator, IL 61364	do.	Livingston.
Fluorspar:			
Ozark-Mahoning Co., a subsidiary of Pennwalt Corp.[1]	Box 57 Rosiclare, IL 62982	Underground mines and plant	Hardin and Pope.
Gypsum (calcined):			
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	Plant	Lake.
Iron oxide pigments (finished):			
Harcros Pigments Inc.	235 East 42d St. New York, NY 10017	do.	St. Clair.
Prince Manufacturing Co.	700 Lehigh St. Bowmanstown, PA 18030	do.	Adams.
Solomon Grind-Chem Service Inc.	Box 1766 Springfield, IL 62705	do.	Sangamon.
Iron and steel:			
Acme Steel Co.	13500 South Perry Ave. Riverdale, IL 60627	Iron and steel furnaces	Cook.
Granite City Div. of National Steel Corp.	Box 365 Granite City, IL 62041	do.	Madison.
LTV Steel Co.	1641 GH Republic Bldg. Cleveland, OH 44101	do.	Cook.
Lime:			
Marblehead Lime Co., a subsidiary of General Dynamics Corp.	222 North La Salle St. Chicago, IL 60601	Plants	Do.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	Plant	Do.
Peat:			
Hyponex Corp.	14111 Scottslawn Rd. Marysville, OH 43041	Bog and plant	Whiteside.
Markman Peat Co.	Route 3 Morrison, IL 61270	do.	Do.
Roots Peat Farm	Box 6005 Lindenhurst, IL 60046	do.	Lake.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Perlite (expanded):			
Manville Corp.	Route 6, Box 3429 Joliet, IL 60434	Plant	Will.
Silbrico Corp.	6300 South River Rd. Hodgkins, IL 60525	do.	Cook.
Strong-Lite Products Corp.	Shipyard Rd. Seneca, IL 71611	do.	La Salle.
Sand and gravel:			
Construction:			
Feltes Sand & Gravel Co. Inc.	Rural Route 25, Box 159 North Aurora, IL 60542	Pits and plants	Kane and Kendall.
Material Service Corp., a division of General Dynamics Corp.	300 West Washington St. Chicago, IL 60606	do.	Grundy, Kane, McHenry.
McHenry Sand & Gravel Co. Inc.	Box 511 McHenry, IL 60050	do.	Boone, Kane, McHenry.
Midwest Sand & Gravel Inc.	Box 218, 101 South Main La Rose, IL 61541	do.	Marshall.
Road Materials Corp.	Box 209 Algonquin, IL 60102	do.	Kane, McHenry, Peoria.
Thelen Sand & Gravel Inc.	28955 West Route 173 Antioch, IL 60002	Pit and plant	Lake.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	Pits and plants	Champaign, Livingston, McHenry, Macon.
Industrial:			
Manito Investment Co.	Box 166 Tremont, IL 61568	Pit and plant	Mason.
Manley Bros. of Indiana Inc.	Box 538 Chesterton, IN 46304	Pits and plant	La Salle.
Unimin Corp.	Box 33 Eiko, IL 62929	Pits and plants	La Salle and Ogle.
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	Pit and plant	La Salle.
Fairmont Minerals Ltd.	Box 167 Wedron, IL 60557	Pits and plant	Do.
Slag (iron and steel):			
Heckett Co.	612 North Main St. Butler, PA 16001	Plants	Whiteside.
International Mill Service Co.	1818 Market St. Philadelphia, PA 19103	do.	Madison.
St. Louis Slag Products Co. Inc., a division of Standard Slag Co.	Box 430 Granite City, IL 62040	Plant	Do.
Stone (crushed limestone-dolomite):			
Columbia Quarry Co.	Box 128 Columbia, IL 62236	Underground mine, quarries, plants	Johnson, Monroe, Puaski, St. Clair, Union.
Material Service Corp., a division of General Dynamics Corp.	300 West Washington St. Chicago, IL 60606	do.	Cook, Logan, Menard, Montgomery, St. Clair, Vermilion, Will.
Rein, Schultz & Dahl, Inc.	5960 Falcon Rd. Rockford, IL 61109	Quarries and plants	Carroll, Douglas, Kane, Stephenson, Will.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	do.	Clark, Cook, Iroquois, Kankakee, Livingston, Will.

See footnotes at end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sulfur (recovered):			
Marathon Oil Co.	Marathon Ave. Robinson, IL 64254	Plant	Crawford.
Mobil Oil Corp.	Box 874 Joliet, IL 60434	do.	Will.
Shell Oil Co.	Box 262 Wood River, IL 62095	do.	Madison.
The Uno-Ven Co.	1650 East Golf Rd. Schaumburg, IL 60196	do.	Will.
Tripoli:			
Unimin Corp.	Box J Tamms, IL 62988	Underground and open pit mines and plant	Alexander.
Vermiculite (exfoliated):			
W. R. Grace & Co., Construction Products Div.	6051 West 65th St. Bedford Park, IL 60638	Plant	Du Page.
Stong-Lite Products Corp.	Shipyard Rd. Seneca, IL 71611	do.	La Salle.

[1]Also barite, copper, lead, silver, and zinc.

THE MINERAL INDUSTRY OF INDIANA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Geological Survey, Indiana Department of Natural Resources, for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.[1]

The value of nonfuel mineral production in Indiana in 1991 was about $403 million. Value declined for the second year in a row, reflecting a general slowdown in the economy. Output of 7 of the 10 nonfuel mineral commodities produced decreased in 1991. The only significant increase in production was for ball clay; minor gains were reported for crushed stone and industrial sand.

Other sectors of the State's mineral-related industries also showed a decline in 1991. Output of coal and steel dropped during the year. Steel production decreased as demand from the automotive and appliance industries declined during the year. The downturn in steel also adversely affected demand for coal.

EMPLOYMENT

In 1991, Indiana's mining industry employed about 3,900 workers in nonfuel minerals and 4,200 workers in the coal industry. The mineral-dependent construction industry employed 117,200 persons, and steel mill workers totaled 37,800. Combined, these mining and mineral-related industries employed 163,100 workers in 1991, about 5,500 fewer employees than in 1990, according to the Indiana Department of Employment and Training Services.

LEGISLATION AND GOVERNMENT PROGRAMS

In 1991, the Indiana Legislature enacted Senate bill 154 transferring the responsibilities for surface coal mining reclamation permits, permit changes, and bonding to the Department of Natural Resources from the Natural Resources Commission.

Enactment of Senate bill 209 requires the State Department of Transportation,

TABLE 1
NONFUEL MINERAL PRODUCTION IN INDIANA[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Cement:							
Masonry	thousand short tons	357	$24,054	368	$27,813	e317	e$24,092
Portland	do.	2,364	108,297	2,417	114,414	e2,252	e105,844
Clays	metric tons	871,179	3,836	[2]1,051,703	[2]3,273	[2]929,964	[2]3,516
Gemstones		NA	W	NA	W	NA	561
Peat	thousand short tons	34	607	37	W	26	W
Sand and gravel (construction)	do.	e29,600	e99,200	23,879	76,886	e18,100	e60,400
Stone:							
Crushed	do.	[3]36,188	[3]136,252	[3] e36,700	[3] e147,700	37,924	152,489
Dimension[3]	short tons	198,531	27,212	e194,728	e29,504	187,580	27,491
Combined value of abrasives (1989), clays [ball (1990-91)], gypsum (crude), lime, sand and gravel (industrial), stone [crushed marl and miscellaneous stones (1989-90), dimension limestone and dolomite (1991), dimension sandstone (1989-90)], and values indicated by symbol W		XX	34,657	XX	32,176	XX	28,902
Total		XX	434,115	XX	431,766	XX	403,293

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.
[3]Excludes certain stones; kind and value included with "Combined value" figure.

in cooperation with the Universities of Indiana and Purdue, to study the use of recycled waste materials in road construction. The study, scheduled for completion in July of 1992, will examine the feasibility of using recycled asphalt, concrete, waste tires, and demolition materials in highway construction projects.

The Indiana Geological Survey (IGS) was the State's lead agency in industrial mineral and fossil fuel resources investigations. These investigations typically discussed the impact of minerals in relation to ground water, geology, and the environment.

Studies in 1991 included preliminary examination of several limestone deposits in south-central Indiana for potential use as a scrubber stone in flue gas desulfurization. The work identified chemical or geological properties of limestone and their absorbing characteristics.[2] Activity in this area was prompted by passage of amendment to the Federal Clean Air Act in 1990, which required a reduction in sulfur dioxide emissions.

The IGS also studied jointing directions and characteristics to determine the effects on roof conditions in underground limestone mines. This study identified methods to stabilize the roof in areas of closely spaced fractures. Information on these studies, as well as others by the Survey, was published in the "Geologic Publications of Indiana."

The Forest Service, U.S. Department of Agriculture, completed a new management plan for the Hoosier National Forest. The plan established natural resource management activities for the forest from 1991 to 2000. Major aspects of the plan relating to mineral activities included emphasis for future management to be placed upon environmental sensitivity and concern for noncommodity forest values. The plan further states that mineral resources are available for exploration and development in selected areas. Oil and gas leasing, exploration, and development will be considered on a case-by-case basis and only in areas adjacent to private mineral development. Gypsum exploration and development is allowed in the Management Area of the Lost River Unit.[3]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

The value of industrial minerals in 1991 declined by about 5% compared with 1990 data. From 1982 through 1989, steady growth in demand for industrial minerals resulted in nonfuel mineral value increasing from $215 million to $434 million. Despite the declines in value in 1990 and again in 1991, industrial minerals remained an essential component of the State's overall economy.

Cement.—Nationally, Indiana became the leading State in masonry cement production despite a 14% decline in output. Nationwide, masonry cement shipments dropped by 20%. In Florida, which led the United States in production in 1990, output dropped by more than 50%. In 1991, Indiana accounted for about 12% of the Nation's output of approximately 2.6 million short tons.

In portland cement, Indiana ranked 11th in output nationally. The State's portland cement shipments declined by 7% in 1991. Nationally, portland cement production dropped by about 9% in 1991 compared with that of 1990.

Clays.—Indiana ranked 10th in production of common clay and shale among the 43 States reporting output in 1991. During the year, 11 pits were in operation in 8 counties with Morgan County the leader in production.

One company in Dubois County reported production of ball clay. Previously, this production had been reported as common clay and according to the Indiana Geological Survey that remains the situation.

Gypsum.—Indiana ranked seventh and eighth, respectively, in the production of crude and calcined gypsum. At Schoals in Martin County, National Gypsum Co. and USG Corp. each operated underground mines and wallboard plants. USG also manufactured wallboard at a plant in East Chicago with the crude gypsum supplied from a company mine in Michigan. The quantity of crude gypsum produced remained about the same, but value decreased sharply by 40% compared with 1990 data. Most of the gypsum mined in Indiana was used in making wallboard. Lesser quantities were used in cement and plasters and for soil conditioning.

The U.S. Department of Energy, in conjunction with the Northern Indiana Public Service Co. (NIPSCO), continued work on a project that was expected to generate a byproduct gypsum suitable for use in wallboard manufacture. The project is primarily designed to lower sulfur dioxide emissions at NIPSCO's Chesterton plant in Porter County. Use of this technology, termed flue gas desulfurization, is beneficial to the State's coal and limestone industries and also provides the byproduct gypsum. The operation was expected to be in service by mid-1992.

Lime.—Indiana ranked 12th in the Nation in lime production in 1991. Although production dropped by 9%, value increased by a similar amount. Most of the lime was sold for use by the steel industry.

Peat.—Nationally, Indiana dropped to eighth from fourth in peat production in 1991, as output dropped by about 30%. Nationally, peat production decreased by about 9% in 1991 compared with that of 1990.

Sand and Gravel.—Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Indiana dropped to 14th in the United States in production of construction sand

TABLE 2
INDIANA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	250	1,047	$4.19
Riprap and jetty stone	895	3,419	3.82
Filter stone	384	1,550	4.04
Other coarse aggregate	58	275	4.74
Coarse aggregate, graded:			
Concrete aggregate, coarse	4,533	14,622	3.23
Bituminous aggregate, coarse	2,562	9,075	3.54
Bituminous surface-treatment aggregate	1,755	6,356	3.62
Railroad ballast	1,042	4,798	4.60
Fine aggregate (-3/8 inch):			
Stone sand, concrete	329	1,095	3.33
Stone sand, bituminous mix or seal	223	990	4.44
Screening, undesignated	247	1,131	4.58
Other fine aggregate	W	W	3.50
Coarse and fine aggregates:			
Graded road base or subbase	3,034	12,103	3.99
Unpaved road surfacing	866	3,767	4.35
Terrazzo and exposed aggregate	1,350	7,389	5.47
Crusher run or fill or waste	921	3,822	4.15
Other construction materials[2]	695	3,190	4.59
Agricultural: Agricultural limestone[3]	1,697	9,348	5.51
Chemical and metallurgical:			
Cement manufacture	3,529	8,711	2.47
Flux stone	W	W	4.30
Glass manufacture	W	W	10.38
Sulfur oxide removal	230	1,678	7.30
Special:			
Asphalt fillers or extenders	W	W	7.32
Other fillers or extenders	W	W	8.66
Other miscellaneous uses[4]	328	2,928	8.93
Unspecified:[5]			
Actual	12,738	54,089	4.25
Estimated	259	1,107	4.27
Total[6]	37,924	152,489	4.02

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes dolomite and limestone.
[2]Includes withheld amounts for fine aggregate (-3/8 inch).
[3]Includes poultry grit and mineral food.
[4]Includes withheld amounts for chemical and metallurgical, and special.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.
[6]Data may not add to totals shown because of independent rounding.

and gravel in 1991. Output has decreased in each of the past 2 years after reaching an alltime high of about 29.6 million short tons in 1989. A general slowdown in construction resulted in about a 25% decline in production in 1991 compared to that of 1990.

Industrial.—Industrial sand production increased slightly in 1991 after having declined in the previous 2 years. Two companies, each operating one pit in Harrison and Portage Counties, accounted for the State's output in 1991.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Indiana stone statistics are compiled by geographical districts as depicted in the State map. Table 3 presents end-use statistics for Indiana's three districts.

Crushed.—Indiana ranked 14th nationally in crushed stone production. Output and value both increased slightly compared with 1990 data, and unit price per ton of $4.02 remained the same. Production occurred at 85 quarries in 39 of the State's 92 counties. Crawford and Putnam had the highest number of active quarries with six each. District 3, or essentially that portion of Indiana south of Bloomington, accounted for about 42% of the State's output.

Developments during the year included construction of a limestone grinding plant by J. M. Huber Corp. at Indiana's Burns International Harbor. The limestone product was expected to be used at the Bailly generating station of NIPSCO in operation of a flue gas desulfurization system. The plant, when completed in mid-1992, was to have a 300,000-short-ton-per-year capacity, according to company officials.

For the second time in 4 years, one of the State's top crushed stone producers was purchased. In 1988, Beazer PLC of the United Kingdom had purchased Koppers Co., which operated under various names in Indiana. In 1991, Hanson PLC, also of the United Kingdom, purchased Beazer. The transaction included 11 limestone quarries and mines in Indiana.

Also during the year, Martin Marietta Corp. opened an underground limestone mine in Howard County. The firm also continued development work on a quarry in Hamilton County.

In a controversy that continued throughout the year, Lowell Mining Co.

TABLE 3
INDIANA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	449	1,949	362	1,708	778	2,632
Coarse aggregates, graded[2]	3,054	13,634	671	3,300	6,168	17,916
Fine aggregates (-3/8 inch)[3]	W	W	W	W	309	1,140
Coarse and fine aggregates[4]	2,307	8,729	2,559	13,133	1,305	5,218
Other construction materials	651	2,671	533	2,596	—	—
Agricultural[5]	992	6,593	172	814	532	1,941
Chemical and metallurgical[6]	(7)	(7)	(7)	(7)	2,294	8,281
Special[8]	(7)	(7)	(7)	(7)	—	—
Other miscellaneous uses	659	1,337	1,134	3,699	—	—
Unspecified:[9]						
Actual	3,753	16,421	3,711	16,458	4,235	17,163
Estimated	481	1,918	461	1,923	357	1,315
Total	12,346	53,252	9,603	43,631	[10]15,977	55,606

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap and jetty stone, filter stone, and other coarse aggregate.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), screening (undesignated), and other fine aggregate.
[4]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run (select material or fill).
[5]Includes agricultural limestone and poultry grit and mineral food.
[6]Includes cement manufacture, flux stone, glass manufacture, and sulfur oxide removal.
[7]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[8]Includes asphalt fillers or extenders and other fillers or extenders.
[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[10]Data do not add to total shown because of independent rounding.

TABLE 4
INDIANA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	71	34,091	$126,742	$3.72	77	35,549	$142,747	$4.02
Dolomite	10	2,095	9,510	4.54	8	2,375	9,742	4.10
Calcareous marl	1	W	W	W	—	—	—	—
Miscellaneous stone	1	W	W	W	—	—	—	—
Total[1]	XX	36,188	136,252	3.77	XX	37,924	152,489	4.02

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

and U.S. Trust Co. sought permission to reopen two inactive quarries in Lake County. The companies received approval from the Lake County Planning Commission in May. The Lake County Council failed to make a decision before an August deadline and, in effect, automatically approved the two quarries.[4] Both quarries are in a high-magnesium dolomitic deposit suitable for use in road construction and possibly as a flux stone in steelmaking.

Dimension.—Indiana, with production in excess of 187,000 short tons of dimension stone, ranked first in the Nation in output of this commodity. In 1991, dimension stone was produced by 12 companies at 16 quarries. Lawrence and Monroe Counties accounted for most of the limestone-dolomite production from the south-central limestone belt.

A plan by the Indiana Department of Transportation (INDOT) to construct a highway from Bloomington to Evansville included a proposed route that would pass through Monroe and Lawrence Counties. The roadway was in the preliminary planning stages with the start of construction not expected until 1996. It

was expected that INDOT would discuss resources and impacts on industry before the final route is determined.

Other Industrial Minerals.—Perlite mined in other States was expanded by four companies in Indiana. The State produced about 23,500 short tons of expanded perlite, ranking 10th in the United States in output. Expanded perlite was used as plaster aggregate, block insulation, filler, and as a filter medium. Two of the plants were in Martin County and operated in conjunction with the gypsum operations. The other plants were in Montgomery and Tippecanoe Counties.

Iron and steel slag from Indiana's steel industry was processed by three companies with four plants in Huntington, Lake, and Porter Counties. Nationally, Indiana ranked third in iron and steel slag production. Elemental sulfur continued to be recovered by Amoco Oil Co. at its Whiting refinery in Lake County.

Metals

No metals were mined in Indiana. Metals discussed in this section were processed from materials received from both foreign and domestic sources. Production and value data for these metals are not included in table 1.

Aluminum.—Indiana again ranked fourth of 14 States producing aluminum. The Aluminum Co. of America (Alcoa) Warrick Operations at Newburgh, Warrick County, was the State's only producer of primary aluminum.

Iron and Steel.—Indiana continued to lead the Nation in production of raw steel. In 1991, about 19.2 million short tons of steel was produced in Indiana, a drop of about 9% in output from that of 1990.[5] The drop in output was in line with a nationwide decline in demand resulting from a downturn in the economy. Orders for automobiles, appliances, and metal containers, all major end products of steel, declined in 1991.

During the year, a number of modernization projects were completed despite the decline in output. USX Corp. completed a $370 million program to upgrade facilities at its Gary Works. In September, the company began production from a $240 million continuous caster with a 1.6-million-short-ton annual capacity. USX also invested $110 million to rebuild a blast furnace and $20 million on a plate mill modernization.

Inland Steel Co., the State's largest employer of steelworkers with a work force of 14,700, cited slowed market conditions for cutbacks in operations during the year. In March, the firm eliminated 325 jobs at a structural mill at its facilities in East Chicago. Inland also continued a program to reduce the work force by an additional 1,000 workers mostly through attrition. In 1991, operations were maintained at about 70% of capacity.

Although conditions at Inland's East Chicago operations were depressed, a new joint-venture facility at New Carlise began production. In December, the I/N Kote plant, a joint venture of Inland Steel and Nippon Steel Corp. of Japan, began production at a second galvanizing line completing the startup of the $550 million operation.[6]

The I/N Kote operation is a sister producer to 6 the I/N Tek cold-rolling mill that began operating in 1990. The new steel galvanizing lines at I/N Kote gave Inland about 1.2 million tons of hot-dip galvanizing capacity and about 500,000 tons of electrogalvanizing capacity.

Bethlehem Steel Corp. also began construction to add galvanizing capacity at its Burns Harbor facility. The new line was designed to have a 450,000-ton-per-year capacity with capability for galvanizing and galvannealing. The work was scheduled for completion in 1993.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related industry and government experience and has covered the mineral activities in Indiana for 1 year. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]Geo News. Indiana Geological Survey, Dep. of Natural Resources, Bloomington, IN, v. 1, No. 2, Summer 1991, p. 1.

[3]Hoosier National Forest. Plan Amendment 1991, Bedford, IN 47421, Apr. 1991, 6 pp.

[4]The Gary Post Tribune. Two Lowell Families Sue Lake Over Mines. Oct. 1, 1991, p. 1.

[5]Northern Indiana Public Service Co. (NIPSCO). Steel Market Perspective. Steel in Indiana, Dec. 1992, p. 4.

[6]Michigan City News Dispatch. I/N Kote Plant Reaches Milestone. Dec. 15, 1991, p. 1.

INDIANA

LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Abr	Abrasives
Al	Aluminum plant
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-L	Dimension Limestone
D-S	Dimension Sandstone
Gyp	Gypsum
IS	Industrial Sand
Lime	Lime plant
Peat	Peat
SG	Sand and Gravel
Steel	Iron and Steel plant

Principal Mineral-Producing Localities

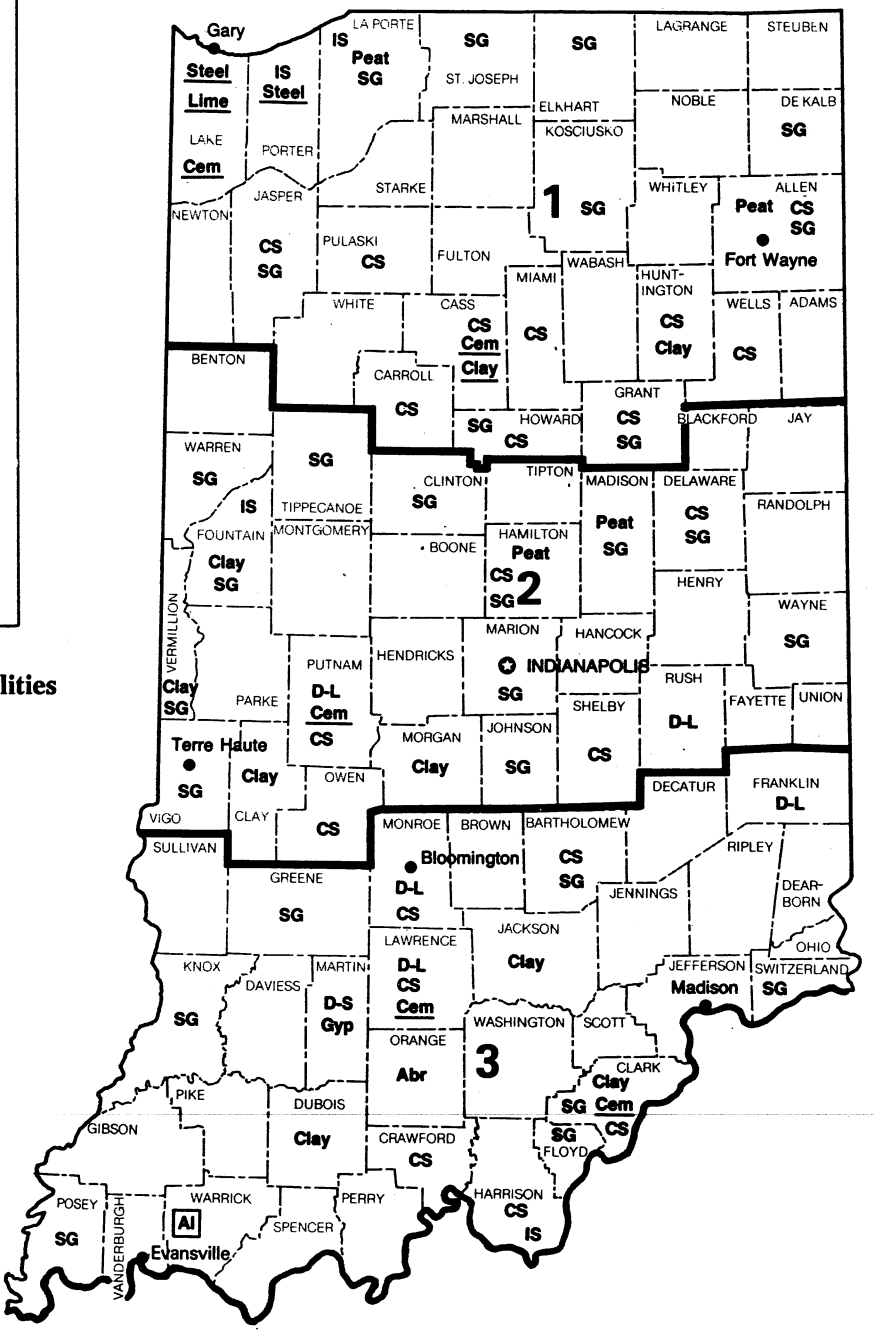

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Aluminum Co. of America	Warrick Operations Box 10 Newburgh, IN 47630	Smelter and fabricating plant	Warrick.
Cement:			
Essroc Materials Inc., a subsidiary of Societe des Ciments Francais:	Box 35750 Louisville, KY 40232		
Logansport plant[1 2]		Plant, quarry, clay pit	Cass.
Speed plant[1 2]		do.	Clark.
Lehigh Portland Cement Co., a subsidiary of Heidelberger Zement AG:	Box 1882 Allentown, PA 18105		
Buffington Station plant		Plant	Lake.
Mitchell plant		Plant and quarry	Lawrence.
Lone Star Industries Inc.: Greencastle plant[1 2]	Box 120014 Stamford, CT 06912	Plant, quarry, clay pit	Putnam.
Clays:			
General Shale Products Corp.	Johnson City, TN 37601	Pits and plant	Morgan.
Hydraulic-Press Brick Co., Haydite Div.	Brooklyn, IN 46111	Pit and plant	Do.
Log Cabin Coal Co.	304 South Depot St. Brazil, IN 47834	Pits and plant	Clay.
Gypsum:			
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	Underground mine and plant	Martin.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Lake.
Iron and steel:			
Bethlehem Steel Corp.	Bethlehem, PA 18016	Mill (integrated)	Porter.
Inland Steel Co., a subsidiary of Inland Steel Industries Inc.	3210 Watling St. East Chicago, IN 46312	do.	Lake.
I/N Tek	30755 Edison Rd. New Carlisle, IN 46552	Mill (rolling)	St. Joseph.
LTV Steel Co. Inc.	3001 Dickey Rd. East Chicago, IN 46312	Mill (integrated)	Lake.
National Steel Corp., Midwest Steel Div.	U.S. 12 Portage, IN 46368	Mill (rolling)	Porter.
Nucor Corp.	4425 Randolph Rd. Charlotte, NC 28211	Minimill	Montgomery.
USX Corp., Gary Works Div.	1 North Broadway Gary, IN 46402	Mill (integrated)	Lake.
Lime:			
Inland Steel Co., a subsidiary of Inland Steel Industries Inc.	3210 Watling St. East Chicago, IN 46312	Plant	Do.
Marblehead Lime Co., a subsidiary of General Dynamics Corp.	222 North LaSalle St. Chicago, IL 60601	do.	Do.
Peat:			
Beusching Peat Moss & Black Dirt	9134 Cook Rd., Route 3 Fort Wayne, IN 46825	Bog and plant	Allen.
Felger's Peat Moss & Black Dirt	9912 Valentine Rd. Fort Wayne, IN 46818	do.	Do.
Filbrun Peat Moss	Route 2, Box 269 Pendleton, IN 46064	do.	Madison.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Peat—Continued:			
Hyponex Corp.	14111 Scotslawn Rd. Marysville, OH 43041	Bog and plant	Hamilton.
Millburn Peat Co. Inc.	Box 236 La Porte, IN 46350	do.	La Porte.
Perlite (expanded):			
Chemrock Corp.	Box 5465 Lafayette, IN 47903	Plant	Tippecanoe.
Grefco Inc.	Box 48 Crawfordsville, IN 47933	do.	Montgomery.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	do.	Martin.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Do.
Sand and gravel:			
Construction:			
American Aggregates Corp., a division of CSR America Inc.	Drawer 160 Greenville, OH 45331	Pits and plants	Hamilton, Marion, Wayne.
Evansville Materials Inc.	Box 3596 Evansville, IN 47734	do.	Posey, Spencer, Vanderburgh.
Hilltop Basic Resources Inc.	630 Vine St. Cincinnati, OH 45202	Pit and plant	Switzerland.
Irving Materials Inc.	Box 369, Route 5 Greenfield, IN 46140	Pits and plants	Fayette, Hamilton, Madison, Wayne.
Martin Marietta Aggregates	Box 30013 Raleigh, NC 27622	do.	Clark, Hamilton, Howard, Marion, Vermillion, Vigo.
OK Sand & Gravel Co. Inc.	5320 South Belmont Indianapolis, IN 46217	Pit and plant	Marion.
Rogers Group Inc.	Box 849 Bloomington, IN 47402	Pits and plants	Fountain, Greene, Knox, Morgan, Owen, Warren.
Vulcan Materials Co.[1]	Box 7497 Birmingham, AL 35253	do.	St. Joseph and Tippecanoe.
Industrial:			
Crisman Sand Co. Inc.	6480 Melton Rd. Portage, IN 46368	Pits and plant	Porter.
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	do.	Harrison.
Slag:			
Iron and steel:			
The Levy Co. Inc.	Box 540 Portage, IN 46368	Plant	Porter.
Steel:			
Heckett Co.	Box 1071 Butler, PA 16001	do.	Lake.
Stone:			
Crushed:			
Limestone:			
American Aggregates Corp., a division of CSR America Inc.	Drawer 160 Greenville, OH 45331-0160	Quarries and plants	Hamilton and Marion.
Hanson PLC (The France Stone Co.)	6100 Ardmore Ave Fort Wayne, IN 46809	do.	Allen, Jennings, Putnam, Riley, Scott, Washington.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone—Continued:			
Crushed—Continued:			
Limestone—Continued:			
Irving Bros. Stone & Gravel Inc.	Box 300, Rural Route 13 Muncie, IN 47302	Quarries and plants	Blackford, Delaware, Grant, Huntington, Wells.
Mulzer Crushed Stone Inc.	Box 248 Tell City, IN 47586	Quarries, mine, plants	Crawford.
Rogers Group Inc.	Box 849 Bloomington, IN 47402	Quarries and plants	Greene, Lawrence, Monroe, Newton, Putnam.
Marl:			
Vernon M. Kaufman	Route 1 Topeka, IN 46571	Pit	Lagrange.
Dimension, limestone:			
Elliot Stone Co. Inc.	Box 743 Bedford, IN 47421	Quarry and plant	Lawrence.
B. G. Hoadley Quarries Inc.	Box 1224 Bloomington, IN 47402	do.	Do.
Independent Limestone Co.	6001 South Rockport Rd. Bloomington, IN 47401	do.	Monroe.
Indiana Limestone Co. Inc.	Box 72 Bedford, IN 47421	Quarries and plants	Lawrence and Monroe.
Reed Quarries Inc.	Box 64 Bloomington, IN 47402	Quarry and plant	Monroe.
Victor Oolitic Stone Co.	Box 668 Bloomington, IN 47402	Quarries and plant	Do.
Sulfur (recovered):			
Amoco Oil Co.	Box 710 Whiting, IN 46394	Elemental sulfur recovered as a byproduct of oil refining	Lake.

[1]Also crushed stone.
[2]Also clays.

THE MINERAL INDUSTRY OF IOWA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Geological Survey Bureau, Division of Energy and Geological Resources, Iowa Department of Natural Resources, for collecting information on all nonfuel minerals.

By Jeanne E. Zelten[1] and Robert M. McKay[2]

The value of nonfuel mineral production in Iowa in 1991 reached a record high of $344 million, a $27.6 million increase over that reported to the U.S. Bureau of Mines by the State's mineral producers in 1990. Crushed stone, portland cement, construction sand and gravel, and crude gypsum accounted for about 96% of the State's total nonfuel mineral production value. Most of these commodities were utilized by the construction industry. Other mineral commodities produced, in order of decreasing value, included masonry cement, clay, lime, peat, dimension stone, and gemstones. Iowa ranked 29th nationally in the value of nonfuel mineral production. The State ranked second of 20 States in crude gypsum production and second of 28 States reporting calcined gypsum production.

Production increased substantially in 1991 for peat, clay, and construction sand and gravel. Increases also occurred in the production of crushed stone and lime. Production of crushed stone, the State's leading mineral commodity in terms of value, increased about 7% in 1991. Estimated production of portland cement, the State's second leading mineral commodity, decreased almost 9%, while construction sand and gravel production increased more than 16% from 1990 levels.

TRENDS AND DEVELOPMENTS

Production of aggregate in the State, hard-hit by the economic recession in 1991, was similar to that throughout the Midwest. Production is expected to increase as much as 5% in 1992 as construction activity begins to rebound. Increased highway construction, resulting from recent State and Federal legislation, could result in increases into the mid-1990's. Proposed highway work and other construction are expected to increase demand for aggregate and cement.

Inspiration Resources Corp. relocated its corporate headquarters from New York City to Sioux City, Woodbury County, where its largest subsidiary, Terra International Inc., was based. Terra announced a 75,000-ton-per-year ammonia expansion, which was scheduled for completion late in 1992. A 30% reduction in emissions also was anticipated at the plant. The company

TABLE 1
NONFUEL MINERAL PRODUCTION IN IOWA[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	47	$4,450	53	$5,054	e34	e$3,264
Portland	do.	2,072	102,387	2,525	122,466	e2,301	e112,749
Clays	metric tons	439,323	1,773	423,227	1,376	530,477	2,226
Gemstones		NA	10	NA	14	NA	8
Gypsum (crude)	thousand short tons	2,273	16,884	2,192	14,243	2,162	12,285
Sand and gravel (construction)	do.	e12,800	e37,800	14,953	46,432	e17,400	e55,800
Stone:							
Crushed	do.	28,049	111,182	e29,000	e118,600	[2]31,057	[2]147,815
Dimension	short tons	15,151	613	W	W	W	W
Combined value of other industrial minerals and values indicated by symbol W		XX	7,603	XX	8,185	XX	9,885
Total		XX	282,702	XX	316,370	XX	344,032

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain stones; value included with "Combined value" data.

was the sixth largest producer of nitrogen solutions and one of the largest purchasers and distributors of crop protection products, seed, potash, and phosphate.

A remediation agreement was reached between Holnam Inc. and the U.S. Environmental Protection Agency (EPA) concerning the company's Mason City cement operation in Cerro Gordo County. Prior to 1986, kiln dust was dumped into the company's west limestone quarry. In 1990, the quarry was included on the National Priority List of Superfund sites. The remediation plan was scheduled to be accomplished between mid-1992 and mid-1993 at an estimated cost of $2.5 million. In 1991, the plant operated at 86% of its 900,000-short-ton-per-year rated capacity. The company estimated a 47-year supply of raw material.

Quanex Corp. continued construction of the company's Nichols-Homeshield Casting plant in Davenport, Scott County. The aluminum minimill was expected to be fully operational in July 1992. The new plant was planned to have the capacity to cast 270 million pounds of coiled aluminum sheet annually, one-third of which would be used for building products in the company's other facilities in Davenport and Illinois.

Lafarge Corp. acquired Davenport Cement Co. and other operations from Cementia Holding AG of Zurich, Switzerland, and its Spanish subsidiary Asland, S. A. Included in the acquisition was an 858,000-ton-capacity clinker dry-process cement plant in Buffalo, Scott County. Also included in the agreement were three cement manufacturing plants in Illinois and Missouri, more than 30 related ready-mixed concrete and aggregate operations, and 15 terminals along the Mississippi River and its tributaries.

Midland Brick of Ottumwa, Wapello County, was shut down. The plant had been in operation for more than 100 years and was one of four remaining brick plants in the State.

EMPLOYMENT

Information used in the preparation of this section was obtained from the Energy Information Administration,[3] the U.S. Department of Labor,[4] and the Iowa Department of Employment Services.[5]

Persons employed in Iowa's nonfuel mining industries in 1991 numbered 2,469, an increase of almost 5.5% from that of 1990. This included 1,572 at surface operations, 205 workers at underground mines, and 692 workers at mills and preparation plants. In addition, an average of 97 coal miners worked daily at surface mines during 1991. This was a decrease of more than 28% from the 135 workers reported in 1990.

In the mineral-dependent construction industry, the annual average number of employees was about 45,600, an increase of about 1.3% from the 45,000 reported in 1990. Employment in the stone, clay, and glass products sector remained stable at 5,800. In the primary metal products sector, employees numbered about 7,800, an increase of about 100 since 1990.

According to the U.S. Department of Labor, injuries reported from Iowa nonfuel surface and underground mines totaled 59 injuries resulting in lost workdays and 53 injuries with no lost workdays during 3.3 million hours worked. More than 1.4 million hours worked at mills and preparation plants resulted in an additional 50 injuries causing lost workdays and 23 injuries with no days lost. Surface coal mines reported eight injuries resulting in lost work days and seven injuries with no days lost during almost 108,000 hours worked.

LEGISLATION AND GOVERNMENT PROGRAMS

Two bills concerning solid and hazardous waste were signed into law in 1991. House file 375 prohibited the final disposal of baled solid waste at a sanitary landfill beginning January 1, 1992, except waste that was baled at the landfill. The law also required the Department of Natural Resources to develop rules to define baled solid waste and to provide for a safe and proper method of disposal.

House file 649 replaced the term "abandoned and uncontrolled sites" with "hazardous waste or hazardous substance disposal sites" relating to the portions of the code regarding hazardous activities, and hazardous waste and substance management. It also provided that such sites include the adjoining real property and ground water affected by the disposal activities and provided that regulation of the sites pertains to hazardous waste and not solid waste disposal.

In September, the Iowa Supreme Court ruled that liability insurance should cover pollution cleanup costs. The State court ruled that 14 insurance companies that provided a defunct brass foundry general liability insurance during its 40-year lifespan were liable for the cost to clean the site and obligated to defend the company in legal actions taken by EPA. The decision was the result of an ongoing court battle between the insurance companies and A. Y. McDonald Industries Inc., the owner of the Dubuque brass foundry, Dubuque County. McDonald ran the foundry from the 1940's to 1983. In 1983, the company moved to a new location. A year or two after closing the plant, EPA inspected the land behind the foundry that had been a dump site for used foundry sand. The site was found to be contaminated with brass particulate, which can contain between 5% and 7% lead. The estimated cleanup cost of the 14-acre site was $1.3 million.

Under the State Mining and Mineral Resources Research Institute Program Act (Public Law 98-409), the U.S. Bureau of Mines awarded a basic allotment grant of $148,000 to Iowa State University. The monies were used to perform basic and applied research related to Iowa's mineral resources and for the general benefit of the Nation's mineral industry. Under stipulations of the act, the State of Iowa was required to match this grant on a 2:1 basis.

The Iowa Geological Survey Bureau continued work on its Groundwater Vulnerability Mapping Program and published a Groundwater Vulnerability

Regions map of the State. As part of this study to determine the susceptibility of ground water aquifers to contamination from surface and near-surface sources and activities, as mandated by the 1987 Groundwater Protection Act, two mapping projects were completed. The bedrock topographic map of the State was revised, and a statewide alluvial aquifer map was completed. These maps were expected to be published in 1992. This research would benefit minerals explorationists as well as ground water researchers. The information would be especially useful to aggregate producers in identifying new sources of crushed stone.

The Department of Natural Resources entered into a cooperative agreement with the U.S. Geological Survey (USGS) to drill a series of core holes across the Manson Meteorite Impact Structure. The crater, centered near the town of Manson in Calhoun County, is 22 miles in diameter and geologically complex. The drilling project was part of the USGS Continental Scientific Drilling Program and was one of only a few selected for funding from the large number of proposals submitted nationally. One site was drilled in 1991, and the recovered core generated much interest in the project. The USGS indicated a desire to fund additional drilling during fiscal year 1993. State budget constraints, however, indicated that funding probably would not be appropriated for continued support of the research drilling program. Scientists involved in the program hoped to discover previously undetected zones of mineralization and water resources.

The Department of Natural Resources continued work on a computerized natural resource geographic information system.

FUELS

In 1991, a total of 344,000 short tons of high volatile bituminous C coal was produced from two surface mines owned by American Coals Corp. and Jude Coal Inc., in Marion County. This was a decrease of about 9.6% from the 381,000 short tons produced in 1990. Except for 1988, when production was 341,000 short tons, this was the lowest production reported from the State in more than 9 years.[6]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Production of industrial minerals in 1991 was affected by changes in the three major areas of construction: residential building, nonresidential building, and nonbuilding construction (including highways). There was a substantial decrease in nonresidential building, while the other two areas experienced modest increases as the year progressed.

Permit-authorized construction in 1991 totaled more than $1,234 million. The number of single- and multifamily residential units increased almost 12%, from 7,637 units in 1990 to 8,545 units in 1991. The value of nonresidential construction decreased about 44%, from $579 million in 1990 to $323 million in 1991. About $5.2 million of this was used for nonbuilding construction, including highways.[7]

Passage in November of the $151 billion Intermodal Surface Transportation Efficiency Act (ISTEA), with its 6-year Federal highway funding provisions, was expected to contribute to increased aggregate production in 1992. Significant improvements in roads and highways were anticipated and could lead to significant increases in aggregate consumption. Cement consumption in the State was expected to increase 5% to 6% in 1992. The increase was attributed to anticipated increases in highway work as well as in commercial and residential building.

Environmental and zoning regulations were cited as the primary reasons for making it increasingly difficult for the construction aggregates industry to expand existing quarries and to develop new quarry operations. As operations must move further from market areas, transportation costs increase, ultimately affecting aggregate prices and competition.

Production of crushed stone, portland cement, construction sand and gravel, and crude gypsum accounted for about 96% of the State's total nonfuel mineral value in 1991. Ten industrial minerals were mined, manufactured, or recovered as byproducts during the year.

Cement.—In 1991, Iowa ranked 10th nationally in the production of portland cement and 18th in masonry cement production. Estimated production and value of portland cement in 1991 decreased almost 9% and 8%, respectively, from 1990 reported values. Production and value of masonry cement each decreased more than 35%.

Four companies produced cement in the State in 1991. Two of the companies produced both portland and masonry cement, while two produced only portland cement. The companies that produced both cements were the Davenport Cement Co., which operated a plant near Buffalo in Scott County, and Holnam Inc.'s Dundee Div. at a plant near Mason City in Cerro Gordo County. Lehigh Portland Cement Co. operated a portland cement plant near Mason City. All three companies operated dry-process kilns. The Monarch Cement Co. ground clinker from its Humboldt, KS, facility at a portland cement plant in Des Moines, Polk County. All of the plants were foreign-owned except for Monarch Cement. Principal markets for the cement were ready-mix concrete companies, concrete product manufacturers, highway contractors, and building material dealers.

Clay.—In 1991, Iowa ranked 18th nationally in the production of common clay, increasing more than 25% from 1990 production. The value of produced clay increased almost 62% over 1990 values. Six companies reported production from eight pits in five counties. Primary uses were portland cement and common brick. Other uses included ceramics, floors, and walls.

Gypsum.—Like the aggregate industry, the gypsum industry also was adversely

TABLE 2
IOWA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	240	1,095	$4.56
Riprap and jetty stone	197	1,047	5.31
Filter stone	243	1,205	4.96
Coarse aggregate, graded:			
Concrete aggregate, coarse	1,620	8,297	5.12
Bituminous aggregate, coarse	1,399	7,099	5.07
Bituminous surface-treatment aggregate	2,172	1,146	5.28
Railroad ballast	41	188	4.59
Fine aggregate (-3/8 inch):			
Stone sand, concrete	W	W	4.04
Stone sand, bituminous mix or seal	185	650	3.51
Screening, undesignated	454	1,323	2.91
Coarse and fine aggregates:			
Graded road base or subbase	2,740	12,942	4.72
Unpaved road surfacing	3,564	14,210	3.99
Crusher run or fill or waste	212	666	3.14
Other construction materials[2]	398	1,396	3.51
Agricultural: Agricultural limestone[3]	1,890	13,383	7.08
Chemical and metallurgical: Cement manufacture[4]	2,842	9,267	3.26
Unspecified:[5]			
Actual	11,246	56,636	5.04
Estimated	1,612	6,951	4.31
Total	[6]31,057	147,815	4.76

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes limestone, sandstone and miscellaneous stone, excludes a minor amount of limestone and dolomite, and dolomite withheld to avoid disclosing company proprietary data.
[2]Includes withheld amounts for fine aggregate (-3/8 inch), pipe bedding, and roofing granules.
[3]Includes agricultural limestone, and poultry grit and mineral food.
[4]Includes lime manufacture, flux stone, glass manufacture, sulfur oxide removal, and asphalt fillers or extenders.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.
[6]Data do not add to total shown because of independent rounding.

impacted by continued decline in the construction industry. Excess production, especially in wallboard, resulted in some companies throughout the United States shipping to other regions of the country. This action created oversupply in those areas, which, in turn, resulted in decreased prices.

Iowa ranked second in the Nation in both crude and calcined gypsum production and third in value, in 1991. Crude gypsum was mined by five companies in Des Moines, Marion, and Webster Counties and calcined by four of the companies in Des Moines and Webster Counties. According to State records, the companies held licenses for a total of 12 mines. Both underground and open pit mining methods were used. In 1991, reported production and value of crude gypsum decreased almost 1.4% and 13.8%, respectively, below 1990 levels. Total gypsum calcined in 1991 amounted to 1,419,747 short tons, an almost 6% decrease from that of 1990. Principal sales were for manufacturing plaster and wallboard products, and for use in cement and agriculture.

United States Gypsum Co., National Gypsum Co., and Georgia-Pacific Corp. were among the top five producing companies nationally. These three companies, along with Celotex Corp., were among the top five companies nationally in the production of calcined gypsum. In 1991, United States Gypsum's Sperry Mine in Fort Dodge, Des Moines County, was fourth in the Nation in total reported crude gypsum production, and the Sperry plant was fourth in reported calcined gypsum production.

Lime.—Reported lime production and value increased almost 6% and about 39%, respectively, in 1991. Linwood Mining and Minerals Corp. produced lime at a plant in Scott County. Most of the production was quicklime; a small amount of hydrated lime also was produced.

Growth in the lime and limestone industry was enhanced by the Clean Air Act Amendments and other environmental legislation, which required the installation of stack scrubbers at coal-fired powerplants. Lime and pulverized limestone are used in the scrubbers to remove sulfur oxides from stack gases. As the required scrubbers are installed and plants are brought into compliance with the new regulations, the demand for lime and limestone is expected to increase over the next several years. Other areas of continued growth in usage included water treatment, to achieve proper pH balances, and the treatment of hazardous wastes.

Peat.—In 1991, peat production was reported by Pikes Peat Co., in Muscatine County, and Colby Pioneer Peat Co., in Worth County. Peat was produced from bogs and used for potting soil and packaged plants. Nationally, Iowa ranked ninth and fifth, respectively, in production and value of peat produced. Production increased almost 77% and value increased more than 89% in 1991.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains

TABLE 3

IOWA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[2]	W	W	130	643	W	W
Coarse aggregates, graded[3]	W	W	672	2,658	W	W
Fine aggregates (-3/8 inch)[4]	W	W	W	W	W	W
Coarse and fine aggregates[5]	W	W	W	W	442	2,013
Other construction materials	834	3,656	1,573	6,564	116	725
Agricultural[6]	W	W	(7)	(7)	433	6,066
Chemical and metallurgical[8]	—	—	(7)	(7)	—	—
Special[9]	—	—	—	—	—	—
Unspecified:[10]	—	—	1,084	5,035	—	—
Actual	366	2,817	922	3,666	4,122	21,130
Estimated	858	5,010	179	360	—	—
Total[11]	2,058	1,482	4,560	18,926	5,113	29,934

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[2]	W	W	119	702	56	228
Coarse aggregates, graded[3]	1,460	7,502	2,265	13,224	341	1,340
Fine aggregates (-3/8 inch)[4]	429	1,266	19	83	W	W
Coarse and fine aggregates[5]	2,230	8,029	613	3,240	1,590	7,592
Other construction materials	614	2,539	6	48	116	255
Agricultural[6]	(7)	(7)	363	2,378	342	1,528
Chemical and metallurgical[8]	(7)	(7)	—	—	—	—
Special[9]	(7)	(7)	—	—	—	—
Other miscellaneous uses	2,350	6,915	—	—	—	—
Unspecified:[10]						
Actual	424	1,671	3,411	19,146	1,242	5,943
Estimated	1,103	3,381	—	—	230	463
Total[11]	8,611	31,303	6,796	38,820	3,918	17,349

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Excludes dolomite, limestone and dolomite; withheld to avoid disclosing company proprietary data.
[2]Includes macadam, riprap and jetty stone, and filter stone.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand (bituminous mix or seal) and screening (undesignated).
[5]Includes graded road base or subbase, unpaved road surfacing, crusher run (select material or fill), pipe bedding, and roofing granules.
[6]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[7]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[8]Includes cement manufacture, lime manufacture, flux stone, glass manufacture, and sulfur oxide removal.
[9]Includes asphalt fillers or extenders.
[10]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[11]Data may not add to totals shown because of independent rounding.

actual data for 1990 and estimates for 1989 and 1991.

Construction sand and gravel was the third leading mineral commodity produced in the State. Estimated production and value in 1991 increased about 16% and 20%, respectively, over amounts reported for 1990. These increases were largely attributable to the increased construction activity in the State. According to State records, 194 companies were licensed to mine sand and gravel from 597 sites in 87 counties. The material was used mainly for concrete aggregate, road base and coverings, fill, and asphaltic concrete.

Stone.—Both crushed and dimension stone were produced in Iowa during 1991. Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1990 and actual data for 1989 and 1991. Iowa's crushed stone

TABLE 4
IOWA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989[1]				1991[2]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	320	27,850	$110,333	$3.96	246	30,946	$147,511	$4.77
Dolomite	2	W	W	3.87	J½1781X—		—	—
Sandstone	1	W	W	5.04	—	—	—	—
Miscellaneous stone	—	—	—	—	2	111	304	2.74
Total	XX	28,049	111,182	3.96	XX	31,057	147,815	4.76

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Includes "limestone/dolomite," reported with no distinction between the two.
[2]Excludes dolomite, limestone and dolomite; withheld to avoid disclosing company proprietary data.

statistics are compiled by geographical districts, as depicted on the State map. Tables 2, 3, and 4 present end-use data for this commodity in the six Iowa districts.

Crushed.—Crushed stone, the leading mineral commodity produced in the State in 1991, accounted for 43% of the State's nonfuel mineral value. Limestone-dolomite was the only type of crushed stone produced. In 1991, reported production and value increased 7% and almost 25%, respectively. Crushed stone was produced by 42 companies operating 250 quarries in 64 counties. Almost 20% of the crushed stone production in 1991 was from Johnson, Madison, and Scott Counties. Martin Marietta Aggregates, The River Products Co. Inc., Schildberg Construction Co. Inc., and Wendling Quarries Inc. together produced about 50% of the State total. Major uses were for road surfacing, cement manufacturing, road base, and bituminous surface aggregate. Other uses included agricultural limestone, concrete aggregate, bituminous aggregate, and numerous other applications.

Dimension.—Dimension limestone production was reported by Weber Stone Co. Inc., in Jones County. Most of the stone was sold as irregular-shaped stone, veneer, sawed blocks, and flagging. Although the production of dimension stone decreased slightly in 1991, the value increased dramatically over estimated 1990 totals.

Other Industrial Minerals.— Anhydrous ammonia was produced by Arcadian Corp.'s 260,000-short-ton-per-year-capacity plant in Clinton, Clinton County; Farmland Industries Inc.'s 210,000-short-ton-per-year-capacity plant in Fort Dodge, Webster County; Green Valley Chemical Corp.'s 35,000-short-ton-per-year-capacity plant in Creston, Union County; and Terra International Inc.' 230,000-short-ton-per-year-capacity plant in Port Neal. The ammonia primarily was used for agricultural applications.

A variety of gemstones, minerals, and fossils were collected by amateur collectors and professionals, both for private collections and for commercial sales. The materials were sold as specimens and formed into a variety of decorative items. Rock and mineral specimens included agate, jasper, and geodes. Fossils included petoskey stone and crinoids. The reported value of gemstones collected in 1991 was $8,000. This value represented a decrease of almost 43% below the 1990 reported value.

National Gypsum Co. expanded crude perlite, received from out-of-state, at two plants in Webster County. The expanded perlite was used primarily for plaster aggregate.

Metals

Several mineral commodities produced in other States were processed or refined in Iowa.

Aluminum Co. of America (Alcoa) completed a $1.2 billion plant and equipment modernization program at its Davenport Works facility in Davenport, Scott County. The program began in 1983, and a new rolling mill came on-line in late 1990. The aluminum sheet and plate mill was capable of producing more than 600 million pounds of premium aluminum per year. During the recent metal slump, the plant operated at only 75% of capacity (450 million pounds per year). Davenport Works produced custom-made products, sheet and plate aluminum, foil products, and finished coils for the aerospace, automotive, and light sheet metal industries.

Keokuk Ferro-Sil Inc. produced silvery pig iron and 50% ferrosilicon at a plant in Keokuk. The plant was the Nation's only producer of silvery pig iron, which was used to manufacture steel alloys.

PMX Industries Inc., a subsidiary of Poongsan Corp. of Seoul, Republic of Korea, continued construction of its new 80,000-ton-per-year copper, brass, and specialty steel mill at Cedar Rapids. By yearend, the copper and brass melt shop was nearly complete. Construction on the stainless melt shop was scheduled to begin in the spring of 1992, with production of metal by early 1993. The company hoped to supply the market that currently imports copper and brass, for use in U.S. service centers, with new PMX output from the Cedar Rapids facility. The copper and brass plant was expected to be fully operational by February 1992.

[1]State Mineral Officer, U.S. Bureau of Mines, Denver, CO. She has 14 years of mineral-related industry and government experience. Assistance in the preparation of the chapter was given by Pat LaTour, editorial assistant.

[2]Geologist, Iowa Department of Natural Resources, Geological Survey Bureau, Iowa City, IA.

[3]Energy Information Administration. Coal Production 1991. Oct. 1992.

[4]U.S. Department of Labor, Mine Safety and Health Administration. Mine Injuries and Worktime, Quarterly. Jan.-Dec. 1991.

[5]Iowa Department of Employment Services. News. Dec. 1991.

[6]Work cited in footnote 3.

[7]U.S. Department of Commerce, Bureau of the Census. Permit Authorized Construction in Permit Issuing Places. Annual 1991.

IOWA

LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-L	Dimension Limestone
Gyp	Gypsum
Lime	Lime plant
Peat	Peat
SG	Sand and Gravel

Principal Mineral-Producing Localities

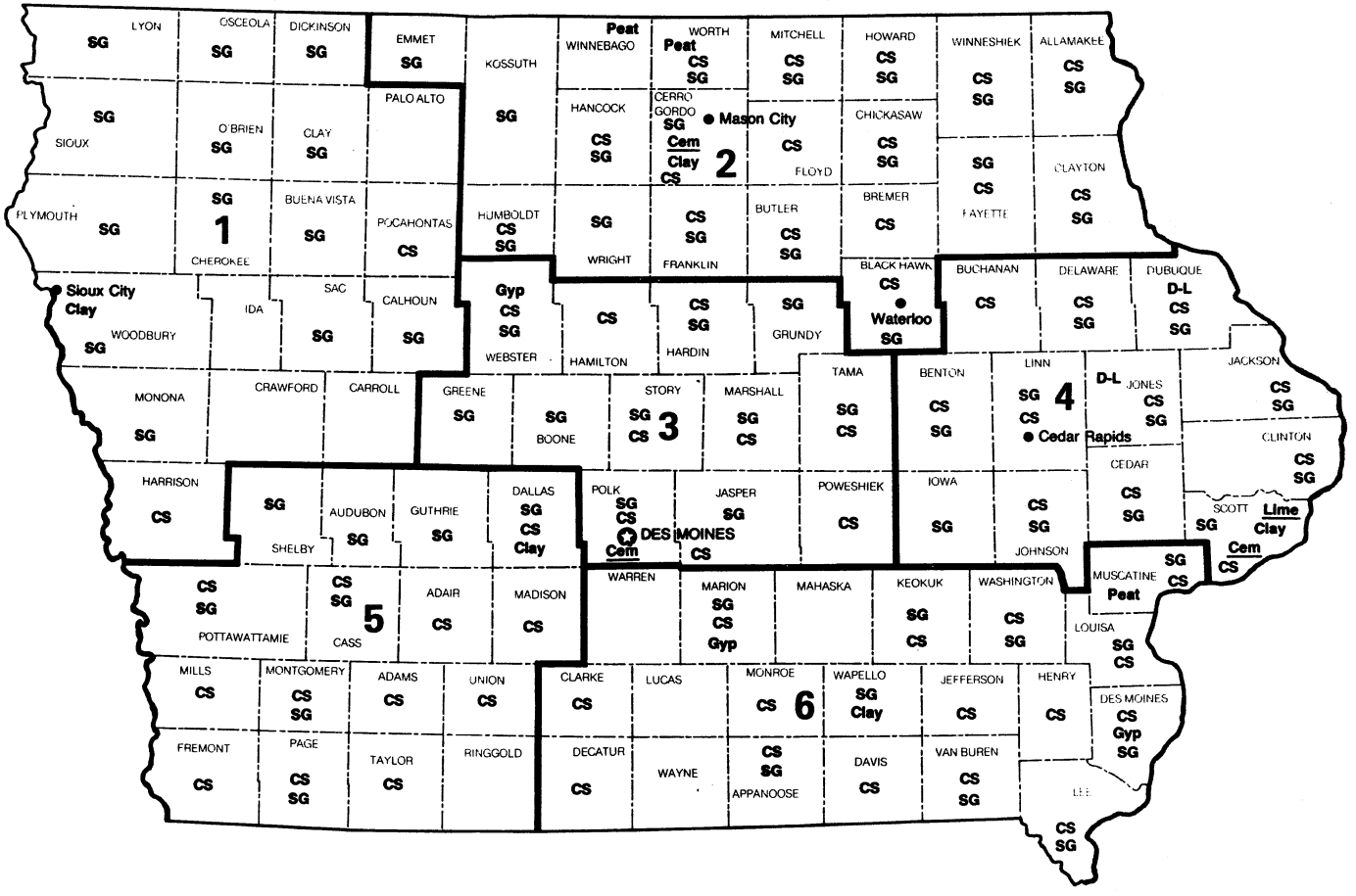

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Davenport Cement Co., a subsidiary of Cementia Holdings AG.	Box 4288 Davenport, IA 52801	Quarries and plant	Scott.
Holnam Inc., Dundee Div.	1840 N. Federal Box 1008 Mason City, IA 50402	Quarry and plant	Cerro Gordo.
Lehigh Portland Cement Co., a subsidiary of Heidelberger Zement AG.[1]	Route 1, Box 200 Mason City, IA 50401	do.	Do.
The Monarch Cement Co.	5200 Park Ave. Des Moines, IA 50321	do.	Polk.
Clay:			
Lafarge Corp.[2]	Box 4049 Davenport, IA 52808	Quarries and plants	Scott.
Midland Brick Co.	Box A Redfield, IA 50233	do.	Dallas.
Sioux City Brick & Tile Co.	Box 807 501 Orpheum Bldg. Sioux City, IA 51102	do.	Dallas and Woodbury.
Gypsum:			
Celotex Corp., a division of Jim Walter Corp.	Box 698 Fort Dodge, IA 50501	Quarries and plant	Webster.
Georgia-Pacific Corp. Gypsum Div.	Box 758 Fort Dodge, IA 50501	Quarry and plant	Do.
Kaser Corp.[3]	Box 3569 Des Moines, IA 50322	Underground mine and plant	Marion.
National Gypsum Co., Gold Bond Building Products Div.	Box 977 Fort Dodge, IA 50501	Quarry and plant	Webster.
United States Gypsym Co.	Box 878 Fort Dodge, IA 50501	Underground mine, quarries, plants	Des Moines and Webster.
Lime:			
Linwood Mining & Minerals Corp.[2]	401 East Front St. Davenport, IA 52804	Quarry, underground mine, plant	Scott.
Peat:			
Colby Pioneer Peat Co.	Box 8 Hanlontown, IA 50444	Plant	Worth.
Pikes Peat Co.	Route 6, Box 21 Muscatine, IA 52761	do.	Muscatine.
Perlite (expanded):			
National Gypsum Co., Gold Bond Building Products Div.	Box 977 Fort Dodge, IA 50501	do.	Webster.
Sand and gravel (construction):			
Acme Fuel & Material Co.	Route 5, Box 34 Muscatine, IA 52761	Quarries and plant	Muscatine.
Basic Materials Corp.[4]	Box 2277 Waterloo, IA 50704	Quarries and plants	Black Hawk and Waterloo.
G. A. Finley Co.	Box 406 Harlan, IA 51537	do.	Cass, Dallas, Montgomery, Page, Pottawattamie, Shelby.
Hallett Construction Co.	Box 3365 Des Monies, IA 50316	do.	Audubon, Boone, Buena Vista, Cherokee, Dallas, Greene, Marshall, Osceola, Polk, Sac, Story.
Martin Marietta Aggregates Inc., Central Div.[5]	30013 SW 42d St. Topeka, KS 66609	Quarries, underground mine, plants	Various (20 counties).

See footnotes at end of table.

TABLE 5-Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel (construction)—Continued:			
Stevens Sand & Gravel Co. Inc.	Route 4, Box 35 Iowa City, IA 52240	Quarries, underground mines, plants	Johnson and Washington.
Stone:			
Crushed:			
Midwest Limestone Co. Inc.	Box 281 Gilmore City, IA 50541	Quarries and plants	Humboldt and Pocahontas.
The River Products Co. Inc.	103 E College, Suite 220 Iowa City, IA 52240	Underground mine, quarries, plants	Johnson, Louisa, Washington.
Schildberg Construction Co. Inc.	Box 358 Greenfield, IA 50849	Quarries and plants	Adair, Adams, Cass, Dallas, Madison, Page, Pottawattamie, Taylor, Union.
Vulcan Materials Co.	5300 North Park Place, NE Box 1428 Cedar Rapids, IA 52406	do.	Benton, Clinton, Jackson, Johnson, Jones, Linn, Tama.
Wendling Quarries Inc.	Box 120 DeWitt, IA 52742	do.	Cedar, Clayton, Clinton, Delaware, Dubuque, Henry, Jackson, Jones, Linn, Muscatine.
Dimension:			
Weber Stone Co.[2]	Route 1 Anamosa, IA 52205	do.	Jones.

[1]Also clay and crushed stone in Cerro Gordo County.
[2]Also crushed stone in Scott County.
[3]Also crushed stone in Jasper, Keokuk, Marion, Monroe, Polk, and Washington Counties.
[4]Also crushed stone in Black Hawk, Bremer, Hancock, and Worth Counties.
[5]Also crushed stone in 23 counties.
[6]Also crushed stone in June County.

THE MINERAL INDUSTRY OF KANSAS

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Kansas Geological Survey for collecting information on all nonfuel minerals mined in the State.

By Jeanne E. Zelten[1] and David A. Grisafe[2]

The value of nonfuel mineral production in Kansas in 1991 was $365.7 million, an increase of almost $19.6 million over that reported to the U.S. Bureau of Mines by the State's mineral producers in 1990. This was a new State record for nonfuel mineral value; the previous record of $346.1 million was established in 1990. The new record was attained primarily because of increased total value of salt, helium, and dimension stone. Sales of these three commodities exceeded the 1990 level by about $49.2 million. Salt retained its first place ranking among the mineral commodities produced in the State. Kansas ranked 25th nationally in mineral value and continued as the Nation's leading producer of crude and refined helium. The State contributed about 1.2% of the Nation's total nonfuel mineral value of $30.2 billion.

TRENDS AND DEVELOPMENTS

Production of aggregate in the State, hard-hit by the economic recession in 1991, was similar to that throughout the Midwest. Production is expected to increase as much as 5% in 1992 as construction activity begins to rebound. Highway appropriations for 1992 are about 12% higher than those for 1991. Increased highway construction, resulting from recent State and Federal legislation, could result in increases into the mid-1990's. Proposed highway work, public works construction, and improvements at the Kansas City airport are expected to increase demand for aggregate and cement.

TABLE 1
NONFUEL MINERAL PRODUCTION IN KANSAS[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	42	$2,514	39	$2,011	e30	e$1,530
Portland	do.	1,505	69,390	1,707	76,564	e1,466	e65,970
Clays[2]	metric tons	533,099	2,700	625,969	4,056	607,419	2,828
Gemstones		NA	W	NA	W	NA	527
Helium (Grade-A)	million cubic meters	W	W	W	W	39	76,540
Salt[3]	thousand short tons	1,948	82,212	2,390	92,119	2,316	97,713
Sand and gravel:							
Construction	do.	e13,000	e33,200	10,863	24,170	e9,600	e22,100
Industrial	do.	230	2,690	W	W	W	W
Stone:							
Crushed[4]	do.	15,850	56,976	e20,800	e79,200	16,802	67,249
Dimension	short tons	W	W	W	W	19,651	2,171
Combined value of clay (bentonite, 1989), gypsum (crude), helium (crude), pumice, salt (brine), stone [crushed quartzite (1991), sandstone and quartzite (1989-90)], and values indicated by symbol W		XX	68,449	XX	67,999	XX	29,051
Total		XX	318,131	XX	346,119	XX	365,679

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.
[3]Excludes salts in brines; value included with "Combined value" figure.
[4]Excludes certain stones; kind and value included with "Combined value" figure.

Despite tight State funds and several attempts to cut the program, construction funds for the State's highway program remained intact. The Kansas Department of Transportation reported that the number of contracts awarded declined about 5% from the 1990 number, but the dollar amount was essentially unchanged at $272 million. Increases were expected during the next few years as part of the State's multiyear program to upgrade the highway system moved into high gear. These upgrades were expected to be important to the mineral industry because of the large amounts of aggregate needed to construct the roads and also because about 78% of aggregate produced in Kansas in 1991 was transported by on-highway trucks. Increasing difficulties in obtaining permits were forcing quarry operators into more remote locations, thus increasing costs, which in turn affected aggregate prices.

Cement plant operators continued to explore the use of waste products as fuel in cement kilns. Faced with consistently low cement prices and a depressed economy, the industry investigated ways to cut fuel costs, which constituted approximately 25% of operating expenses. The high temperatures needed in cement kilns were used to burn waste materials, such as waste fuels, industrial wastes, spent organic solvents, and used tires. The canned wastes and tires were placed directly into the cement kilns along with the other raw materials, and the high temperature completely decomposed the organic material. Because portland cement clinker requires a certain amount of iron, the metal containers and the steel radial belts from the tires are simply incorporated into the clinker. Hazardous wastes have been burned in cement kilns for years, and in 1991, waste fuels accounted for about 6.6% of the energy used for making cement in the United States. It appeared to be an environmentally safe and efficient way to dispose of hazardous waste and other material that has long been a problem, thereby eliminating the need to mine other resources to satisfy fuel requirements.

The Monarch Cement Co. at Humboldt, in Allen County, received a temporary permit from the Kansas Department of Health and Environment in January to burn scrap tires as an alternate fuel source. By October, the company began using the tires 7 days per week to supply as much as 10% to 15% of its fuel requirements. Scrap tire sources included county landfills and tire companies and were acquired through brokers in the Kansas City and Wichita areas. Monarch was the only cement plant in the State that used only solid, nonhazardous material as an alternate fuel.

Ash Grove Cement Co. at Chanute, in Neosho County, also experimented with the use of scrap tires as an alternate fuel source, but elected to go with canned waste products. Heartland Cement Co. began using spent organic solvents and canned organic wastes in its clinker operation in Independence, Montgomery County.

Lafarge Corp., the first cement producer in the State to use waste fuels, set a company record in 1991 by using supplemental fuels for more than 80% of its fuel requirements. Industrial wastes, such as a refinery byproduct banned from land disposal, were used successfully in the kilns. As of late 1991, all of the State's cement plants were using waste material as a fuel source.

Expansion plans at Texaco Refining and Marketing Inc.'s El Dorado refinery, in Butler County, included building a hydrotreater and related equipment that enabled the refinery to meet specifications of the Clean Air Act of 1990. The project began in late 1991 and was anticipated to cost about $125 million. The changes were expected to increase the production of low-sulfur diesel fuel.

Lone Star Industries Inc. continued reorganization procedures under chapter 11 of the Federal Bankruptcy Act. The company's Bonner Springs cement plant and quarry in Wyandotte County were shut down, and the operation was put up for sale. The center continued operation as a cement distribution terminal only. Subsidized imports and shrinking construction markets were cited as the major reasons for the reorganization.

Killough Inc., a crushed stone producer, formerly in Ottawa, Franklin County, acquired W. A. Dunbar & Sons and Dunbar Asphalt, both in Lawrence, Douglas County. At the same time, Killough moved to new offices in Lawrence and changed its name to Killough Quarries Inc.

Centana Energy Corp. (National Helium Corp.), a subsidiary of Panhandle Eastern Corp., completed a 2-year upgrade of a helium extraction plant that had been idle since 1973. Located at Liberal, in Seward County, the plant was described in newspaper articles as one of the world's largest, capable of producing 20% of the world requirements for crude helium. Crude helium was delivered to Air Products and Chemicals Inc. in Liberal for purification and to the U.S. Bureau of Mines helium conservation pipeline system for storage.

Worked-out portions of underground limestone quarries and salt mines in the Kansas City and Hutchinson areas continued to be used for controlled-environment storage, manufacturing, and office space. Constant temperature, pressure, and humidity are useful for storage of sensitive materials such as movie film and paper documents. Several companies were evaluating expansion possibilities while others were considering alternate uses of their mines.

In a move to double production, Lyons Salt Co. upgraded its Rice County mine with a new crusher and other equipment. Near yearend, company officials announced that they were considering the development of unused space in the salt mine for storage purposes, including both computer storage and physical storage of items such as government and corporate documents. The storage company facility would have to be compatible with existing mining operations.

A sinkhole in east Hutchinson, Reno County, first discovered in late 1990, was filled with sand in an attempt to stabilize it. The site is on property belonging to North American Salt Co.; the company monitored the site on a continual basis to ensure safety of the area.

Konza Construction Co. in Junction City, Geary County, entered the

aggregates business after acquiring More Sand Co. of Junction City and the crushed limestone operation near Junction City, formerly operated by George Myers Inc.

Hunt Midwest Minerals Inc. of Kansas City, MO, began operating a large limestone quarry east of De Soto in Johnson County.

Martin Marietta Aggregates, whose regional offices were in Topeka, Shawnee County, received final approval in February of its revised plans for a 720-acre limestone quarry. The tract lies along the western edge of Douglas County and may well be the largest single limestone quarry permit ever approved in the State.

In the same area, the Shawnee County Public Works Department planned to begin operating a 385-acre limestone quarry on the eastern edge of Shawnee County. The county purchased the land and set it aside for future quarrying for its own use. However, with the approval of the previously mentioned Martin Marietta quarry, the Shawnee County operation was not expected to begin for some time and Shawnee County was expected to acquire crushed stone from the Martin Marietta quarry.

Bayer Stone Inc., headquartered in St. Marys, Pottawatomie County, completed its first major Canadian project contract. The Cathedral Place, in Vancouver, British Columbia, is a 23-story office building faced with bottom-ledge Cottonwood Limestone quarried by Bayer in Chase County. The company received the contract, competing with companies from Indiana, Minnesota, Texas, and France.

In July, the U.S. Department of Defense announced it would begin work to dispose of more than 350 barrels of depleted uranium stored in a warehouse in De Soto, Johnson County. Chemical Commodities Inc., owner of its warehouse and uranium, had purchased the surplus uranium from Defense Department agencies 26 years ago. The company had agreed to cease all operations and begin to dispose of hazardous wastes at its warehouses in De Soto, Kansas City, and Shawnee, but later said it lacked the funds to do the work.

EMPLOYMENT

At yearend, the total mineral industry employment in Kansas was 9,600 workers. This figure represented a decrease of 900, or about 8.6% less than the same period in 1990. Employment in the nonfuel mining sector remained stable at 1,400 from December 1990 to December 1991. This included an average of 99 workers per day at surface operations and an average of 17 workers at mills and preparation plants.[3] Employment in the oil and gas extraction sector at yearend decreased sharply from 9,100 in 1990 to 8,200 in 1991, a decrease of 900 or nearly 10%. In addition, an average of 92 coal miners worked daily during 1991. This was a decrease of about 30% from the 132 workers employed at coal mines in 1990.[4]

After a very slow start, employment in the mineral-dependent construction industry increased by yearend, from 41,000 in 1990 to 43,100 in 1991. Less dramatic decreases of 200 and 100 employees occurred in the stone, clay, and glass products sector and in the primary metals sector, respectively. Employment in 1991 in the stone, clay, and glass products sector was 6,000 and that in the primary metals sector was 2,800.[5]

According to the U.S. Department of Labor, injuries reported from nonfuel surface and underground mines totaled 54 injuries resulting in lost workdays and 70 injuries with no lost workdays during nearly 2 million hours worked. More than 1.7 million hours worked at mills and preparation plants resulted in an additional 100 injuries causing lost workdays, 128 injuries with no days lost, and 1 fatality. In addition, surface coal mines reported four injuries resulting in lost work days and one injury with no days lost during about 176,000 hours worked. One injury causing lost workdays was reported from more than 34,000 hours worked at mills and preparation plants.[6]

REGULATORY ISSUES

The Kansas Aggregate Producers Mining Group (109 members) and the Kansas Ready Mixed Association's Concrete Group (107 members) both submitted group applications with regard to the U.S. Environmental Protection Agency's (EPA) Stormwater Discharge Rules. These rules were designed to minimize point source pollution from all types of pits, quarries, and mines. Prior to submitting the applications, the associations held a Stormwater Conference in Topeka during August that covered all aspects of the rules, including permit applications, and also allowed producers to discuss the new rules with government officials.

Production limits imposed by the U.S. Army Corps of Engineers on dredge operations along the Kansas River went into effect at the beginning of the year. As expected, production of sand and gravel declined, particularly in the vicinity of Kansas City, where production was reduced by 40% to 50%.

LEGISLATION AND GOVERNMENT PROGRAMS

House bill 2195, involving land reclamation of pits and quarries, was overwhelmingly tabled (only one dissenting vote) by the House and Energy Resources Committee on the basis of the limited study given to the subject and concerns raised by industrial mineral producers. This marked the second consecutive year that such a measure had been rejected and offered encouragement to the Kansas Aggregate Producers Association and the Kansas Ready Mixed Concrete Association, which were seeking favorable consideration from the legislature for the Associations' sponsored land reclamation bill.

House bill 2021 related to annual fees imposed on persons handling hazardous material and the safe disposal of such wastes. Included in this bill was a provision to tax cement kiln operators that burn waste material. Initially, the proposed tax ranged from $0.001 to

$0.01 per pound of waste. The bill was enacted, and the Kansas Department of Health and Environment established a maximum tax of $0.001 per pound of recycled material. The tax, although small, will affect the State's cement producers.

Senate bill 260 did not pass during the 1991 session, but would have provided rules requiring local governments to pay for construction supplies and services on a timely basis or pay interest. Because contractors often must pay penalties to local governments when they are late completing a project, the bill would have provided a more equitable atmosphere in dealings between contractors and local governments.

Senate Concurrent Resolution 1626 was passed, establishing a Commission on Natural Gas Policy. Composed of 12 industry and legislative members, the Commission will "study and review the policies, laws, and regulations of the State of Kansas, other natural gas producing States, and the Federal Government as they affect the gas industry." Recommendations are to be made to the Governor and legislature as to what actions may be taken by the State of Kansas to enable the State to participate with other natural gas-producing States in creating new State and national energy policies affecting natural gas. A written report, including recommendations for legislative alternatives, is to be presented to the legislature by January 31, 1992.

In a development involving abandoned coal surface mine land, the Kansas Department of Health and Environment began reclaiming a 45-acre tract in northeastern Crawford County at a projected cost of $500,000.

Several ongoing State and Federal Government programs were of possible interest to the Kansas mineral industry. The Kansas Geological Survey published two maps of the northern midcontinent, showing the distribution of alkaline igneous rocks and associated carbonatites and peridotites and showing lithologic cross sections of phanerozoic rocks. Several maps of the Joplin 1° by 2° quadrangle, Kansas and Missouri, also were completed. These maps show industrial mineral resources, summary geochemistry, and interpretive subcrop of the Precambrian basement. In addition, a computer-generated, revised version of the geologic map of Kansas (M-23) also was released.

In July 1990, the Kansas Department of Health and Environment was awarded a $387,000 grant for a 2-year study on the effects of lead and cadmium from abandoned mines and smelters on residents in the Galena area, Cherokee County. The study was funded by the Agency for Toxic Substances and Disease Registry. The Galena area was a "subsite" in an EPA Superfund Project, on the National Priority List. In 1991, phases 1 and 2 of the project were completed and phase 3 was begun. Phase 1 included preliminary background work such as developing protocols, awarding contracts, and compiling existing data. Phase 2, completed in September, included conducting a house-to-house census and distributing extensive questionnaires to residents. A random study group was selected, samples were taken, and other data collected. Phase 3, the data analysis phase, was begun. The final report was expected to be completed in early 1993.

The University of Kansas and Kansas State University received a grant of about $100,000 from the National Science Foundation to study fossils at five localities in the United States. Two of the sites to be studied are in Greenwood and Franklin Counties, KS.

FUELS

Oil, gas, and coal were produced in Kansas in 1991, primarily for use as fuels. The State received mineral revenues, distributed to States by the Minerals Management Service and the Bureau of Land Management for onshore mineral leases on Federal lands, totaling $921,000 in 1991. This was a decrease of $305,000 from 1990 distributions of $1,226,000.[7]

Oil and gas continued as a major portion of the Kansas mineral value produced. Production increased relative to that of 1990, but the production values declined. Production of oil was about 57 million barrels and increased 2.4% over that of 1990. Natural gas showed an even greater increase, 9.4%, over 1990 production, just shy of 634 billion cubic feet. A combination of factors, such as mild weather for 1991, plenty of supply, and a lackluster economy, led to unit value declines for both commodities. Total production value for oil dropped sharply, 12.6%, while total value of natural gas declined a more modest 4%.

Kansas ranked third in oil and gas well drilling in the United States in 1991, with a total of 2,008 wells drilled. This was a slight decrease from the 2,068 completions in 1990. Of the total, 720 were oil wells, 377 were gas wells, and 911 were dry holes. New field wildcats accounted for 354 wells, 305 of which were dry holes. Interest in the Hugoton Basin in southwestern Kansas remained high. Drilling was expected to increase in 1992 due to Federal tax incentives provided for 1991 and 1992.[8]

Exploration for coalbed methane in coalbeds throughout eastern Kansas continued, particularly in Montgomery and Wilson Counties. Some activity also occurred in Coffey, Jackson, Labette, Leavenworth, Linn, Miami, and Shawnee Counties. Coalbeds in the Cherokee Group are good candidates for coalbed methane gas.

A sharp drop in production occurred for coal. Total production, about 416,000 short tons, was a decline of 42% from the 1990 production of 721,000 short tons and the lowest production reported in the State in more than 9 years. High volatile bituminous coal was produced from three mines in Crawford County, in the southeastern portion of the State. Bituminous coal prices increased slightly from $22 per short ton in 1990 to $22.50 per short ton in 1991. Principal sales were to electric companies.[9]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Production of industrial minerals in 1991 was affected by declines in the three major areas of construction: residential building, nonresidential building, and nonbuilding construction (including highways). By yearend, however, slight increases in construction became evident.

Permit-authorized construction in 1991 totaled almost $1,169 million. The number of single- and multifamily residential units totaled 8,204. The value of nonresidential construction was nearly $194.8 million, while nonbuilding construction, including highways, totaled about $6.7 million.[10]

Passage in November of the $151 billion Intermodal Surface Transportation Efficiency Act (ISTEA), with its 6-year Federal highway funding provisions, was expected to contribute to increased aggregate production in 1992. Significant improvements to roads and highways were anticipated and could lead to significant increases in aggregate consumption. Cement consumption in the State was expected to increase 5% to 6% in 1992. The anticipated increase was attributed to foreseen increases in highway work as well as in commercial and residential building.

Environmental and zoning regulations were cited as the primary reasons for making it increasingly difficult for the construction aggregates industry to expand existing quarries and to develop new quarry operations. As operations must move further from market areas, transportation costs increase, ultimately affecting aggregate prices and competition.

Thirteen industrial minerals were mined, manufactured, or recovered as byproducts during 1991. Salt, helium, and crushed stone, the leading industrial mineral commodities in terms of value, accounted for about 66% of the State's total nonfuel mineral value.

Cement.—Portland and masonry cement sales, estimated at $67.5 million, ranked that commodity fourth among the industrial minerals produced and accounted for more than 18% of the total 1991 mineral value. The State ranked 16th among the 38 portland cement-producing States and 21st among the 33 States with masonry cement facilities. Sales of portland cement decreased almost $10.6 million and masonry cement sales decreased $481,000 below those reported in 1990.

Cement operations included four plants in the southeastern part of the State: The Monarch Cement Co. at Humboldt, in Allen County; Heartland Cement Co. at Independence, in Montgomery County; Ash Grove Cement Co. at Chanute, in Neosho County; and Lafarge Corp.'s Fredonia Co-Processing Facility at Fredonia, in Wilson County. Monarch was the only cement producer to operate a ready-mixed concrete plant, in the Kansas City area of Wyandotte County. The four companies produced both portland and masonry cement from four wet-process and seven dry-process kilns.

Clay.—Kansas ranked 17th among 43 States producing clay, and sales accounted for less than 1% of the Kansas mineral value in 1991. Only common clay production was reported. Common clay tonnage and value declined 18,550 metric tons and $1.2 million below the figures reported by the industry in 1990.

Common clay production was reported by 10 companies operating 18 mines in 10 counties. The three leading counties, Allen, Neosho, and Wilson, accounted for about 63% of the tonnage produced. The principal end use (about 76%) reported by clay producers was portland cement manufacture. Common and face brick, lightweight aggregate, and animal feed supplements accounted for the remainder.

Gypsum.—Like the aggregate industry, the gypsum industry also was adversely impacted by continued decline in the construction industry. Excess production, especially in wallboard, resulted in some companies throughout the United States shipping to other regions of the country, including Kansas. This action created oversupply in those areas, which, in turn, resulted in decreased prices.

Two companies, Georgia-Pacific Corp. in Blue Rapids, Marshall County, in northeastern Kansas, and Gold Bond Building Products Div. of National Gypsum Co. in Medicine Lodge, Barber County, in the south-central part of the State, reported gypsum production in 1991. Both companies calcined the crude ore at plants near their mines. National Gypsum's Sun City Mine was 10th in the Nation in total reported crude gypsum production in 1991. Crude gypsum production and value decreased slightly below the levels reported by the two producers in 1990. Principal sales were for manufacturing wallboard products and for use in cement and agriculture.

Helium.—Kansas was one of two States reporting production of crude helium in 1991, and the State was the world's largest producer. Crude helium (at least 50% purity) was produced from natural gas and then purified to Grade-A helium (at least 99.995% purity). Reported crude helium production increased by almost 84.6% above the 1990 level, and the estimated value increased from $0.793 to $0.901 per cubic meter ($22 to $25 per thousand cubic feet). Reported Grade-A helium production by private industry increased in both quantity and value. Five States reported production of Grade-A helium in 1991.

Crude helium extraction facilities were operated by four companies: Enron Helium Co. at Bushton, in Ellsworth County; Kansas Nebraska Energy Inc. at Scott City, in Scott County; Centana Energy Corp. (National Helium Corp.) at Liberal, in Seward County; and Trident Helex Inc. at Ulysses, in Grant County. Grade-A helium was produced by Air Products and Chemicals Inc. at Liberal, in Seward County; Kansas Refined Helium Co. at Otis, in Rush County; and Union Carbide Corp.'s Linde Div. plants at Bushton, in Ellsworth County, and at

Ulysses, in Grant County. The plants producing Grade-A also liquified helium.

Crude helium was sold to helium purification companies or stored. Surplus crude helium was stored under contract in the U.S. Bureau of Mines Cliffside Storage Reservoir near Amarillo, TX. The stored helium was returned to the owners for purification and sale when crude demand exceeded production.

Salt.—The State ranked fourth among the 14 salt-producing States. Salt sales, excluding salt in brines, accounted for about 27% of the 1991 Kansas mineral value. Reported salt production and value decreased 74,000 short tons below and increased $5.6 million above reported 1990 levels.

Several companies produced salt from Ellsworth, Reno, and Rice Counties in the south-central part of the State. Two companies operated both underground mines and brine wells, and three operated underground room-and-pillar mines. In addition, one company in Sedgwick County operated only brine recovery wells, for chlor-alkali feedstock used in the production of chlorine caustic and chlorinated chemicals.

The large winter storms at the beginning of the year produced a January boom in the rock salt industry as inventories were rapidly depleted and trucks waited in line as long as 24 hours to obtain their load. Salt companies were sometimes loading around the clock and had to add temporary employees to handle the increased work. Independent Salt Co. at Kanopolis, in Ellsworth County, set a company monthly production record in January of 111,000 tons.

Sand and Gravel.—Both construction and industrial sand and gravel were mined in Kansas during 1991. According to State records, 173 companies produced sand and gravel from mines in 75 of the State's 105 counties.

Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1990 and estimates for 1989 and 1991.

Mining and sales of construction sand and gravel accounted for 6% of the Kansas mineral value in 1991. Production was estimated to be 9.6 million short tons, 1.3 million short tons below that reported in 1990, reflecting decreased construction activity. Estimated value decreased almost $2.1 million below that reported by industry in 1990.

Industrial.—Production of industrial sand was reported by three companies, Alsop Sand Co. Inc., Holliday Sand and Gravel Co. Div., and Kaw Valley Sand and Gravel Inc., operating mines in Republic and Wyandotte Counties. Reported production and value decreased slightly below 1990 levels. Sales were for fiberglass production, sandblast applications, and for traction sand.

Stone.—Both crushed and dimension stone were produced in Kansas during 1991. Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990. Kansas crushed stone statistics are compiled by geographical districts, as depicted on the State map. Tables 2, 3, and 4 present end-use data for this commodity in the six Kansas districts.

Growth in the lime and limestone industry was enhanced by the Clean Air Act Amendments and other environmental legislation, which required the installation of stack scrubbers at coal-fired powerplants. Lime and pulverized limestone were used in the scrubbers to remove sulfur oxides from stack gases. As the required scrubbers are installed and plants are brought into compliance with the new regulations, the demand for lime and limestone is expected to increase over the next several years. Other areas of continued growth in usage included water treatment, to achieve proper pH balances, and the treatment of hazardous wastes.

Crushed.—Crushed stone production reported in 1991 was 16.8 million short tons valued at $67.2 million. This was a decrease of almost 4 million tons from the 1990 estimated production. Value decreased approximately $12 million. Sales accounted for about 18.4% of the State's mineral value in 1991, and nationally Kansas ranked 25th in crushed stone production.

The crushed stone industry reported the operation of 137 quarries in 43 of the State's 105 counties. Limestone, sandstone, and quartzite were the stone types quarried. Limestone comprised more than 98% of the total. Chat also was produced.

The five leading counties, in decreasing order of tonnage produced, were Johnson, Allen, Elk, Dickinson, and Lincoln. Four companies, N. R. Hamm Quarry Inc., Martin Marietta Aggregates, McAdam Limestone Products Inc., and J. H. Shears & Sons Inc., together produced about 36% of the State total. Major end uses reported by limestone and sandstone producers were for graded road base (14%), cement manufacture (12%), and bituminous and concrete aggregate (about 8% each).

Sandstone and quartzite production was reported from five counties in 1991. Sandstone was quarried by Ash Grove Cement Co., Bayer Construction Co. Inc., Bohl Construction Inc., and J. H. Shears & Sons Inc., operating four quarries in Neosho, Franklin, Phillips, and Graham Counties. Sales were for cement manufacture and other unspecified uses. Quartzite was quarried by Lyon Rock Quarry, in Smith County, and sold for landscaping applications.

Chat, fragments of siliceous rock, limestone, and dolomite remaining from lead-zinc milling operations, is found in Cherokee County. According to State records, Bingham Sand and Gravel produced chat in 1991.

Dimension.—In the Kansas dimension stone industry, three companies, Bayer Stone Inc., H. J. Born Stone Co. Inc.,

TABLE 2

KANSAS: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	26	120	$4.62
Riprap and jetty stone	94	705	7.50
Filter stone	96	423	4.41
Coarse aggregate, graded:			
Concrete aggregate, coarse	1,305	6,677	5.12
Bituminous aggregate, coarse	1,316	6,212	4.72
Bituminous surface-treatment aggregate	287	1,419	4.94
Railroad ballast	8	36	4.50
Fine aggregate (-3/8 inch):			
Stone sand, bituminous mix or seal	169	507	3.00
Screening, undesignated	383	1,234	3.22
Coarse and fine aggregates:			
Graded road base or subbase	2,361	7,336	3.11
Unpaved road surfacing	599	2,405	4.02
Crusher run or fill or waste	380	1,712	4.51
Other construction materials[2]	103	547	5.31
Agricultural:			
Agricultural limestone	186	642	3.45
Chemical and metallurgical: Cement Manufacture[3]	2,006	5,637	2.81
Special:			
Unspecified:[4]			
Actual	5,071	22,007	4.34
Estimated	2,411	9,629	3.99
Total[5]	16,802	67,249	4.00

[1]Includes limestone and sandstone, excludes a minor amount of quartzite withheld to avoid disclosing company proprietary data.
[2]Includes dam construction and roofing granules.
[3]Includes other specified uses not listed.
[4]Includes production reported without a breakdown by use and estimates for nonrespondents.
[5]Data may not add to totals shown because of independent rounding.

and Pray Building Stone Co., operated four quarries in Chase, Cowley, and Pottawatomie Counties and produced building limestone. Reported production and value increased significantly above those reported in 1989 and those estimated in 1990. According to the Kansas Geological Survey, six other companies produced building limestone, while another company produced building sandstone. The State ranked 15th nationally in dimension stone production.

Volcanic Ash, Pumice, Pumicite.—Kansas was one of six States producing volcanic ash, pumice, and/or pumicite in 1991. Calvert Mines Inc. in Norton, Norton County, and Kansas Minerals Inc. in Mankato, Jewell County, operated the State's only volcanic ash mines. Reported production and value increased substantially over 1990 values. Processed volcanic ash was sold for use as absorbents, abrasives, filter aids, fillers, and specialty applications.

Other Industrial Minerals.—Several industrial minerals, not included in the tonnage and value on table 1, were produced or shipped into the State and manufactured into higher value products.

Anhydrous ammonia was produced by Farmland Industries Inc.'s 440,000-short-ton-per-year-capacity plant in Lawrence, Douglas County. The ammonia primarily was used for agricultural applications.

Two companies, Texaco Refining and Marketing Inc. at El Dorado, in Butler County, and Farmland Industries Inc. at Coffeyville, in Montgomery County, recovered sulfur as a byproduct of petroleum refining. Recovery and sales increased slightly from the 1990 amounts reported by the two companies.

PQ Corp.'s zeolite plant in Kansas City, Wyandotte County, produced both detergent- and catalyst-grade zeolite. Sodium silicate, made from sand and soda ash, and aluminum trihydrate are the feed materials for the synthetic zeolites (sodium aluminosilicate). Expansions at the plant, which has been in operation since 1982, were completed in 1991. The expansions were needed because of an increased demand for detergent builder for use in phosphate-free detergents. The company also produced catalyst-grade zeolite.

A variety of gemstones, minerals, and fossils was collected by amateur collectors and professionals, both for private collections and for commercial sales. The materials were sold as specimens and formed into a variety of decorative items. Rock and mineral specimens included sphalerite, spinel, dolomite, chalcopyrite, aragonite, barite, calcite, geodes, covellite, galena, garnet, selenite gypsum, halite, hemimorphite, limonite, marcasite, opal, pyrite, pyrolusite, quartz (clear, amethyst, agate, chert), and chalk. Both massive and crystalline varieties of many of these minerals were collected. Fossils included trilobites and petrified wood.

Cultured quartz crystals were produced by Thermo Dynamics Corp. in Merriam, Johnson County. The company was one of the two largest producers of cultured quartz crystals in the country. Crystal was produced for both domestic and foreign use in electronics and optical devices.

Micro-Lite Inc., a subsidiary of Clarkson Construction Co. of Kansas City, MO, mined lamproite by surface methods near Chanute, in Neosho County. The material was dried, screened, and sold for animal feed supplements.

TABLE 3

KANSAS: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	84	541	W	W	W	W
Coarse aggregates, graded[2]	2,032	9,697	W	W	W	W
Fine aggregates (-3/8 inch)[3]	303	1,080	W	W	—	—
Coarse and fine aggregates[4]	1,139	4,954	W	W	W	W
Other construction materials	113	539	760	4,037	7	30
Agricultural[5]	31	92	W	W	—	—
Chemical and metallurgical[6]	—	—	—	—	—	—
Other miscellaneous uses	W	W	—	—	—	—
Unspecified:[7]						
Actual	2,346	12,588	1,345	4,039	230	380
Estimated	370	1,593	—	—	—	—
Total[8]	6,418	31,084	2,104	8,077	238	409

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	—	—	W	W	120	652
Coarse aggregates, graded[2]	—	—	—	—	583	2,555
Fine aggregates (-3/8 inch)[3]	—	—	—	—	W	W
Coarse and fine aggregates[4]	—	—	389	597	1,478	4,477
Other construction materials	—	—	22	46	179	421
Agricultural[5]	—	—	W	W	121	436
Chemical and metallurgical[6]	—	—	—	—	1,957	5,461
Other miscellaneous uses	—	—	—	—	W	W
Unspecified:[7]						
Actual	—	—	105	604	1,045	4,396
Estimated	—	—	666	3,199	1,375	4,837
Total[8]	—	—	1,183	4,446	6,858	23,234

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap and jetty stone, and filter stone.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[3]Includes stone sand (bituminous mix or seal) and screening (undesignated).
[4]Includes graded road base or subbase, unpaved road surfacing, crusher run (select material or fill), dam construction, and roofing granules.
[5]Includes agricultural limestone.
[6]Includes cement manufacture.
[7]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[8]Data may not add to totals shown because of independent rounding.

TABLE 4

KANSAS: CRUSHED STONE SOLD OR USED BY PRODUCERS, BY KIND

Kind	1989[1]				1991[2]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	132	15,850	$56,976	$3.59	115	16,494	$66,401	$4.03
Sandstone and quartzite	—	—	—	—	5	308	847	2.75
Total[3]	XX	15,850	56,976	3.59	XX	16,802	67,249	4.00

XX Not applicable.
[1]Excludes sandstone and quartzite; withheld to avoid disclosing company proprietary data.
[2]Excludes quartzite; withheld to avoid disclosing company proprietary data.
[3]Data may not add to totals shown because of independent rounding.

Perlite was expanded by Lite Weight Products Inc. at a plant in Wyandotte County. The crude perlite was obtained from mines in the Western United States. Sales were for horticultural aggregate, cavity fill insulation, and concrete aggregate.

Dimension stone, primarily granite and marble, was shipped to a number of stone companies throughout Kansas and sold for cemetery monuments and for building applications.

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[1]State Mineral Officer, U.S. Bureau of Mines, Denver, CO. She has 14 years of mineral-related industry and government experience. Assistance in the preparation of the chapter was given by Pat LaTour, editorial assistant.

[2]Associate scientist, Geologic Investigations, Kansas Geological Survey, Lawrence, KS.

[3]U.S. Department of Labor. Mine Injuries and Worktime, Quarterly. Jan.-Dec. 1991.

[4]Energy Information Administration. Coal Production 1991. Oct. 1992.

[5]Kansas Department of Human Resources, Labor Market Information Services. Monthly Labor Summary. Mar. 3, 1992.

[6]Work cited in footnote 3.

[7]Minerals Management Service. Mineral Revenues 1991.

[8]Petroleum Information. Resume 1991.

[9]Work cited in footnote 4.

[10]U.S. Department of Commerce, Bureau of the Census. Permit Authorized Construction in Permit Issuing Places. Annual 1991.

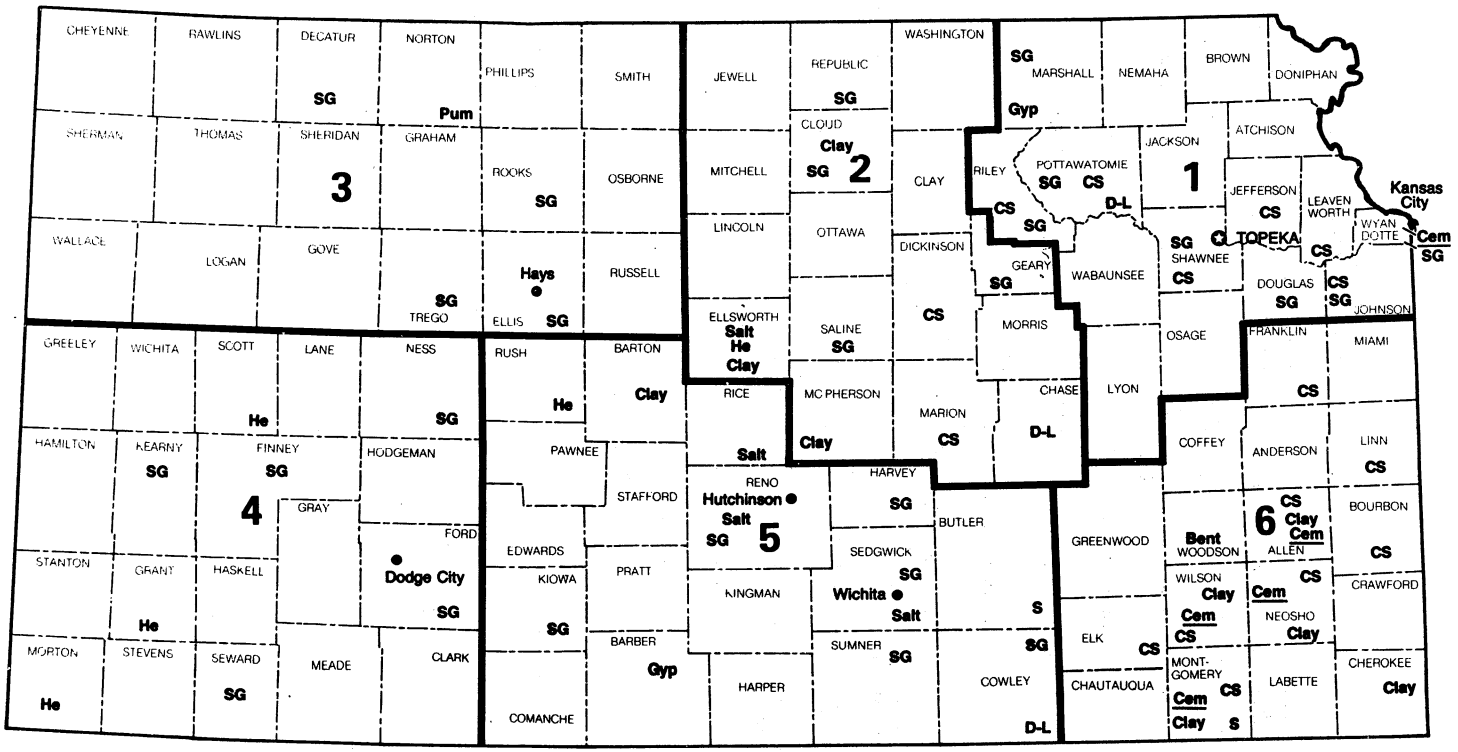
KANSAS

LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Bent	Bentonite
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-L	Dimension Limestone
Gyp	Gypsum
He	Helium
Pum	Pumice
S	Sulfur
Salt	Salt
SG	Sand and Gravel



Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Ash Grove Cement Co.[1 2]	Box 25900 Overland Park, KS 66225	Plant and quarry	Neosho.
LaFarge Corp.[3]	Box 479 Fredonia, KS 66736	do.	Wilson.
Heartland Cement Co.[4]	Box 428 Independence, KS 67301	do.	Montgomery.
Lone Star Industries Inc.	Box 297 Bonner Springs, KS 66012	do.	Wyandotte.
The Monarch Cement Co.[5]	Box 187 Humboldt, KS 66748	do.	Allen and Wyandotte.
Clay:			
Acme Brick Co., Justin Industries Inc.	Box 247 Weir, KS 66781	Quarries and plants	Cherokee and Ellsworth.
Buildex Inc., a division of Clemens Coal Co.	Box 15 Ottawa, KS 66067	Quarry and plant	McPherson.
Cloud Ceramics, a division of General Finance Inc.	Box 369 Concordia, KS 66901	Quarries and plant	Cloud.
Featherlight Building, Justin Industries Inc.	Box 247 Weir, KS 66781	Quarry	Ellsworth.
Kansas Brick & Tile Co. Inc.	Box 450 Hoisington, KS 67544	Quarry and plant	Barton.
Mission Clay Products Corp.	826 E. 4th St., Box 6 Pittsburg, KS 66762	Quarry	Crawford.
Gypsum:			
Georgia-Pacific Corp., Gypsum Div.	Box 187 Blue Rapids, KS 66411	Underground mine and plant	Marshall.
National Gypsum Co., Gold Bond Building Products Div.	Box 143 Sun City, KS 67143	Quarry, underground mine, plant	Barber.
Helium:			
Air Products and Chemicals Inc.	Box 2527 Liberal, KS 67905-2527	Plant	Seward.
Centana Energy Corp. (National Helium Corp.) a subsidiary of Panhandle Eastern Corp.	Box 2079 Liberal, KS 67905-2079	do.	Do.
Enron Helium Co.	Route 1, Box 5A Bushton, KS 67427	do.	Ellsworth.
Kansas Nebraska Energy Inc.	Route 3, Box 175 Scott City, KS 67871	do.	Scott.
Kansas Refined Helium Co.	Box 312 Otis, KS 67565	do.	Rush.
Trident Helex Inc.	Route 1, Box 14D Satanta, KS 67870-9511	do.	Grant.
Union Carbide Corp., Linde Div.	Route 1, Box 14DD Satanta, KS 67870	Plants	Ellsworth and Grant.
Perlite (expanded):			
Lite-Weight Products Inc.	1706 Kansas Ave. Kansas City, KS 66105	Plant	Wyandotte.
Salt:			
Cargill Inc., Salt Div.	Box 1403 Hutchinson, KS 67501	Wells	Reno.

See footnotes at the end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Salt—Continued:			
Hutchinson Salt Co.	1800 Carey Blvd. Hutchinson, KS 67501	Underground mine	Reno.
Independent Salt Co.	Box 36 Kanopolis, KS 67454	do.	Ellsworth.
Lyon's Salt Co., a division of B.S.C. Holding Co.	Box 498 Lyons, KS 67554	do.	Rice.
Morton Salt Div., a division of Morton-Norwich Product Inc.	1000 Morton Rd. S. Hutchinson, KS 67505	Wells	Reno.
North American Salt Co.	6950 West 56th Mission, KS 66202	Wells and underground mine	Reno and Rice.
Vulcan Materials Co., Chemical Div.	Box 12283 Wichita, KS 67277	Wells	Sedgwick.
Sand and gravel:			
Construction:			
Alsop Sand Co. Inc.[6]	Box 345 Belleville, KS 66935	Quarries and plants	Republic.
Associated Material Supply Co. Inc.	6015 N. Broadway, Box 4064 Wichita, KS 67204	Quarries	Sedgwick and Sumner.
Builders Sand Co.	4919 Lamar Ave. Mission, KS 66202	Dredges and plants	Johnson, Shawnee, Wyandotte.
Central Sand Inc.	990 N. Westlink Wichita, KS 67212	Quarry	Sedgwick.
L. A. Knebler Construction Inc.	6611 N. Ridge Rd Wichita, KS 67205	Dredges and plants	Dickinson and Sedgwick.
Miles Sand Inc.	4852 N. Meridian Wichita, KS 67204	Quarry	Do.
Ritchie Sand Inc., a division of Ritchie Corp.	Box 8901 Wichita, KS 67208	Dredge and plant	Sedgwick.
J.H. Shears & Sons Inc.	Box 1605 Hutchinson, KS 67501	Quarries and plant	Reno.
Industrial:			
Holiday List and Clark Construction Co., Holiday Sand and Gravel Co. Div.	6811 W. 63d Overland Park, KS 66202	Dredges and plants	Wyandotte.
Kaw Valley Sand and Gravel Inc.	Box 11055 Kansas City, KS 66111	do.	Do.
Stone:			
Crushed:			
Bayer Construction Co. Inc.	509 Yuma, Box 889 Manhattan, KS 66502	Quarry	Franklin.
Bingham Sand and Gravel	Box 728 Baxter Springs, KS 66713	do.	Cherokee.
Bohl Construction Inc.	120 7th St. Phillipsburg, KS 67661	do.	Phillips.
Folge Quarry Co. Inc.	800 E. 23rd St., Route 1 Ottawa, KS 66067	do.	Franklin.
N. R. Hamm Quarry Inc.	Box 17 Perry, KS 66073	Quarries and plants	Brown, Clay, Jefferson, Leavenwort, Osage, Pottawatomie, Riley, Washington.
Inland Quarries, Americold Corp.	Box 2926 Kansas City, KS 66110	Underground mine and plant	Wyandotte.

See footnotes at the end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone—Continued:			
Crushed—Continued:			
Killough Quarries Inc.	Box 623 Ottawa, KS 66067	Quarries and plants	Anderson, Douglas, Osage.
Lyon Rock Co.	214 1/2 S. Main Smith Center, KS 66967	Quarry	Smith.
McAdam Limestone Products Inc.	Route 1 Moran, KS 66755	do.	Allen, Anderson, Bourbon, Cowley, Greenwood, Linn.
Martin Marietta Aggregates, Central Div.	Box 5904 Topeka, KS 66605	do.	Anderson, Dickinson, Elk, Greenwood, Leavenwort, Marion, Rice, Riley, Shawnee.
Midwest Minerals Inc.	Box 412 Pittsburg, KS 66762	do.	Cherokee, Crawford, Labette, Montgomery, Neosho, Wilson.
George M. Myers Inc.	Box 299 El Dorado, KS 67042	do.	Butler.
Walker Stone Co. Inc.	Box 563 Chapman, KS 67431	Quarries and plants	Dickinson and Geary.
Dimension:			
Bayer Stone Inc.	Box 889 Manhattan, KS 66502	Quarries	Pottawatomie.
H. J. Born Stone Co. Inc.	Box 45 Silverdale, KS 67005	Quarry	Chase and Cowley.
Pray Building Stone Co.	Route 5, Box 46A Winfield, KS 87156	do.	Do.
Sulfur (recovered):			
Farmland Industries Inc.	Box 570 Coffeyville, KS 67337	Secondary recovery plant	Montgomery.
Texaco Refining & Marketing Co.	Box 1121 El Dorado, KS 67042	do.	Butler.
Volcanic materials:			
Calvert Mines Inc.	Box 97 Norton, KS 67654	Pit and plant	Norton.
Kansas Minerals Inc.	Box 385 Mankato, KS 66956	do.	Jewell.
Micro-Lite Inc.	3802 South Santa Fe Chanute, KS 66720	do.	Neosho.

[1]Also clay in Neosho County.
[2]Also crushed stone in Johnson and Neosho Counties.
[3]Also clay and crushed stone in Wilson County.
[4]Also clay and crushed stone in Montgomery County.
[5]Also clay and crushed stone in Allen County.
[6]Also industrial sand in Republic County.

THE MINERAL INDUSTRY OF KENTUCKY

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Kentucky Geological Survey for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.,[1] and Garland R. Dever, Jr.[2]

The value of nonfuel mineral production in Kentucky dropped slightly in 1991 to about $343 million. Overall, production of nonfuel minerals declined but higher unit prices for most commodities offset the expected losses in value. Despite a 5-million-short-ton decrease in output of construction aggregates (construction sand and gravel and crushed stone), the combined value of these two commodities increased by about $6.6 million.

Other sectors of the State's mineral-related industries reported lower or similar levels of production in 1991 compared with that of 1990. Coal production fell by about 10% as Kentucky dropped to third nationally in output. The State maintained its U.S. ranking as the second leading producer of aluminum with output matching that of the previous year. Weaker demand for steel resulted in layoffs and cutbacks in production for that industry.

TRENDS AND DEVELOPMENTS

Most of the major mining and mineral-related industries of Kentucky were involved in the production of coal, industrial minerals, aluminum, and steel. Following a nationwide trend, output levels declined in 1991 because of a general downturn in the economy. Least affected in Kentucky by the weaker demand were producers of industrial minerals. Output of crushed stone was the lowest since 1987 but 11 million short tons higher than the average tonnage produced from 1981 through 1986. Similar production trends occurred for other industrial minerals produced in the State in 1991.

Based on industry reports for coal, aluminum, and steel, the downturn in demand was more significant for these industries in Kentucky in 1991. Coal production dropped to 159 million short tons in 1991, according to the Energy Information Administration of the U.S. Department of Energy. As a result, Kentucky fell from second to third nationally in output. More importantly, employment in the coal industry in the State fell below 30,000 for the first time. Further job losses were expected particularly in western Kentucky by 1995 when amendments to the Federal Clean Air Act requiring lower sulfur dioxide emissions take effect.

The State's aluminum and steel industries slumped in 1991. Lower sales of automobiles and appliances adversely affected demand for these commodities. During the year, layoffs and cutbacks were reported by the steel industry and an aluminum rolling mill plant was shut down.

TABLE 1
NONFUEL MINERAL PRODUCTION IN KENTUCKY[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	metric tons	716,990	$3,357	826,205	$8,282	707,587	$2,942
Gemstones		NA	W	NA	W	NA	548
Sand and gravel (construction)	thousand short tons	e5,500	e15,100	8,802	29,581	e7,700	e27,200
Stone (crushed)	do.	[3]48,178	[3]187,849	e[3]50,100	e[3]182,900	46,266	191,893
Combined value of cement, clays [ball fire (1989)], lead (1990), lime, sand and gravel (industrial), silver (1990), stone [crushed dolomite (1989-90)], zinc (1990), and values indicated by symbol W		XX	124,353	XX	138,101	XX	120,541
Total		XX	330,659	XX	358,864	XX	343,124

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.
[3]Excludes certain stones; kind and value included with "Combined value" figure.

LEGISLATION AND GOVERNMENT PROGRAMS

During a special session of the General Assembly, Senate bill 2 was enacted. This legislation included a provision that limited the severance tax on ball clay to 12 cents per short ton. Previously, ball clay producers paid a severance tax ranging from 15 cents to 23 cents per short ton. Plans by the State Revenue Cabinet to raise the tax from 30 cents to 45 cents per short ton spurred the legislative action. Kentucky remained the Nation's second leading producer of ball clay.

Amendments to the Federal Clean Air Act passed in late 1990 were of concern to the State's coal industry, particularly in western Kentucky. The Tennessee Valley Authority (TVA) has been a major consumer of coal mined in western Kentucky purchasing about 37% of that region's coal in 1990. As a result of the Federal legislation, some coal-burning electric utility plants have considered switching to lower sulfur coal mined in the western United States. Late in the year, the TVA announced plans to continue to use coal from western Kentucky; to comply with the clean air amendments, the TVA planned to install scrubbers. However, the plans were dependent on final interpretation of clean air amendments (expected in 1992) by the U.S. Environmental Protection Agency.

The Kentucky Geological Survey (KGS) has issued several reports in response to enactment of the new clean air regulations. These reports provided information on compliance coal resources and limestone and dolomite for use in scrubbing and fluidized bed combustion systems. The KGS also continued studies of carbonate rocks used by coal producers and coal-burning industries in environmental control measures already required by State and Federal regulations. Reports published by KGS during the year included one on low-silica and high-calcium stone in Harlan County[3] and another on the geology of carbonates for use as sorbents of sulfur.[4]

The KGS, in conjunction with the U.S. Geological Survey, West Virginia Geological Survey, Virginia Geological Survey, Illinois State Geological Survey, and Ohio Geological Survey, has conducted research into the availability of coal resources for mining over the past 5 years. In Kentucky, assessments for five 7.5-minute quadrangles have been completed in Bell, Leslie, Perry, and Pike Counties, and were continuing for two more in Boyd and Owsley Counties.

In the areas investigated, coal resources available for mining were, on an average, only 50% of the original resources. Technological factors restricted about 35% of the original resource and land use factors about 6%; about 10% of the original resource has been mined.[5]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Industrial minerals were produced in Kentucky at about 128 operations according to data reported to the U.S. Bureau of Mines and listed in table 1. Crushed stone was produced at 86 quarries, sand and gravel at 20 pits and dredges, common clay and shale at 12 pits, ball clay at 6 pits, lime at 2 plants, and cement and industrial sand at 1 operation each. Production from these operations accounted for the State's mineral production value of $343 million in 1991.

In addition, the following mineral commodities were processed in Kentucky: synthetic graphite, iron oxide materials, synthetic mullite, expanded perlite, iron and steel slag, sulfur (recovered), and exfoliated vermiculite. The combined value of these commodities as reported to the U.S. Bureau of Mines was about $34 million.

Lime.—Kentucky again ranked fourth in the United States in lime production. In 1991, output remained about the same as that of 1990.

Late in the year, Dravo Lime Co. was awarded a 10-year contract with Cincinnati Gas & Electric Co. to supply 2 million short tons of lime. The lime was to be produced at Dravo's Black River plant in Carntown and used in a flue gas desulfurization system at the Zimmer Power Plant in southern Ohio.

Stone (Crushed).—Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Kentucky crushed stone statistics are compiled by geographical districts as depicted in the State map. Table 3 presents end-use statistics for Kentucky's four districts.

Crushed stone was the leading industrial mineral produced in Kentucky, accounting for about 56% of the State's total value of nonfuel mineral output. During the past 4 years, Kentucky's crushed stone industry has reported the highest production of any other period in State history. In 1988, the State first reached the 50-million-short-ton level in output. From 1988 through 1991, more than 195 million short tons of crushed stone was produced in the State valued at about $770 million.

The construction industry remained the dominate consumer of crushed stone. Demand for limestone and limestone-based products used in environmental applications also continued to increase. In 1991, two coal-fired powerplants began installing wet scrubbing systems designed to use limestone as the scrubbing agent. The plants operated by Kentucky Utilities and Owensboro Municipal Utilities were expected to purchase about 300,000 short tons of limestone per year.

For the second time in 4 years, one of the State's top crushed stone producers was purchased. In 1988, Beazer PLC of the United Kingdom had purchased Koppers Co., which operated in the State as Kentucky Stone Co. In 1991, Hanson PLC, also of the United Kingdom, purchased Beazer. The transaction

TABLE 2

KENTUCKY: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	212	718	$3.39
Riprap and jetty stone	3,030	11,908	3.93
Filter stone	809	3,296	4.07
Other coarse aggregate	W	W	5.00
Coarse aggregate, graded:			
Concrete aggregate, coarse	5,703	21,887	3.84
Bituminous aggregate, coarse	2,320	9,961	4.29
Bituminous surface-treatment aggregate	2,758	10,479	3.80
Railroad ballast	384	1,415	3.68
Fine aggregate (-3/8 inch):			
Stone sand, concrete	718	2,475	3.45
Stone sand, bituminous mix or seal	1,342	5,586	4.16
Screening, undesignated	1,280	4,417	3.45
Coarse and fine aggregates:			
Graded road base or subbase	6,977	26,733	3.83
Unpaved road surfacing	2,170	8,533	3.93
Crusher run or fill or waste	695	3,050	4.39
Other construction materials[2]	1,791	4,930	2.75
Agricultural:			
Agricultural limestone	1,204	5,064	4.21
Poultry grit and mineral food	35	381	10.89
Other agricultural uses	3	43	14.33
Chemical and metallurgical[3]	3,995	25,276	6.33
Special:			
Mine dusting or acid water treatment	228	3,357	14.72
Asphalt fillers or extenders	W	W	4.26
Other fillers or extenders	39	341	8.74
Other miscellaneous uses[4]	274	1,121	4.09
Unspecified:[5]			
Actual	6,459	24,822	3.84
Estimated	3,838	16,100	4.19
Total	[6]46,266	191,893	4.15

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes limestone.
[2]Includes withheld amounts for coarse aggregate (+1 inch), pipe bedding, and roofing granules.
[3]Includes cement manufacture, lime manufacture, flux stone, chemical stone, and sulfur oxide removal.
[4]Includes withheld amounts for special and chemicals.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.
[6]Data do not add to total shown because of independent rounding.

included 13 limestone quarries and mines in Kentucky.

Also during the year, Standard Slag Co., a subsidiary of Lafarge Corp., purchased Acme Stone Co.'s quarry at Olive Hill, Carter County. Standard Slag also operated another quarry in Carter County.

Metals

In 1991, no metals production was reported in Kentucky. However, for the first time in 10 years, mineral exploration occurred in the south central part of the State. Cyprus Exploration and Development Co. conducted a drilling program in Cumberland and Monroe Counties in an area where at least two zinc deposits have been previously identified.[6] The Lafayette Mine in Crittenden County that had produced small quantities of fluorspar and zinc in 1989 and 1990 was inactive in 1991.

Aluminum.—Kentucky remained the Nation's second leading producer of primary aluminum, and output remained at about the same level as that of the previous year. However, weak demand resulted in lower prices. The value of aluminum shipments in Kentucky fell by about 20% and was similar to the decline experienced by the industry nationwide.

The drop in prices affected secondary producers, and Alumax Inc. shut down a rolling mill plant in Hawesville, Hancock County. Also in 1991, Commonwealth Aluminum Co. cut back production at its rolling mill in Lewisport, Hancock County, and Barmet Aluminum Corp. closed its recycling operations in Livia, Daviess County. Combined, about 450 workers lost their jobs as a result of these actions.

Iron and Steel.—Armco Inc., the State's major producer of carbon flat-rolled steel products, cut back employment and production at its Ashland operations. Sales and shipments of steel were down by about 20%, reflecting the soft demand from automotive, construction, appliance, and service center markets.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related industry and government experience and has covered the mineral activities in Kentucky for 6 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]Geologist, Coal and Minerals Section, Kentucky Geological Survey, Lexington, KY.

[3]Dever, G. R., Jr., J. R. Moody, T. L. Robl, and L. S. Barron. Low-Silica and High-Calcium Stone in the Newman Limestone (Mississippian) on Pine Mountain, Harlan County, Southeastern Kentucky. KY Geol. Surv. IC 34, Series XI, 1991, 34 pp.

[4]Barron, L. S., G. R. Dever, Jr., and T. L. Robl. Geology of Six Kentucky Carbonates: Sulfur Sorbents for AFBC. Reprint 28, Series XI, 1991, 20 pp.

[5]Kentucky Geological Survey Annual Report 1990-91. University of Kentucky, Lexington, KY, p. 4.

[6]Mining Engineering, 1991 Annual Review. State Activities 1991 Kentucky. V. 44, No. 5, May 1992, p. 435.

TABLE 3
KENTUCKY: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregates (+1 1/2 inch)[1]	2,920	10,306	W	W	575	3,053	W	W
Coarse aggregates, graded[2]	4,687	17,009	970	3,983	3,454	14,178	2,054	8,573
Fine aggregates (-3/8 inch)[3]	W	W	W	W	1,221	5,198	823	3,252
Coarse and fine aggregates[4]	2,849	9,052	1,191	5,197	4,629	19,288	1,173	4,778
Other construction materials	2,451	6,281	469	2,022	148	576	576	2,642
Agricultural[5]	561	2,219	(6)	(6)	(6)	(6)	74	248
Chemical and metallurgical[7]	(6)	(6)	(6)	(6)	(6)	(6)	—	—
Special[8]	(6)	(6)	—	—	(6)	(6)	—	—
Other miscellaneous uses	732	4,237	392	1,494	4,020	27,385	—	—
Unspecified:[9]								
Actual	741	2,936	1,163	4,036	3,436	14,520	1,119	3,330
Estimated	—	—	1,649	6,911	389	1,657	1,800	7,532
Total[10]	14,941	52,041	5,834	23,644	17,872	85,854	7,619	30,355

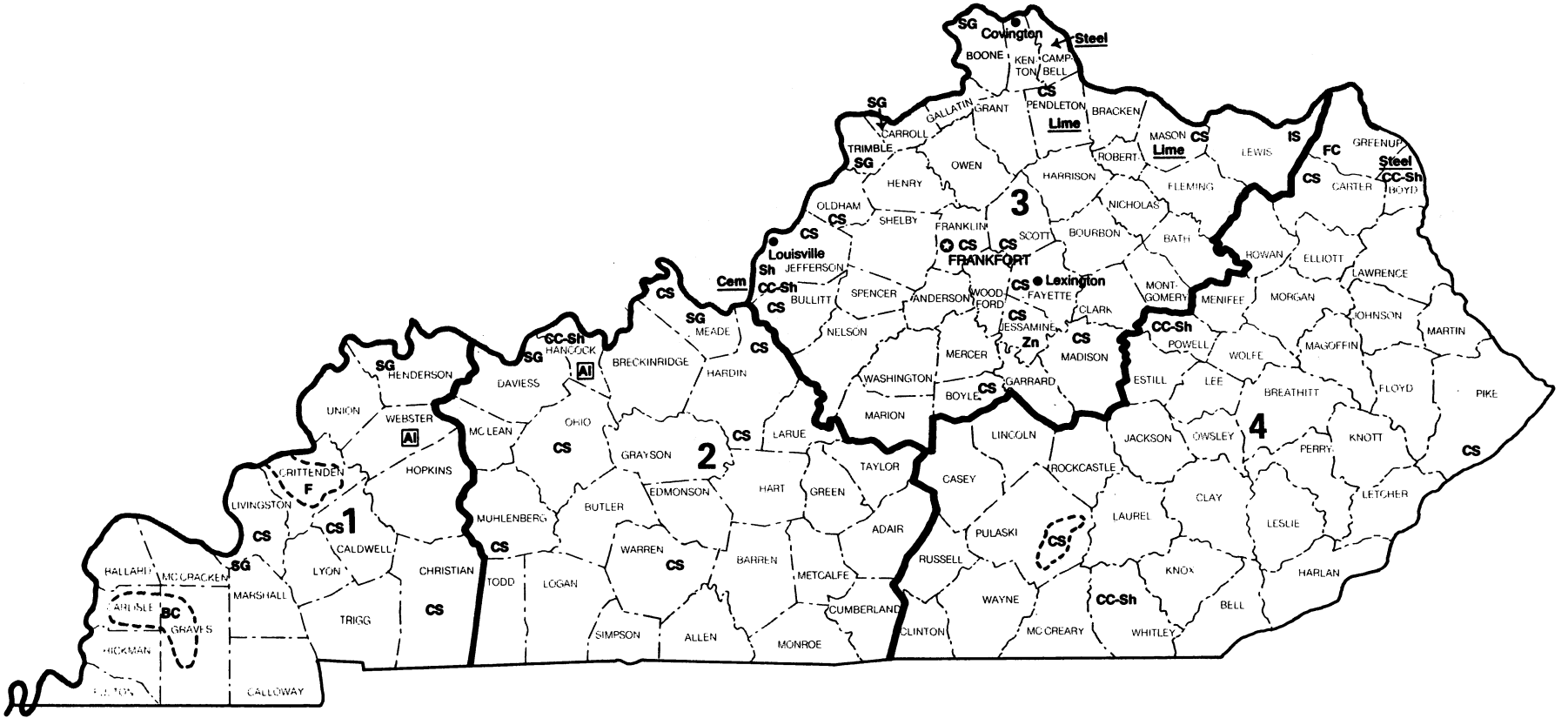
W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap and jetty stone, filter stone, and other coarse aggregate.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[4]Includes graded road base or subbase, unpaved road surfacing, crusher run (select material or fill), pipe bedding, and roofing granules.
[5]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[6]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[7]Includes cement manufacture, lime manufacture, flux stone, chemical stone for alkali works, sulfur oxide removal, and chemicals.
[8]Includes mine dusting or acid water treatment, asphalt fillers or extenders, and other fillers or extenders.
[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[10]Data may not add to totals shown because of independent rounding.

TABLE 4
KENTUCKY: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989[1]				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	90	48,178	$187,849	$3.90	86	46,266	$191,893	$4.15

[1]Excludes dolomite; withheld to avoid disclosing company proprietary data.

KENTUCKY



LEGEND

MINERAL SYMBOLS

State boundary	
County boundary	
Capital	
City	
Waterway	
Crushed stone/sand & gravel districts	

Al	Aluminum plant
BC	Ball Clay
CC-Sh	Common Clay & Shale
Cem	Cement plant
CS	Crushed Stone
F	Fluorspar
FC	Fire Clay
IS	Industrial Sand
Lime	Lime plant
SG	Sand and Gravel
Steel	Iron and Steel plant
Zn	Zinc
	Concentration of mineral operations

Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum (primary):			
Alcan Aluminum Corp.	Box 44 Sebree, KY 42555	Smelter	Webster.
Southwire Co.	Box M Hawesville, KY 42348	do.	Hancock.
Cement:			
Kosmos Cement Co.[1 2]	Dixie Highway Box 72319 Louisville, KY 40272	Plant	Jefferson.
Clays:			
Ball clay:			
Kentucky-Tennessee Clay Co.	Box 449 Mayfield, KY 42066	Mines and plant	Carlisle and Graves.
Old Hickory Clay Co.	Box 66 Hickory, KY 42051	do.	Graves.
Common clay:			
General Shale Products Corp.	Box 3547 CRS Johnson City, TN 37602	Mine and plant	Jefferson and Whitley.
Kentucky Solite Corp.	Box 27211 Richmond, VA 23261	do.	Bullitt.
Sipple Brick Inc.	Box 567 Stanton, KY 40380	do.	Boyd and Powell.
Ferroalloys:			
SKW Alloys Inc.	Box 217 Calvert City, KY 42029	Plant	Marshall.
Iron and steel (pig iron):			
Armco Inc.	Middletown, OH 45202	do.	Boyd.
NS Group Inc.	9th and Lowell Sts. Newport, KY 41072	Plants	Boyd and Campbell.
Lime:			
Dravo Lime Co.[2]	One Gateway Center Pittsburgh, PA 15222	Underground mines and plants	Mason and Pendleton.
Sand and gravel (construction):			
Bellview Sand & Gravel Inc.	5725 Bellview Rd. Petersburg, KY 41080	Pit	Boone.
Boone County Sand & Gravel Co. Inc.	Box 476 Burlington, KY 41005	Pit	Do.
Ingram Materials Inc.	10 Fatherland St. Nashville, TN 37213	Dredges	Livingston.
Morrow Gravel Co.	11641 Mosteller Rd. Cincinnati, OH 45241	Pits and plant.	Boone.
Nugent Sand Co.	Box 6072 1833 River Rd. Louisville, KY 40206	Dredges	Jefferson and Trimble.
Stone (crushed):			
Elkhorn Stone Co.	Box 737 Elkhorn City, KY 41522	Quarry	Pike.
Hanson PLC	Box 7529 Louisville, KY 40707	Underground mines, quarries, plants	Various.
Ken-More Stone Inc.	Box 729 Morehead, KY 40351	Quarries	Carter and Morgan.
Medusa Aggregates Co.	880 Corporate Dr., Suite 101 Lexington, KY 40503	Quarries and plants	Edmonson, Nelson, Ohio, Pendleton, Warren.

See footnotes at end of table.

TABLE 4—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone (crushed)—Continued:			
Nally & Gibson Georgetown Inc.	100 Farmers Bank Dr. Georgetown, KY 40324	Quarries	Green, Scott, Taylor.
Rogers Group Inc.[3]	Box 310 Shepherdsville, KY 40165	Underground mine, quarries, and plants	Bullitt, Christian, Jefferson, Oldham.
Vulcan Materials Co.	3001 Alcoa Highway, Box 7 Knoxville, TN 37901	Underground mines, quarries, plants	Fayette, Hardin, Livingston, Meade.

[1]Also clays.
[2]Also stone.
[3]Also sand and gravel.

THE MINERAL INDUSTRY OF LOUISIANA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Louisiana Geological Survey for collecting information on all nonfuel minerals.

By Doss H. White,[1] William E. Marsalis,[2] and John E. Johnston[3]

In 1991, Louisiana's nonfuel mineral industry produced $351.8 million of mineral commodities. This was a $16.1 million decrease from the value reported for 1990. The decline was due to the effects of the recession on certain segments of the economy and the closing of two of the State's sulfur operations because of depleted reserves.

Despite the decline in value, the State continued to rank 27th in mineral value among the 50 States. Louisiana mineral producers continued to lead the Nation in salt production and ranked second in the output of sulfur. Louisiana was the third largest petroleum producer nationally and the second largest supplier of natural gas. The State is the world's leading offshore oil and gas area in terms of number of wells drilled, number of production platforms, and prospects for future production.

TRENDS AND DEVELOPMENTS

Industrial expansion survey data indicated that the Louisiana economy, which bottomed in 1986, has exhibited an upward growth despite the 1990-91 recession and a muted demand for mineral commodities mined in-State. Although overall mineral output and value declined, stone production and value reached a record high. A current survey by the Port of South Louisiana found that recently completed, under construction, or proposed projects represent almost $10.9 billion in new or expanded plant investments. These projects will create 11,000 to 12,000 permanent jobs and 26,000 to 30,000 construction jobs.

Major economic factors influencing the industrial expansion included increased worldwide demand for petrochemicals and a favorable exchange rate of foreign currencies to the dollar. This exchange rate was a principal factor behind increased exports in 1991. Chemical exports through the Port of South Louisiana rose 14% compared to those of 1990.

In 1991, foreign prospects that viewed Louisiana as a site for new plants included companies from Belgium, England, France, Germany, Japan, and Taiwan. In spite of the increased export activity and the interest in Louisiana for new plant facilities, nonresidential construction contracts were 25% below the 1990 level.

The increased level of plant construction raised the demand for construction mineral commodities, which historically have accounted for approximately 20% to 25% of the State's mineral value.

TABLE 1
NONFUEL MINERAL PRODUCTION IN LOUISIANA[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Clays	metric tons	233,992	$6,115	368,322	$1,066	360,154	$3,646
Gemstones		NA	14	NA	7	NA	27
Salt	thousand short tons	13,218	115,203	14,348	120,827	14,595	130,587
Sand and gravel:							
Construction	do.	e13,600	e54,400	14,589	55,902	e13,300	e48,900
Industrial	do.	572	9,664	559	10,003	W	W
Stone (crushed)	do.	3,206	24,414	e2,100	e16,800	W	W
Sulfur (Frasch)	thousand metric tons	1,334	W	1,337	W	1,063	W
Combined value of gypsum (crude), lime, stone (crushed miscellaneous [1991]), and values indicated by symbol W		XX	169,912	XX	163,313	XX	168,642
Total		XX	379,722	XX	367,918	XX	351,802

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

The 1989-90 period is the latest with available data for gross State product activity. The three areas of the economy that experienced the greatest growth were (1) agriculture, (2) forestry and fisheries, and (3) mining. The mining sector grew by 9.8%

The prime interest and mortgage interest rates declined steadily from the 4th quarter of 1990 to the 4th quarter of 1991. This was reflected in the value of residential construction, which increased 32% from 1990 to 1991.

Despite signs of economic growth, the State's economy is not as diversified as that of the Nation. The primary difference is the reliance of the Louisiana economy on the oil industry. Only 0.6% of the Nation's employment is in mining (including petroleum and natural gas extraction), although more than 3% of Louisiana's employment and almost 14% of the employment of the Lafayette area is mining related (primarily in the oil and natural gas sector).[4]

Several major mineral-related industrial developments were announced, underway, or completed during the year. Shell Oil Co. announced a $1.3 billion award for the construction of the world's largest offshore oil platform in the Gulf of Mexico. Freeport-McMoRan Resources Partners continued work on its offshore Gulf of Mexico sulfur/petroleum and natural gas project. Completed were the following: Rhone-Poulenc's new wet-process acid unit at its Geismar plant; Olin Chemicals Co.'s new sulfur regeneration unit at the Shreveport plant; and titanium dioxide pigment plant expansions at E. I. du Pont de Nemours & Co. Inc., DeLisle, and Kronos Inc., Lake Charles.

The State's Transportation Infrastructure Model for Economic Development (TIME) program, funded by a $0.04 gasoline and diesel tax, will four lane almost 500 miles of highways, pay for a number of bridge projects, and provide capital for New Orleans' port and airport.[5]

In November, Koch Industries of Wichita, KS, signed a letter of intent to acquire IMC Fertilizer's two ammonia plants at Sterlington.

During the year, Freeport Sulfur Co. closed its Garden Island Bay Frasch sulfur operation in Plaquemines Parish and its Grand Island Frasch sulfur operation in the Gulf of Mexico. Sulfur reserves were depleted at both sites.

REGULATORY ISSUES

An inventory of abandoned mines by the Department of Natural Resources (DNR) indicated 1,246 abandoned operations covering 132,000 acres. A DNR report noted that many of the deeper excavations intersected near-surface aquifers and endangered water supplies. Illegal dumping into the abandoned mines was also identified as a problem.[6]

On September 30, the last shell dredging lease on Lake Pontchartrain expired. The Department of Environmental Quality repeatedly denied shell dredging wastewater permits for dredge operations in the lake. Without the permits, the Department of Wildlife and Fisheries suspended dredging leases.[7]

Texas Brine Corp. was granted the necessary permits to dissolve storage caverns in the Starks Salt Dome in Calcasieu Parish despite protests by local citizens. The cavities were to be used for storage of two light hydrocarbons, ethylene and ethane.

The Louisiana Wildlife and Fisheries Commission awarded a 3-year contract to Louisiana Dredging Co. for shell dredging offshore along a section of the central coast. The company bid $2.67 per cubic yard for royalties.[8]

The Louisiana Geological Survey (LGS), a nonregulatory component of the State Department of Natural Resources, continued a long-standing program to provide geological and engineering support to Louisiana's Coastal Management Div. and the Corps of Engineers on oil- and gas-related matters. The Survey was involved in a study on the effects of current environmental regulations on the exploitation of oil and gas reserves in wetland areas and an evaluation of the use of cyclocranes as an alternate access method into wetland areas.

LEGISLATION AND GOVERNMENT PROGRAMS

The Louisiana Legislature passed a bill, which was signed into law by the Governor, that required materials dredged from ship channels be used to replace the State's rapidly eroding wetlands. Canals longer than 1 mile and projects in which an excess of 250,000 cubic yards of material is dredged require beneficial use of the spoil materials. The law included a provision to allow waivers when the funds were not available to use spoil to build wetlands and when the costs outweighed any expected benefits.

The Louisiana Non-Coal Mining Act was introduced in the 1991 legislature, but it did not pass. The legislation would have required that any mining activity such as "gravel, dirt, or shell" be taxed at a $0.03-per-ton surcharge. The moneys collected would have been used for funding reclamation of previously mined sites.

A controversy between the State's DNR and the Corps of Engineers over the placement of dredge spoil was temporarily resolved, and emergency dredging of the Mississippi River, Gulf Outlet (MR-GO) was approved. The MR-GO, along the eastern border of St. Bernard Parish, was constructed in 1960 as a short cut between New Orleans and the Gulf of Mexico.[9] Shoaling in the lower MR-GO had restricted ships with drafts of more than 33 feet from using the waterway. This restricted some vessels from access to the Port of New Orleans.

The State required the Corps to use the dredged spoil to rebuild a portion of the marsh eroded by the river. State plans called for the construction of a metal barrier along the shore and the placement of spoil behind it. The Corps contended that it was not authorized to spend funds for marsh restoration.[10]

The Louisiana Office of Mineral Resources (OMR) was responsible for governing mineral activity on 5 million acres of State-owned land. OMR's responsibility included leasing, monitoring lease operations, royalty

accounting, and reacquisition of nonproductive or nonutilized leases.

During 1990-91, 266 leases totaling 63,701 acres were awarded by OMR for cash payments of $11,646,521. Royalty volumes credited to the State included 6.9 million barrels of oil and 64.2 billion cubic feet of gas. The average price per barrel of oil and per billion cubic feet of gas was $23.39 and $1.62, respectively. The State's treasury received an additional $268 million from bonuses, rentals, plant products, and other minerals.

During 1991, the LGS was involved with nonfuel and fuel mineral research and basic geological mapping.

Nonfuel mineral research underway during 1991 included a Statewide analysis of aggregate resource trends, the preparation of a history of the State's sulfur industry, and a summary of mineral production and geographic patterns. Work was ongoing on the effects of aggregate mining along the Amite River floodplain.

Among the ongoing fuels work was a cooperative lignite resources program with the U.S. Geological Survey (USGS), initiated in 1982, in which well logs from more than 9,000 core holes were interpreted by the LGS and computerized as part of the USGS National Coal Resources Data System. The LGS continued to monitor U.S. Department of Energy (DOE) geopressured-geothermal tests in Louisiana for possible microseismic activity and subsidence. The LGS completed an atlas of major gas reservoirs in the State in conjunction with the Texas Bureau of Economic Geology and the Gas Research Institute. Publication was scheduled for late 1992 or early 1993.

DOE invited bids for the Strategic Petroleum Reserve's (SPR) Sulfur Mines facility in the southwestern part of the State. The Sulfur Mines facility, one of six SPR's operated by DOE, was the most costly to operate. The site included three salt dome storage caverns, pumping and control facilities, several maintenance and administration buildings, and fire protection and electrical service facilities. Off-site facilities included four brine disposal wells and a fresh water intake system.

The U.S. Fish and Wildlife Service began construction of a $13.6 million National Wetlands Research Center on the University of Southern Louisiana campus in Lafayette. When completed, the center will employ a staff of approximately 70 scientists and 50 support personnel.[11]

In May, mine rescue teams from several States met in Delcambre to participate in the Southern Regional mine rescue contest that simulated mine rescue operations. Each underground mine in the United States is required by Federal law to have two rescue teams available at all times. The law is enforced by the Mine Safety Regulatory Commission, a division of the U.S. Department of Labor.[12]

FUELS

The fuels sector of Louisiana's mineral industry produced petroleum, natural gas, and coal (lignite). In the petroleum sector, the Louisiana rig count decreased considerably from the 4th quarter of 1990 to the 4th quarter of 1991. Petroleum output, however, remained at the 1990 level.[13] Seventeen petroleum refineries are in Louisiana, ranking the State second nationally in refining capacity.

Shell Oil Co. awarded a contract for the construction of a massive $1.3 billion offshore oil platform. This platform, the largest ever constructed, will have the capability of drilling in waters up to 2,860 feet deep.

Natural gas output declined from 1,675 billion cubic feet in 1990 to 1,657 billion cubic feet in 1991. Natural gas production has declined for the past two decades.

Lignite production, 3,150,748 short tons, fell below the 3,186,189 short tons mined in 1990. Production was by two firms in DeSoto and Red River Parishes, and the lignite was sold to an electric utility near Mansfield for power generation. Lignite severance tax, $0.12 per short ton, totaled $358,402.56.

At yearend, an Atlanta-based company, Royal Oak Enterprises, was considering mining lignite in Red River Parish. Royal Oak would burn the lignite into a carbon state and press it into charcoal briquettes.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

The State's 200 plus mineral firms produced 8 different mineral commodities valued at $351.8 million in 1991. Salt, sand and gravel, and sulfur accounted for more than three-quarters of the State's mineral value. The Port of New Orleans handled several different mineral commodities imported from other countries, and several other minerals were shipped by rail or barge to Louisiana firms for processing into higher value products.

Clays.—Louisiana's clay industry, five companies in five parishes, produced 360,000 metric tons of clay valued at $3.6 million. This was an 8,000-metric-ton decrease from the production and a $2.5 million increase over the value reported by industry in 1990. The State ranked 25th among the 44 clay-producing States, up two positions from its 27th national ranking in 1990. More than one-half of the clay produced in Louisiana came from Caddo and Pointe Coupee Parishes.

Approximately 21% of the clay mined was used in the manufacture of brick. Other major uses were for the manufacture of concrete block, structural concrete, and in highway construction.

Lightweight aggregate was produced by calcining clay mined in Pointe Coupee Parish northwest of Baton Rouge. The aggregate was used in the manufacture of lightweight concrete blocks and fire-retardant materials. The aggregate was barged as far north as Minnesota for use in lightweight products manufacture.

The city of Baker began "chip sealing" of 50 miles of its 70 miles of roadways using the expanded clay aggregate over a layer of cationic emulsified asphalt. The roadway was immediately usable, and the

new road surface had a higher skid resistance than with natural aggregate.[14]

Gypsum.—Winn Rock Inc. mined anhydrite, a variety of gypsum, from a quarry near Winnfield. The anhydrite was crushed and sold for surfacing access roads to petroleum and natural gas well sites. Output and value increased above the 1990 level.

Salt.—Louisiana continued as the leading salt-producing State in the Nation and produced about 37% of the U.S. total in 1991. Salt sales accounted for approximately 16% of the State's nonfuel mineral value during the year. Output, 13.2 million metric tons valued at $131 million, increased 200,000 metric tons and $9.8 million, respectively, over the 1990 production and value.

Three companies, Akzo Salt Inc., Avery Island; Morton International Inc., Weeks; and Carey Salt Co., Baldwin, each operated an underground, room-and-pillar mine. Several other companies produced salt or a salt-bearing medium for Louisiana's chemical industry from the mechanical evaporation of brines.

In March, Morton furloughed 31 employees and Carey cut the workweek from 5 days to 4, resulting in a 20-employee reduction. The cuts were blamed on a mild winter negating the need for ice and snow control in several northern States.[15]

Louisiana severance tax for salt, $0.06 per short ton, added $327,623 to the State's treasury. Salt brine severance tax, $0.005 per short ton, totaled $12,069,954.

Sand and Gravel.—The 1991 value of sand and gravel, estimated at more than $50 million, ranked third in value among the mineral commodities produced in-State. The value of sand and gravel sales, both construction and industrial, accounted for about 14% of the State's 1991 mineral value. The severance tax on sand, $0.06 per short ton, added $455,253, and the gravel severance tax, $0.06 per short ton, added $414,397 to the State's economy.

Construction.—The production of construction sand and gravel is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates This chapter contains estimates for 1989 and 1991 and actual data for 1990.

The 1991 estimate for construction sand and gravel ranked Louisiana 20th in tonnage among the 50 construction sand and gravel-producing States. The estimated output, 12.1 million metric tons valued at $48.9 million, was 1.1 million metric tons below the 13.2 million metric tons mined in 1990. Value declined $7.0 million.

Historically, more than 50% of the tonnage has come from, in descending order of production, St. Tammany, St. Helena, Washington, Rapides, and East Feliciana Parishes. Concrete aggregate, asphaltic concrete, and road materials accounted for the major end uses reported in past years.

Industrial.—The State fell from 12th to 23d nationally among the 38 States with industrial sand and gravel production. Output and value were concealed, but value was significantly lower than that in 1990. In past years, the industrial sand industry was composed of four firms that operated four mines in Allen, East Baton Rouge, Red River, and Webster Parishes. In 1991, only two companies reported production. Historically, principal sales were to the sandblasting, glass container, silicon carbide, and chemical and foundry industries. Other sales were for antiskid runway surfacing and filter material within the Aquarium of the Americas.[16]

Stone (Crushed).—]The production of crushed stone is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1889 and 1991 and estimates for 1990.

Louisiana's stone production reported to the U.S. Bureau of Mines, which included shell dredged from the Gulf of Mexico, was withheld for 1991 to protect company proprietary information. State of Louisiana severance tax data indicated that stone production was 288,310 short tons (261,543 metric tons) and shell output totaled 1,518,747 short tons (1,377,784 metric tons). In 1989, the last year that industry data were available, the average value per ton for stone, including shell, was $7.61.

Anhydrite, a variety of gypsum, was produced from a quarry in Winn Parish. Much of Louisiana's stone requirements was satisfied by material barged into the State from quarries in Arkansas, Kentucky, Missouri, and Illinois. One firm imported stone to the New Orleans area from a quarry on the Yucatan Peninsula, and a second imported stone from The Bahamas. Three firms produced a synthetic aggregate from waste materials. At least one firm was crushing scrap concrete and selling the resulting concrete/crushed stone mix for aggregate.

Sulfur.—Historically, Louisiana's leading mineral commodity, value wise, was sulfur, which accounted for about 40% of the State's mineral value. In 1991, however, sulfur value fell to second behind salt. The decline was due to mine closings rather than the recession. Louisiana was 1 of 2 States with Frasch sulfur production and 1 of 26 with byproduct sulfur production from petroleum and/or natural gas refining. Frasch sulfur output totaled almost 1.1 million metric tons; the value was withheld.

In January, three of the five operating Frasch sulfur mines in the United States were in Louisiana; Freeport Sulfur Co. operated all three. Two of these mines closed in 1991 because of reserve depletion. The Caminada Pass Mine in the Gulf of Mexico operated all year, while the Garden Island Bay Mine on the Mississippi River delta and the Grand Isle Mine in the Gulf of Mexico closed.[17]

Work continued on Freeport-McMoRan Resources Partner's Main Pass sulfur/oil and gas project in the gulf, 17 miles off the coast of Louisiana. The project combined the efforts of Freeport-McMoRan Partners, an affiliate of

Freeport McMoRan Inc., and its joint-venture partners, IMC Fertilizer Inc. and Homestake Mining Co. When completed, the facility, 15 platforms and connecting bridges standing in 210 feet of water, will be the largest offshore structure in the Gulf of Mexico. One report stated that "...the Main Pass joint venture owns recoverable reserves of 67 million long tons (68.1 million metric tons) of sulfur, 39.4 million barrels of oil, and 7.2 billion cubic feet of natural gas."[18]

Gas production began in October, and petroleum production began in November at a rate of 40,000 barrels per day. Frasch sulfur production was scheduled to begin in 1992; byproduct sulfur recovery, associated with the oil and gas production, began in November at a rate of 30 short tons per day. The sulfur recovery unit had a capacity of 50 short tons per day. The Frasch sulfur design capacity was 2 million long tons (2.03 million metric tons) per year by the end of 1993.

In December, the 5,450-metric-ton powerplant module was positioned on its platform in the Main Pass complex. The module will supply the thermal and electrical power for the entire sulfur/oil and gas operations and facilities. The module is designed to heat 11 million gallons of water per day to 325° F while producing 17 megawatts of electrical power. The plant will consume approximately 24 million cubic feet of natural gas per day.[19]

In conjunction with the Main Pass construction, Freeport Sulfur Co., a division of Freeport-McMoRan Resource Partners, was involved in a $10 million renovation of its Port Sulfur terminal. Included were a new dock and pipeline facilities to accommodate two 400-foot-long, self-propelled tankers that will transport liquid sulfur from Main Pass. The renovation also includes process facilities that will process the Main Pass sulfur to commercial specifications.

Late in December, Freeport-McMoRan held dedication ceremonies for its new $5 million logistical base for the Main Pass operation. The new base in Venice included more than 5,000 square feet under roof, three helipads, living quarters, a dispatch office and conference room, parking facilities, a warehouse, crane facilities, a waiting room, fuel facilities, a plane ramp, and two boat docks.[20]

In February, Freeport-McMoRan's tanker, Louisiana Brimstone, ran aground in the Mexican port of Coatzacoalcos and suffered heavy bottom damage. The company sought and received a 6-month waiver of the U.S. Jones Act; the act requires a U.S. company to use a U.S. vessel to carry cargo. The other three U.S. sulfur vessels were in use. The company used a British-flag tanker, the Nordic Louisiana, in its fleet with a U.S. crew to transport molten sulfur from Port Sulfur to Tampa, FL, where it was used in fertilizer manufacture.[21]

At yearend, Freeport Sulfur Co. reduced Frasch sulfur prices $12 per ton to $98 per long ton. The reduction, the third since June, was to counteract Canadian sulfur imports into the United States. Canadian sulfur had captured almost 1 million of the 5-million-long-ton-per-year(4.59-million-metric-ton-per-year) Tampa market. The reduction ensured that the Canadian sulfur imports were held to a minimum.[22]

Recovered sulfur was reported by nine natural gas/petroleum refineries. Recovery tonnage, 692,000 metric tons, increased 23,000 metric tons over the 1990 level. However, value, $61.1 million, fell $300,000 as a result of a reduction of the Frasch sulfur price level. During the year, Olin Chemicals Co. of Stanford, CT, installed a 130,000-metric-ton-per-year sulfur regeneration unit at its Shreveport plant.

Other Industrial Minerals.—Several industrial minerals not mined in Louisiana were shipped into the State and used as raw materials in a variety of industrial processes or processed into a higher value product.

Hydrated alumina was imported by Alumina Products Inc. for the production of sodium aluminate. Ireland was the exporting country. Sodium aluminate was sold to the aluminum, paper, titanium dioxide, and water purification industries.

Anhydrous ammonia, produced by 14 firms, was sold to the chemicals industry. The annual capacity of Louisiana's anhydrous ammonia industry was approximately 40% of the U.S. capacity.

Koch Industries signed a letter of intent to purchase IMC Fertilizer's two ammonia plants at Sterlington. The two have a combined capacity of almost 1 million metric tons per year.[23]

Southern Filter Media maintained a supply of anthracite coal for use with industrial sand in water purification.

The barium sulfate mineral barite was imported, primarily from China, crushed, ground and bagged, and sold for use in chemical manufacture and oil well drilling fluids. Mil-Park Drilling Fluids, Baroid Drilling Fluids Inc., and Old Soldiers Ltd. comprised the barite industry in Louisiana. Much of the crude barite was shipped through the port at Lake Charles.

Carbo Ceramics, New Iberia, imported calcined bauxite for use in the manufacture of proppants. The proppants were used by the petroleum industry to support subsurface rock microfractures to increase oil production.

The State's calcium chloride industry consisted of Tetra Chemicals and Allied Signal Inc. Tetra Chemicals produced synthetic calcium chloride from a plant near Lake Charles and from the company's liquids plant at Norco. Allied Signal Inc. recovered calcium chloride as a byproduct at its Baton Rouge facility. Hydrochloric acid and limestone were the raw materials in the Allied process. Principal sales were for a concrete setup agent, dust control, oil and gas drilling, and to northern State highway departments to mix with sodium chloride (salt) for ice and snow control. Some calcium chloride was exported to Canada.

International Garnet Abrasives Inc. reclaimed garnets at a 10,000-short-ton-per-year plant at Harvey. Garnet concentrates were obtained from foreign producers.

Westvaco Corp., DeRidder, purchased iodine obtained from subsurface brines for use as a stabilization agent in tall oil treatment. Tall oil fatty acids and rosins

compete with other types of oil in polymer products. Westvaco completed a 25,000-short-ton capacity increase at the DeRidder tall oil facility during 1991.

USG Corp. produced both quicklime and hydrated lime at a plant in Orleans Parish. Calcite obtained from The Bahamas and limestone shipped from a Missouri quarry were used in the manufacturing process. The chemical and industrial sectors were the principal customers for USG's output.

Reynolds Metals Co., Lake Charles, shipped in synthetic graphite for the manufacture of carbon anodes. The company completed a $47 million expansion during 1991.

Crude perlite, purchased from New Mexico producers, was expanded by Filter Media Co. Inc. at a plant in Reserve. The principal markets were the filter, insulation, and lightweight concrete industries.

Rock phosphate was imported from Morocco for Rhone-Poulenc's phosphoric acid plant at Geismar. The plant produced super phosphoric acid for liquid fertilizer manufacture.

Canadian potash was transferred to the Port of New Orleans and unloaded from covered hopper cars directly onto cargo vessels for shipping. The potash was destined for Central American customers.[24]

Pumice pebbles were imported through the Port of New Orleans for firms producing "stone-washed" jeans. The pebbles were obtained from a Turkish source.

Both domestic and foreign stone were shipped to stone companies in the State. Sales were for building and monumental purposes.

Two companies, E.I. du Pont de Nemours & Co. Inc. and Kronos Inc., produced titanium dioxide pigments in Louisiana. The former completed a second 90,000-short-ton-per-year production line at its DeLisle plant, and the latter at yearend was preparing the startup of a new 90,000-short-ton-per-year titanium dioxide line at its Lake Charles plant. The added production will make Kronos the world's third largest supplier of titanium dioxide pigments.[25]

Metals

Alumina.—The Ormet Corp., Kaiser Alumina & Chemical Corp., and LaRoche Chemicals Inc. composed Louisiana's alumina industry. The three operated refineries at Burnside and Gramercy to produce alumina from imported bauxite.

Iron and Steel.—Bayou Steel Corp. operated a 635-metric-ton-capacity steel mill at LaPlace. The mill was equipped with two 65-ton electric furnaces. In February, the company cut its work force by 100 employees because of a slump in orders.[26]

The Port of New Orleans "captured" the winter steel shipments of USX Corp.'s Gary, IN, mill. Approximately 60,000 metric tons of steel coil moved through the port's Nashville Avenue Wharf from December 1991 to April 1992.[27]

Uranium.—Freeport Uranium Recovery Co. produced uranium oxide at a plant at Uncle Sam. The 700,000-pound-per-year plant produced fuel for the electric utility industry.

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[1]State Mineral Officer, U.S. Bureau of Mines, Tuscaloosa, AL. He has 31 years of mineral-related industry and government experience and has covered the mineral activities in Louisiana since 1989. Assistance in the preparation of the annual report was given by Maylene E. Hubbard, editorial assistant.

[2]State geologist, Louisiana Geological Survey, and Chief Geologist, Office of Mineral Resources, Louisiana Department of Natural Resources.

[3]Deputy State geologist, Louisiana Geological Survey.

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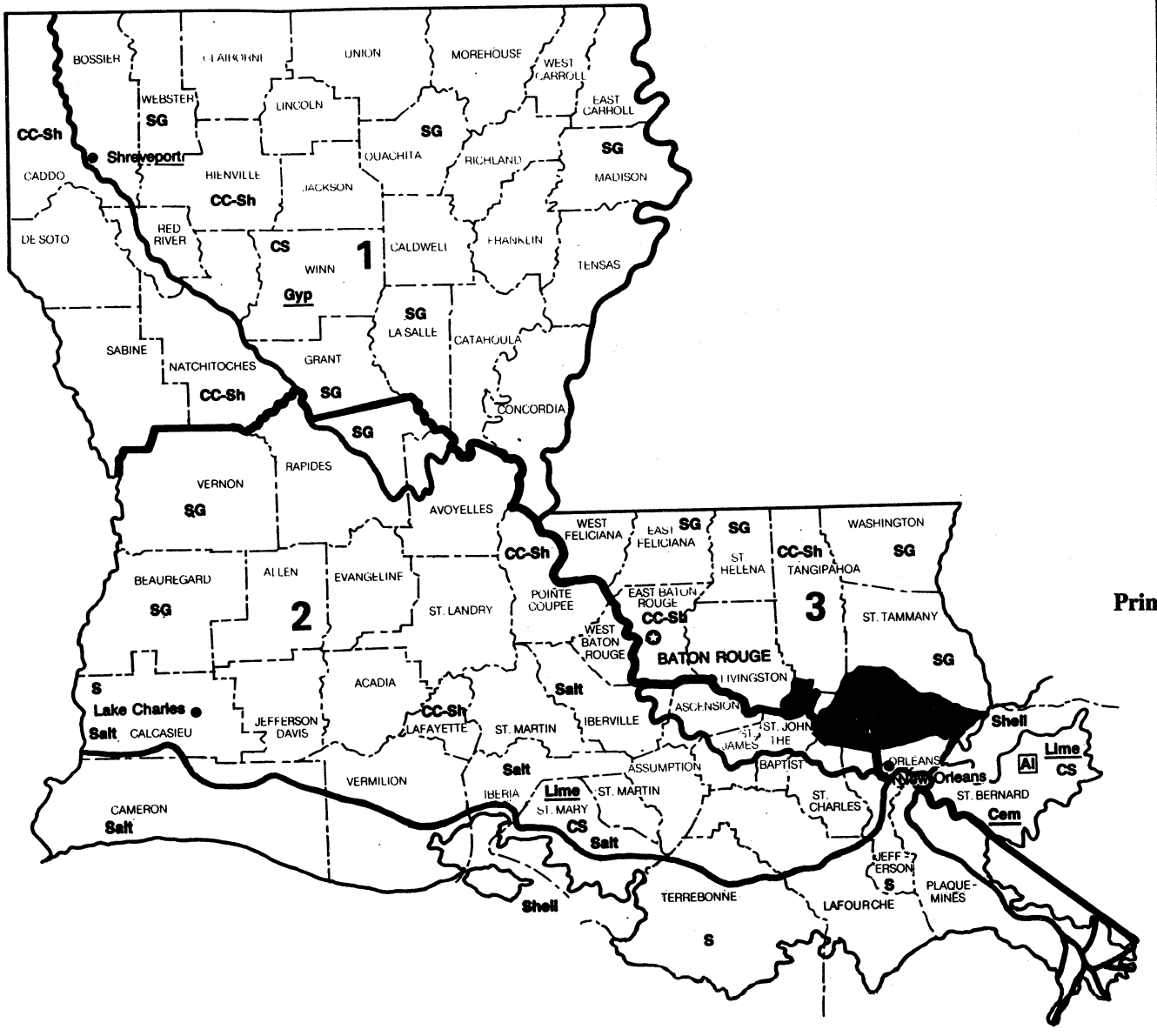
LOUISIANA



LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Al	Aluminum plant
CC-Sh	Common Clay & Shale
Cem	Cement plant
CS	Crushed Stone
Gyp	Gypsum plant
Lime	Lime plant
S	Sulfur
Salt	Salt
SG	Sand and Gravel
Shell	Shell

Principal Mineral-Producing Localities

TABLE 2

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	Parish
Clays:			
Athens Brick Co. Inc.	Box 70 Athens, TX 75751	Mines and plant	Caddo.
Big River Industries Inc.	Box 66377 Baton Rouge, LA 70806	Mine and plant	Pointe Coupee.
Featherlite Building Products	Box 5044 Jamestown, LA 70145	do.	Bienville.
Gypsum:			
National Gypsum Co.	Box 128 Westwego, LA 70094	Plant	Jefferson.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Orleans.
Lime:			
USG Corp.	do.	do.	Do.
Salt:			
Akzo Salt Inc.	Box 106 Avery Island, LA 70513	Mine	Iberia.
Cargill Salt Inc.	Box 91130 Lafayette, LA 79509	Brine wells	St. Martin.
North American Salt Co.	Box 10 Lydia, LA 70569	do.	St. Mary.
Morton International Inc.	Box 1996 New Iberia, LA 70561	Mine, brine wells	Iberia.
Sand and gravel:			
Gifford-Hill & Co. Inc.	Box 6615 Shreveport, LA 71136	Dredges, pits, plants	Jefferson, Davis, Rapides, Tangipahoa, Webster.
Louisiana Sand and Gravel Co.	Box 963 Baton Rouge, LA 70821	Dredge and plant	St. Helena.
Standard Gravel Co. Inc.	Route 7, Box 53 Franklinton, LA 70438	Dredges and plants	St. Tammany and Washington.
Texas Industries Inc.	Box 5472 Alexandria, LA 71301	Dredges, pits, plants	Beauregard, Grant, LaSalle, Ouachita, Rapides, St.Tammany.
Stone (crushed):			
Pontchartrain Dredging Corp.	Box 8005 New Orleans, LA 70182	Quarry and plant	Winn.
Dravo Lime Co.	One Gateway Center 7th Floor Pittsburgh, PA 15222	Dredges	Orleans and St. Mary.
Winn Rock Inc.	Box 790 Winnfield, LA 71483	Quarry and plant	Winn.
Sulfur:			
Native:			
Recovered:			
Exxon Co. U.S.A.	Box 551 Baton Rouge, LA 70821	Plant	East Baton Rouge.
Vermiculite (exfoliated):			
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	do.	Orleans.

THE MINERAL INDUSTRY OF MAINE

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Maine Geological Survey for collecting information on all nonfuel minerals.

By Donald K. Harrison,[1] Walter Anderson,[2] and Michael E. Foley[3]

The value of Maine's nonfuel mineral production in 1991 was $41.3 million, a $21.2 million decrease compared with that of 1990. Decreases in output and value were reported for most of the nonfuel minerals produced. The largest decreases in both production and value were for construction sand and gravel and dimension stone. Smaller decreases were estimated for both masonry and portland cement. Other mineral commodities produced in the State included common clay, gemstones, and peat. Perlite was shipped in from out-of-State and expanded at one plant in the State.

TRENDS AND DEVELOPMENTS

Maine's economy remained depressed in 1991. Residential, nonresidential, and nonbuilding construction, which rely heavily on mineral aggregates, remained well below the peak building year of 1988. In 1991, the value of total construction contracts in the State declined by 7% from that of 1990. The largest decrease in value was reported for nonbuilding construction contracts, which fell 21%. The value of residential construction contracts was down by 19% while the value of nonresidential building construction was up by a modest 1.5%. The 1991 total construction contract value was also 63% lower than that of 1988, the peak building year. As a result of the continuing construction declines, the State's mineral output and value, which rely heavily on a healthy construction industry, have been steadily declining since 1988. Mineral value in 1991 was 39% lower than that of 1988 and was close to the 1985 mineral output value of $41.1 million.

EMPLOYMENT

In 1991, the average number of workers employed in the mineral extractive industries in Maine was 615, about 450 less than that of 1990.[4] This included 405 workers in the sand and gravel industry, 104 in the stone industry, and 1 at other nonmetal operations. In addition, 105 workers were employed at mineral-related mills and preparation plants in the State.

Employment in the mineral-dependent construction industry was also lower in 1991. The number of construction jobs declined by 24% during the year, from an average of 28,500 in 1990 to 21,800 in 1991. The job losses totaled 3,100 in building construction, 700 in heavy construction, and 2,900 in special trade contracting. Between 1988, when the building boom ended, and 1991, approximately 35% of all construction jobs in the State were lost. This was the largest decline for any period since World War II.

LEGISLATION AND GOVERNMENT PROGRAMS

In July, the Maine Land Use Regulation Committee (LURC) and the Maine Department of Environmental Protection (DEP) adopted Maine's first Metallic Mineral Exploration and Mining Rules (Chapter 13). The rules, which

TABLE 1
NONFUEL MINERAL PRODUCTION IN MAINE[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gemstones		NA	W	NA	W	NA	$174
Sand and gravel (construction)	thousand short tons	e8,600	e$30,100	7,865	$29,349	e3,900	e14,800
Stone:							
Crushed	do.	1,591	8,801	e1,700	e8,700	1,706	9,899
Dimension	short tons	W	W	W	W	73	88
Combined value of cement, clays (common), peat, and values indicated by symbol W		XX	25,753	XX	24,495	XX	16,343
Total		XX	64,654	XX	62,544	XX	41,304

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

became effective in August, were written in response to Public Law 1989, Chapter 874, which was signed into law in April 1990. The law charged the LURC, jointly with the DEP, with developing comprehensive rules for metallic mining activities in the State. In addition, the LURC undertook rule development to integrate its zoning requirements for unorganized areas of Maine into a comprehensive approach to mining regulation. In developing these rules, the LURC and DEP held informational workshops and meetings with the regulated community, environmental interest groups, and interested members of the public to discuss technical, processing, and policy issues.

In May, the Legislative Taxation Committee killed a bill (L.D. 1755) that would have allowed towns to impose excise and severance taxes on sand and gravel companies based on the volume of material they excavate. The committee was reluctant to approve any plans for local option taxes in light of the State's revenue crunch and because the State itself was considering a mining tax proposal.[5]

In December, selectmen in the town of Warren extended the town's metal mining moratorium for an additional 120 days. Earlier in the year, voters in the town unanimously approved a 6-month metal mining moratorium, which expires in January 1992. The vote and extension was prompted by a proposal by Knox Nickel Corp., a Canadian mining firm, to mine nickel, copper, and cobalt within the town limits. In addition to passing the moratorium, residents voted unanimously to allocate $2,000 for the Planning Board to draw up metal mining regulations. A town vote on the proposed new local mining regulations is expected in mid-1992.

The Maine Geological Survey, a bureau of the Department of Conservation, continued to map, interpret, and publish geological information and provide technical assistance to the mineral industry, planning and regulatory agencies, and the general public.

The Maine State Geologist, together with the other New England State Geologists, investigated the future demand for construction aggregates—sand and gravel and crushed stone—in the six-State New England region. The aggregates demand study was initiated by the New England Governors Council with funds provided by the U.S. Department of the Interior, Minerals Management Service. The study was the first of a two-part investigation to determine what potential difficulties may exist in establishing the availability of construction aggregates in New England. Results of the first part of the investigation, which focused on aggregate demand and the problems faced by aggregate producers in opening new production facilities, was to be published in January 1992. The second part of the investigation, which will focus on the location and quantities of sand and gravel deposits that are available for eventual development, will be initiated in 1992.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Maine was the only New England State that produced cement. Dragon Products Co., a subsidiary of CDN Cementos del Norte, produced portland and masonry cement at a plant in Thomaston, Knox County. In 1991, the estimated production and value of both portland and masonry cement declined from 1990 levels. The decline was largely the result of the continuing building slump in the Northeast.

Dragon announced in October that it was postponing indefinitely construction of a proposed $4 million transfer facility in Wiscasset. The railroad-to-barge transfer station would have enabled Dragon to send cement and crushed stone by rail to Wiscasset where they would be transferred to a barge for delivery to customers. Coal and other raw materials used in cementmaking would have been off-loaded at the terminal and shipped by rail to the Thomaston plant. The company indicated that the poor economy in the Northeast made the project unaffordable.

Clays.—Morin Brick Co., the State's only producer of clay, mined common clay at operations in Androscoggin and Cumberland Counties. The clay was used primarily to manufacture brick.

Over the objections of neighborhood residents, the Lewiston Planning Board approved a conditional use permit for H.E. Sargent Inc. to mine clay in the community. The company was seeking permission to extract about 100,000 cubic yards of clay from a 72-acre tract. The clay will be used to cap the city landfill. In granting the permit approval, the board imposed conditions on the company, including posting a bond to repair any damage to the road, restricting mining to material used for municipal projects, limiting hours of operation from 7:00 a.m. to 5:30 p.m., and restricting truck travel to the most direct route between the pit and the landfill.

Garnet.—Pittston Mineral Ventures of Greenwich, CT, announced plans to reactivate a dormant garnet quarry near Rangeley. Before the quarry and a proposed adjacent processing plant can be developed, the company's plans must be approved by State environmental authorities. In addition, the quarry area would need to be rezoned by the town. Industrial Garnet Extractives Inc. (IGE), a garnet processor, had developed the existing quarry between 1979 and 1987. The company ceased processing garnet at a plant near West Paris in early 1988. IGE had produced industrial-grade garnet used primarily for sandblasting and water filtration.

Gemstones.—The Maine Geological Survey lists about 50 quarries in Oxford County that are open to the public for exploring. Although gemstones are found in many counties in Maine, Oxford County has the largest concentration of pegmatites in the State. More than 1,000 different minerals have been found in Maine including the State gemstone, the

TABLE 2
MAINE: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Riprap and jetty stone	10	47	$4.70
Filter stone	4	36	9.00
Fine aggregate (-3/8 inch): Screening, undesignated[2]	127	436	3.43
Coarse and fine aggregates: Crusher run or fill or waste	9	45	5.00
Other construction materials[3]	573	2,713	4.73
Unspecified:[4]			
Actual	581	3,532	6.08
Estimated	402	3,089	7.68
Total	1,706	[5]9,899	5.80

[1]Includes granite, limestone, miscellaneous stone, quartzite, and traprock.
[2]Includes stone sand, concrete and stone sand, bituminous mix or seal.
[3]Includes concrete aggregate, coarse, bituminous aggregate, coarse, bituminous surface-treatment aggregate, roofing granules, and cement manufacture.
[4]Includes production reported without a breakdown by use and estimates for nonrespondents.
[5]Data do not add to total shown because of independent rounding.

watermelon tourmaline, as well as amethyst, aquamarine, citrine, morganite, rose and smoky quartz, and topaz, to name just a few.[6]

Graphite (Synthetic).—Synthetic graphite was produced by Fiber Materials Inc. at a plant in Biddeford, York County.

Peat.—Nationally, Maine ranked fourth of 19 States that produced peat. Peat was mined by two companies in the State in 1991. Folson Marine Service Corp. mined peat for horticultural purposes in York County. Down East Peat LP used peat as fuel at a 22.8-megawatt, peat-fired electric powerplant near Deblois, Washington County. Fuel for the plant was harvested from the adjacent 1,200-acre Denbo Heath Bog by a private contractor. In addition to the companies mining peat in the State, more than 71,000 short tons of poultry and fertilizer-grade peat, valued at $8.9 million, was imported from Canada into Maine through the Portland Customs district.

Perlite (Expanded).—Crude perlite shipped in from New Mexico was expanded by the Chemrock Corp. at a plant in Rockland, Knox County. Both quantity and value remained essentially unchanged from those of 1990. The expanded perlite was sold primarily as a filter aid.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Construction sand and gravel was the State's second leading mineral commodity in terms of value and accounted for 36% of the State's mineral value. Estimated output of 3.9 million short tons of construction sand and gravel was 50% lower than that produced in 1990. The 1991 estimated output was also the lowest since 1947 when 3.7 million short tons was produced. The estimated low output in 1991 can be largely attributed to fewer construction starts and a decrease in highway construction projects.

After more than 1 year of State review and sustained local opposition, the DEP granted conditional approval to Tilcon-Maine Inc. to develop a sand and gravel pit in North Belgrade. The DEP attached 11 conditions to the approval that must be met before the project could begin. Tilcon is seeking approval to mine 525,000 cubic yards of sand and gravel from a 6.8-acre site near Great Pond. The proposal has also generated considerable media coverage since the pit will be near the pond that inspired the play and movie, "On Golden Pond." A final decision by the DEP on whether or not to allow mining at the site is expected sometime in mid-1992.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Crushed.—Output of crushed stone remained essentially the same as the 1990 estimated output. In 1991, 1.7 million short tons valued at $9.9 million was produced. Knox, Androscoggin, and Cumberland Counties were the leading counties, in descending order of production, and accounted for the majority of stone produced. Other counties that produced crushed stone were Aroostook, Kennebec, and Penobscot. Limestone was the dominant stone quarried. Other rock types mined included calcareous marl, granite, traprock, and quartzite. Leading uses were for cement manufacture and bituminous aggregate.

In September, the Naples Zoning Board of Appeals approved a request by Dragon Products to open an 11-acre crushed stone quarry on Madison Mountain near Edes Falls. The decision overturned the Planning Board's denial of the project in June. The Planning Board denied Dragon's request on grounds that the quarry would exceed reasonable traffic limits and would adversely impact town roads and ground water quality and quantity. The Zoning Board of Appeals'

TABLE 3
MAINE: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	5	1,143	$5,104	$4.47	4	837	$4,348	$5.19
Calcareous marl	1	W	W	5.33	—	—	—	—
Granite	2	W	W	9.12	3	W	W	5.97
Traprock	2	W	W	6.76	1	W	W	2.58
Quartzite	1	W	W	8.33	1	W	W	9.16
Miscellaneous stone	—	—	—	—	1	W	W	3.07
Total[1]	XX	1,591	8,801	5.53	XX	1,706	9,899	5.80

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

decision in September raised a storm of protest with residents living near the proposed quarry. In October, a citizens' group against the quarry filed a lawsuit with the Cumberland County Superior Court to overturn the Board of Appeals' decision. If the quarry begins operating, it would provide feedstock for Dragon's concrete plant in Thomaston.

Dimension.—Fletcher Granite Co. Inc. sold dimension granite produced at its Stonington operation in Hancock County. All of the material sold was sawed stone blocks.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related experience and has covered the mineral activities in Maine for 7 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]Director and State Geologist, Maine Geological Survey, Augusta, ME.

[3]Resource Administrator, Maine Geological Survey, Augusta, ME.

[4]"Average number of workers" is a summary of the average number of workers at individual mining establishments during periods (not necessarily continuous) of active operations.

U.S. Department of Labor, Mine Safety and Health. Mine Injuries and Worktime Quarterly, Jan.-Dec. 1991, 33 pp.

[5]Central Maine Morning Sentinel. Legislative Committee Kills Proposed Tax on Gravel. May 21, 1991.

[6]Kennebec Journal. Day Tripping Can Be Near or Far. July 15, 1991, p. 7.

MAINE

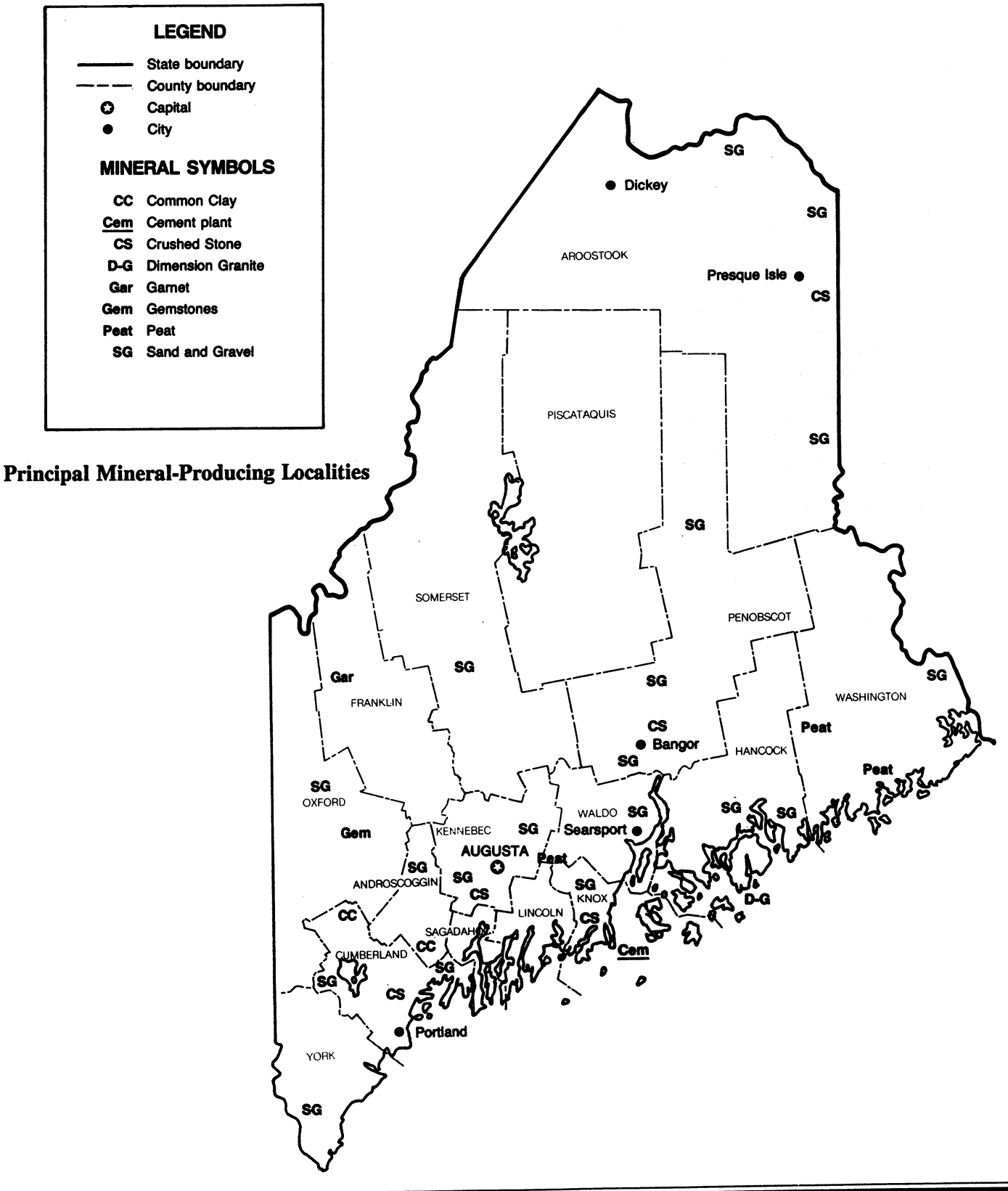
LEGEND
State boundary
County boundary
Capital
City
MINERAL SYMBOLS
CC Common Clay
Cem Cement plant
CS Crushed Stone
D-G Dimension Granite
Gar Garnet
Gem Gemstones
Peat Peat
SG Sand and Gravel
Principal Mineral-Producing Localities
AROOSTOOK
Dickey
Presque Isle
PISCATAQUIS
SOMERSET
PENOBSCOT
FRANKLIN
Gar
Bangor
HANCOCK
WASHINGTON
Peat
OXFORD
Gem
KENNEBEC
AUGUSTA
WALDO
Searsport
ANDROSCOGGIN
KNOX
D-G
LINCOLN
SAGADAHOC
Cem
CUMBERLAND
Portland
YORK

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Dragon Products Co.[1]	Box 191 Thomaston, ME 04861	Quarry and plant	Knox.
Clays:			
Morin Brick Co.	Mosher Rd. Gorham, ME 04038	Pits and mills	Androscoggin and Cumberland.
Graphite (synthetic):			
Fiber Materials Inc.	Biddleford Industrial Park Biddleford, ME 04005	Plant	York.
Perlite (expanded):			
Chemrock Corp.	1101 Kermit Dr. Suite 503 Nashville, TN 37217	do.	Knox.
Sand and gravel (construction) (1990):			
W. E. Cloutier Co. Inc.[2]	Box 1849 Lewiston, ME 04240	Pit	Androscoggin.
Harry C. Crooker & Sons Inc.[2]	Old Bath Rd. Brunswick, ME 04011	Pits and plants	Androscoggin, Lincoln, Sagadahoc.
Dragon Products Co.[2]	Box 191 Thomaston, ME 04861	do.	Androscoggin, Aroostook, Franklin, Hancock, Oxford, Somerset.
R. J. Grondin & Son[2]	Rural Route 4 Gorham, ME 04038	Pit	Cumberland.
Lane Construction Corp.[2]	Box 103 Bangor, ME 04401	Pits	Aroostook, Penobscot, Waldo, Washington.
Maine Department of Transportation	State House Station 16 Augusta, ME 04333	Pits and plants	Aroostock, Cumberland, Oxford, Penobscot, Somerset, York.
Stone:			
Crushed:			
Blue Rock Industries[3]	58 Main St. Westbrook, ME 04092	Quarries	Cumberland and Kennebec.
Pike Industries Inc.[3]	U.S. Route 3, Box 91 Titton, NH 03276	do.	Androscoggin.
H.E. Sargent Inc.[3]	101 Bennoch Rd. Stillwater, ME 04489	Quarry	Penobscot.
Dimension:			
Fletcher Granite Co.	Groton Rd. W. Chelmsford, MA 01863	do.	Hancock.

[1]Also sand and gravel and stone.
[2]Also crushed stone.
[3]Also sand and gravel.

THE MINERAL INDUSTRY OF MARYLAND

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Maryland Geological Survey for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.[1]

The value of nonfuel mineral production in Maryland in 1991 was about $348 million. Production dropped for all the nonfuel minerals produced in the State. Maryland's value of output decreased by only $20 million primarily because of a significant increase in the price of crushed stone.

TRENDS AND DEVELOPMENTS

Since the mid-1980's, Maryland's nonfuel minerals industry had reported increased production and value almost every year until 1991. For the first time since 1985, crushed stone output fell below 26 million short tons. Production of 13 million tons of construction sand and gravel was the lowest since 10.6 million tons was reported in 1983. During the 1980's, these two commodities accounted for approximately 70% of the State's total value of nonfuel mineral production of almost $2.6 billion.

In 1991, demand from the construction industry, the major consumer of crushed stone and sand and gravel, weakened. As a result, the combined output of these commodities dropped by about 20% or more than 10 million tons. The decline in construction also affected the State's other nonfuel minerals as output decreased for portland cement by 12%, for clays by 24%, and for dimension stone by 50%.

Mineral commodities shipped into Maryland through the Port of Baltimore also showed a significant decline in 1991. Total import trade declined from 12.8 million short tons to about 9.4 million tons. Imports of industrial minerals that dropped in 1991 included gypsum by 12%, sand by 28%, and salt by 56%. Cement imports were at a low point of 277 tons, down from about 162,000 tons in 1990 and 420,000 tons in 1989.[2] This reduction in imports improved the Nation's trade balance, but nonetheless, was indicative of the weaker demand for minerals in Maryland.

LEGISLATION AND GOVERNMENT PROGRAMS

The Maryland General Assembly passed two bills that increased regulation of the State's mining industry. Senate bill 115 required the Department of Natural Resources (DNR) to conduct public information meetings for new mines in excess of 5 acres or expansion of mines of more than 20 acres; it became effective July 1, 1991. House bill 499 required the DNR to establish a "zone of influence" (area affected by quarrying) at limestone quarries during dewatering operations and for replacement of lost water. Rulemaking for this legislation was expected to be developed during 1992.

The Maryland Department of the Environment (MDE) published a guide to

TABLE 1
NONFUEL MINERAL PRODUCTION IN MARYLAND[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Cement (portland)	thousand short tons	1,871	$94,002	1,798	$91,172	e1,580	e$80,580
Clays	metric tons	351,464	1,882	338,775	1,712	e258,760	e1,141
Gemstones		NA	3	NA	3	NA	3
Peat	metric tons	3	W	3	W	—	—
Sand and gravel (construction)	thousand short tons	e16,900	e84,500	18,271	104,023	e13,000	e72,800
Stone:							
Crushed	do.	30,841	153,375	e30,500	e163,900	25,545	188,001
Dimension	short tons	27,529	2,072	e24,102	e1,751	12,090	967
Combined value of other industrial minerals and values indicated by symbol W		XX	6,216	XX	6,053	XX	4,720
Total		XX	342,050	XX	368,614	XX	348,212

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

TABLE 2
MARYLAND: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	133	834	$6.27
Riprap and jetty stone	197	1,479	7.51
Filter stone	W	W	2.68
Coarse aggregate, graded:			
Concrete aggregate, coarse	771	4,181	5.42
Bituminous aggregate, coarse	1,015	5,797	5.71
Bituminous surface-treatment aggregate	W	W	5.02
Railroad ballast	52	298	5.73
Fine aggregate (-3/8 inch):			
Stone sand, concrete	72	462	6.42
Stone sand, bituminous mix or seal	W	W	5.61
Screening, undesignated	345	1,730	5.01
Coarse and fine aggregates:			
Graded road base or subbase	2,071	11,392	5.50
Unpaved road surfacing	W	W	5.17
Crusher run or fill or waste	618	2,492	4.03
Other construction materials[2]	358	1,510	4.22
Chemical and metallurgical: Cement manufacture	2,451	4,991	2.04
Unspecified:[3]			
Actual	17,333	151,708	8.75
Estimated	128	1,126	8.80
Total[4]	25,545	188,001	7.36

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes granite, limestone, miscellaneous stone, quartzite, sandstone, and traprock.
[2]Includes withheld amounts for coarse aggregate (+1 inch), coarse aggregate, graded, fine aggregate (-3/8 inch), and coarse and fine aggregates.
[3]Includes production reported without a breakdown by use and estimates for nonrespondents.
[4]Data may not add to totals shown because of independent rounding.

permits entitled, "Environmental Regulation."[3] In the guide, requirements of 36 permits under 6 different MDE agencies were listed.

The Maryland Geological Survey (MGS) was the primary State agency responsible for geologic and mineral resource studies. In 1991, the MGS, in cooperation with the Maryland Water Resources Administration and the U.S. Geological Survey (USGS), published a study on water withdrawal and use in the State.[4]

Hydrology studies by the MGS were of interest to the mining sector because of the possible impact on water resources resulting from quarrying. The MGS also investigated ground water resources in Somerset County in a joint effort with county officials and the USGS.[5] Also in 1991, another joint local, State, and Federal government cooperative water resources report was published for the Waldorf area of Charles County.[6]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

The decline in construction slowed the activity in the opening and expanding of mining operations during the year. Most companies considering new or expanded development delayed plans as producers were able to meet demand with existing capacity.

Cement.—Production of portland cement dropped below the 1.8-million-short-ton level for the first time in 5 years. The decline in output to slightly less than 1.6 million tons reflected the downturn in construction.

Peat.—After 30 consecutive years, no peat mining was reported from Maryland in 1991. In 1961, peat had been produced near Betterton, Kent County, by the Maryland Peat Humus Co. In 1990, peat was mined near Accident, Garrett County, by Garrett County Peat Products.

Peat bogs in six States reportedly closed in 1991 as U.S. production dropped by 9%. Environmental and wetland regulations were in part factors that affected the peat industry.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Estimated output for 1991 dropped to about 13 million short tons. The decline in production was about 5.3 million tons compared to that reported in 1990.

Stone (Crushed).—Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Maryland crushed stone statistics are compiled by geographical districts as depicted in the State map. Table 3 presents end-use statistics for Maryland's three districts.

Despite a 5-million-short-ton drop in production, the value of crushed stone in Maryland increased by about $24 million. One operation in the State reported a significant increase in production of a higher-than-average-priced stone. The increase in output at this one operation offset the declines in value as were reported by most of the State's industry

TABLE 3
MARYLAND: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	41	232	110	318	274	2,017
Coarse aggregates, graded[2]	257	1,251	607	2,777	1,021	6,480
Fine aggregates (-3/8 inch)[3]	214	1,199	161	680	90	585
Coarse and fine aggregates[4]	784	3,366	515	1,831	1,468	9,090
Other construction materials	728	1,796	1,814	3,546	—	—
Chemical and metallurgical[5]	W	W	W	W	—	—
Unspecified:[6]						
Actual	1,379	5,957	15,954	145,750	—	—
Estimated	—	—	128	1,126	—	—
Total[7]	3,404	13,802	19,288	156,028	2,853	18,171

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap, and jetty stone.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), screening (undesignated).
[4]Includes graded road base or subbase, unpaved road surfacing, and crusher run (select material or fill).
[5]Includes cement manufacture.
[6]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[7]Data may not add to totals shown because of independent rounding.

TABLE 4
MARYLAND: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	19	19,554	$94,436	$4.83	19	16,236	$130,700	$8.05
Shell	1	W	W	8.01	—	—	—	—
Granite	3	3,399	20,741	6.10	3	5,633	33,155	5.89
Traprock	3	3,401	12,657	3.72	1	W	W	8.80
Sandstone and quartzite	3	W	W	6.18	2	W	W	5.49
Miscellaneous stone	2	W	W	5.47	2	W	W	6.53
Total	XX	30,841	153,375	4.97	XX	25,545	188,001	7.36

W Withheld to avoid disclosing company proprietary data, included in "Total." XX Not applicable.
[1]Data do not add to total shown because of independent rounding.

as a whole.

In 1991, producers indicated that demand had dropped because of a slowdown in the economy. Maryland's crushed stone industry had reported steady growth beginning in 1983 when output totaled about 19 million tons. That growth reached a peak in 1988 when a State record of 32.7 million tons of stone was produced. In addition to generally weaker markets for stone as a result of economic conditions, the completion of a portion of Interstate Highway 68 in western Maryland also accounted for the lower output in 1991.

Metals

Metals discussed in this section were processed from materials received from both foreign and domestic sources. No metallic ores were mined in Maryland. Production and value data for these processed metals, which are not included in table 1, are given if available.

Metals were imported into Maryland primarily through the Port of Baltimore. The port received lower quantities of most metals in 1991. Iron ore imports dropped from 3.9 million short tons in 1990 to about 2.9 million tons in 1991. Shipments from overseas of ferroalloys dropped from about 177,000 tons to 146,000 tons.[7] Imports of industrial minerals at the port are discussed in Trends and Developments.

Aluminum.—Eastalco Aluminum Co., a subsidiary of Alumax Inc., continued to produce aluminum at its smelter near Frederick.

Copper.—Cox Creek Refining Co. shut down its copper anode casting operation and rod mill in Baltimore. The company termed the shutdown as temporary.

Iron and Steel.—Bethlehem Steel Corp., the State's major producer of steel, shut down coke batteries at its Sparrows Point facility. The firm announced plans late in the year to idle 210 coke ovens for 2 years while developing a program for air pollution compliance. Bethlehem produced about 750,000 short tons of coke at the operation; about 50% of the quantity was used in the firm's steelmaking operations at Sparrows Point.[8] The action was taken in response to enactment of amendments to the Federal Clean Air Act in 1990, which called for lower emissions from industrial sources by 1995, as well as changing market conditions for coke.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related industry and government experience and has covered the mineral activities in Maryland for 7 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]Maryland Port Administration. Foreign Commerce Statistical Report 1991, July 1992, 250 pp.

[3]Maryland Department of the Environment. Environmental Regulation: A Business Guide to the Maryland Dept. of the Environment's Permitting Process. July 1991, 52 pp.

[4]Wheeler, J. C. Water Withdrawal and Use in Maryland 1987. U.S. Geol. Surv. Open File Rep. 90-572, 1991, 28 pp. (Available from USGS, Books and Open File Reports Section, Denver Federal Center, Box 25425, Denver, CO 80225).

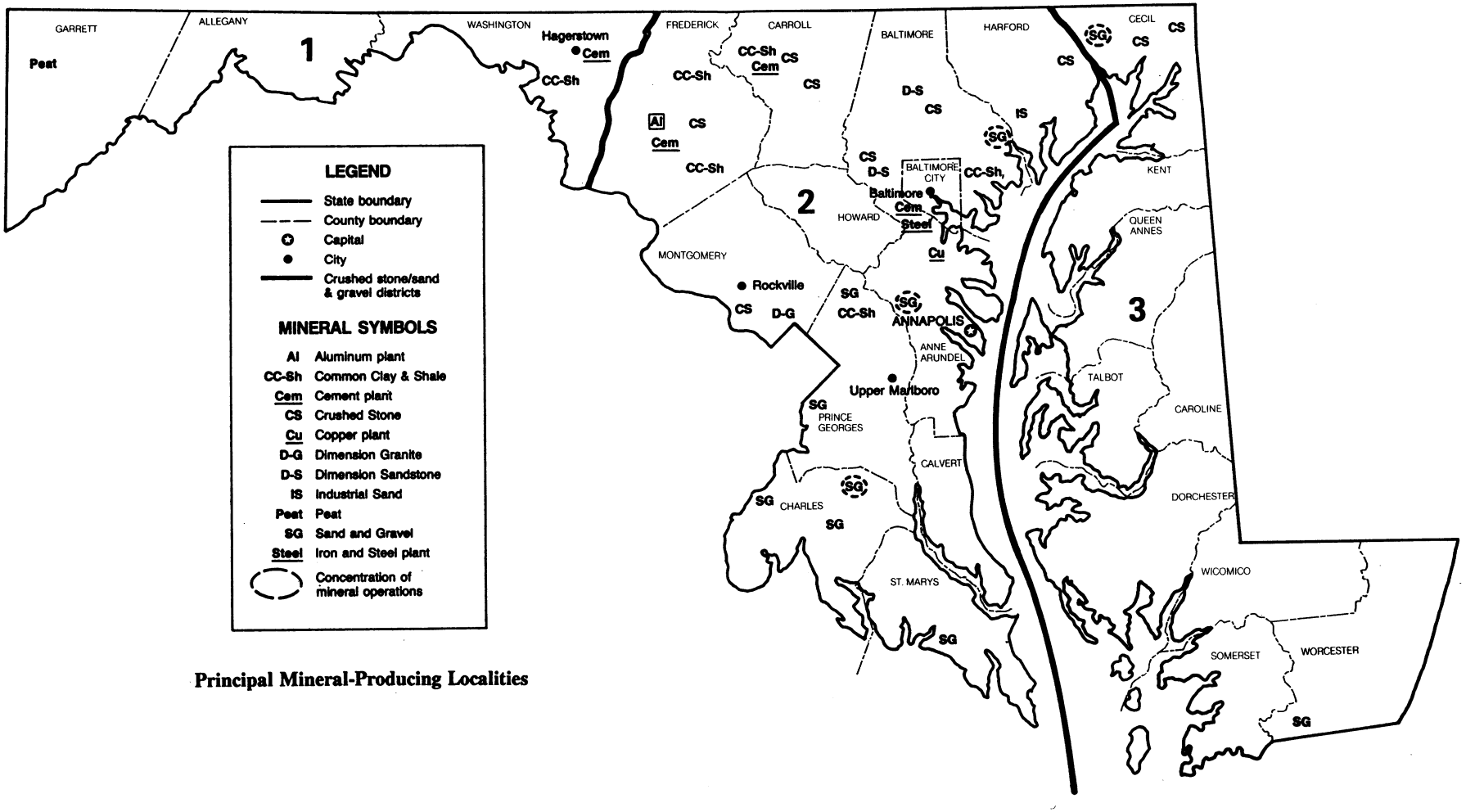
[5]Weakheiser, W. H. Hydrology and Ground Water Resources of Somerset County. MD Geol. Surv. Bull. 35, 1990, 156 pp.

[6]Wilson, J. M., and W. B. Fleck. Geology and Hydrologic Assessment of Coastal Plain Aquifers in the Waldorf Area, Charles County, MD. MD Geol. Surv. RI No. 53, 1991, 138 pp.

[7]Maryland Port Administration. Foreign Commerce Statistical Report 1991, July 1992, 250 pp.

[8]American Metal Market. Bethlehem Steel To Idle Coke Unit. V. 99, No. 178, p. 1.

MARYLAND



Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Eastalco Aluminum Co. (Alumax Inc.)	5601 Manor Woods Rd. Frederick, MD 21701	Reduction plant	Frederick.
Cement:			
Portland:			
Essroc Materials Inc.[1]	Box D Frederick, MD 21701	Quarry and plant	Do.
Portland and masonry:			
Independent Cement Corp.[1] (St. Lawrence Cement Inc.	Box 650 Hagerstown, MD 21740	do.	Washington.
Lehigh Portland Cement Co.[1 2] (Heidelberger Zement AG)	Box L Union Bridge, MD 21791	do.	Carroll.
Slag:			
Blue Circle—Atlantic (Blue Circle Industries PLC)	Box 6687 Sparrows Point, MD 21219	Plant (slag cement)	Harford.
Clays:			
Common clay and shale:			
Baltimore Brick Co.	9009 Yellow Brick Rd. Baltimore, MD 21237	Pit and plants	Frederick.
Cherokee Sanford Group Inc.	7100 Muirkirk Rd. Beltsville, MD 20705	Pit and plant	Prince Georges.
Cushwa Brick Inc.	Clearspring Rd. and Route 68N Box 160 Williamsport, MD 21795	do.	Washington.
Copper:			
Cox Creek Refining Co.	Box 3407 Baltimore, MD 21226	Refinery	Anne Arundel.
Gypsum:			
Byproduct:			
SCM Chemicals Inc.[3]	3901 Glidden Rd. Baltimore, MD 21226	Plant	Baltimore.
Calcined:			
National Gypsum Co., Gold Bond Building Products Div.	2301 South Newkirk St. Baltimore, MD 21224	do.	Do.
USG Corp.	500 Quarantine Rd. Box 3472 Baltimore, MD 21226	do.	Do.
Iron and steel:			
Bethlehem Steel Corp.	Sparrows Point, MD 21219	Mill (integrated)	Do.
Eastern Stainless Corp. (subsidiary of Cyclops Industries Inc.)	Box 1975 Baltimore, MD 21203	Melting furnace	Do.
Sand and gravel:			
Construction:			
Charles County Sand & Gravel Co.	Box 322 Waldorf, MD 20601	Pits and plant	Anne Arundel, Charles, St. Marys.
Laurel Sand & Gravel Inc.[1]	Van Dusen Rd., Box 719 Laurel, MD 20707	Pits and plants	Anne Arundel and Prince Georges.
Seven Star Aggregates Inc.	Box 1668 La Plata, MD 20646	Pit	Charles.

See footnotes at end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued:			
Construction—Continued:			
Silver Hill Aggregates & Concrete Co.	4714 Barnabas Rd. Temple Hills, MD 20748	Pits and plant	Prince Georges.
Southern Maryland Sand & Gravel Corp.	8700 Ashwood Dr. Capital Heights, MD 20743	Pit	Charles.
York Building Products Co. Inc.	Box 1708 York, PA 17405	Pits and plant	Cecil.
Industrial:			
Harford Sands Inc.	Box 25 40 Fort Hoyle Rd. Joppa, MD 21085	Pits	Harford.
Stone:			
Crushed:			
The Arundel Corp.[4]	110 West Rd. Baltimore, MD 21204	Quarries and plants	Baltimore, Frederick, Harford.
Genstar Stone Products Co.[4]	Executive Plaza 4 11350 McCormick Rd. Hunt Valley, MD 21031	do.	Baltimore, Carroll, Frederick.
Martin Marietta Aggregates Corp.[3]	Box 30013 Raleigh, NC 27612	Quarries	Washington.
Maryland Materials Inc.	Box W North East, MD 21901	Quarry and plant	Cecil.
H. B. Mellott Inc.	Box 188 McConnelsburg, MD 17233	Quarries and plant	Washington.
Phoenix Inc.	Box 676 Frederick, MD 21701	Quarry	Frederick.
Rockville Crushed Stone Inc. (Evered Bardon PLC)	Box 407 133900 Piney Meetinghouse Rd. Rockville, MD 20850	do.	Montgomery.
D. M. Stoltzfus & Son Inc.	Box 11 Talmage, PA 17580	do.	Cecil.
Dimension:			
Piccirilli Quarries Inc.	Marriottsville Rd. Marriottsville, MD 21104	do.	Baltimore.
Stoneyhurst Quarries	15215 Shady Grove Rd. Rockville, MD 20850	do.	Montgomery.
Vinci Stone Products Inc.	10920 Marriottsville Rd. Marriottsville, MD 21104	do.	Baltimore.
Vermiculite (exfoliated):			
W. R. Grace & Co., Construction Products Div.	12340 Conway Rd. Beltsville, MD 20705	Plant	Prince Georges.

[1]Also crushed stone.
[2]Also clays.
[3]Also titanium dioxide (pigments).
[4]Also sand and gravel.

THE MINERAL INDUSTRY OF MASSACHUSETTS

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Commonwealth of Massachusetts, Executive Office of Environmental Affairs, for collecting information on all nonfuel minerals.

By Donald K. Harrison[1] and Joseph A. Sinnott[2]

The value of nonfuel mineral production in 1991 was $111.6 million, a decrease of $16 million compared with the 1990 value. The decrease in 1991 was largely attributable to lower sales of construction sand and gravel and crushed stone, the State's two leading mineral commodities. Other mineral commodities produced included common clay, industrial sand, dimension stone, lime, and peat. Nationally, the State ranked 41st in the production of nonfuel minerals. It ranked fifth of 34 States that produced dimension stone. Industrial minerals processed or manufactured in the State included abrasives, synthetic graphite, gypsum, perlite, and vermiculite.

TRENDS AND DEVELOPMENTS

Since the peak year of 1988, the value of nonfuel mineral production in Massachusetts has been steadily declining. The 1991 value is almost 50% lower than the record-high value reported in 1988 and is close to the 1984 level of mineral production value. The decrease since 1988 was largely attributable to overbuilding in the mid- to late-1980's. Because mineral producers relied heavily on construction contractors as one of their main consumers, the building bust in 1988 resulted in a continued declining production of crushed stone and sand and gravel since then. In 1991, cement consumption in the State declined by 18% from that of 1990 and was only 50% of 1986 consumption.[3]

In 1991, the annual average value (AAV) of total construction contracts in Massachusetts was down 6% from that of 1990. Although the AAV of nonbuilding construction contracts was up 30%, this was offset by decreases in the AAV of nonresidential building construction contracts (down 29%) and residential construction contracts (down 8%).

EMPLOYMENT

In 1991, the average number of workers[4] employed in the mineral extractive industries in Massachusetts was 977. This included 391 workers in the sand and gravel industry, 261 in the stone industry, and 6 workers at other nonmetal mines. In addition, 319 personnel were employed at mineral-related mills and preparation plants in the State.

LEGISLATION AND GOVERNMENT PROGRAMS

In the summer of 1991, the Federal Highway Administration granted its approval for Boston's Central Artery/Tunnel Project. The $5 billion project is the largest highway transportation initiative currently underway in the United States. The project is designed to extend the Massachusetts Turnpike (I-90) to Logan

TABLE 1
NONFUEL MINERAL PRODUCTION IN MASSACHUSETTS[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Gemstones		NA	$3	NA	$1	NA	$1
Sand and gravel:							
Construction	thousand short tons	e13,900	e57,000	12,774	51,466	e10,100	e39,400
Industrial	do.	34	601	30	401	30	401
Stone:							
Crushed	do.	11,880	67,768	e9,200	e54,500	7,131	51,362
Dimension	short tons	67,533	10,302	e56,254	e10,992	69,332	11,646
Combined value of clays (common), lime, and peat		XX	8,452	XX	10,138	XX	8,787
Total		XX	144,126	XX	127,498	XX	111,597

eEstimated. NA Not available. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Airport through a four-lane tunnel under Boston Harbor and then widening the six-lane Central Artery (I-93) to eight lanes and putting it underground as it passes through downtown. It is expected that the project will advertise more than $1 billion worth of construction work in fiscal year 1992, which began July 1, 1991, and create, in the same year, approximately 6,000 jobs. One-third of these jobs will be in construction.[5] This project should give both the State's construction and mineral-related industries a much needed boost.

Near yearend, Recontek Inc., a San Diego-based recycler of hazardous nonferrous metal wastes, was facing opposition in its efforts to build a metals recycling plant in Orange, about 40 miles northwest of Worcester. Two area environmental groups have asked the State's Hazardous Waste Facility Site Safety Council (SSC) to reconsider its previous decision granting Recontek "feasible and deserving" status for the proposed metals recycling facility. The proposed plant would be one of eight such plants Recontek plans to build in the United States to reclaim metals from waste discarded by companies in the electronics, metal finishing, and aerospace industries. The company, a subsidiary of PS Group Inc., uses a hydrometallurgical process that extracts metals from the wastes.[6]

A Massachusetts Institute of Technology (MIT) researcher has developed a process to yield high-quality metals, with just oxygen as its chief byproduct. The process, called pyroelectrolysis, superheats metal ores to temperatures as high as 1,700° C. The heat shatters the chemical bonds without the use of sulfur or chloride salts. According to the researcher, the process would save two-thirds of the energy consumed during titanium processing. However, some obstacles remain. For one thing, carbon is the key component of the electrodes used to heat some ores. Researchers are hopeful an advanced ceramic will be found to replace the carbon.[7]

To encourage State support for basic research in the mineral sciences and engineering, the U.S. Bureau of Mines awarded an allotment grant of $145,000 to MIT. The allotment was part of the mineral institute's program created by Public Law 98-409, The State Mining and Mineral Resources Research Institute Program Act. Additional monies were also provided for respirable dust research projects. Under stipulations of the act, the State of Massachusetts was required to match this grant on a 2:1 basis.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Abrasives (Manufactured).—Norton Co., the world's leading manufacturer of abrasives, produced nonmetallic abrasive products at its plant in Worcester. The company manufactured bonded and coated abrasives primarily used in the surface conditioning, cutting, shaping, and finishing of many types of materials. Primary end users included foundries and steel mills, metal fabricators, glass and ceramic grinders, stonecutters, and the construction industry.

Clays.—One company, in Plymouth County, mined common clay for the manufacture of common and face brick.

Graphite (Manufactured).—Two companies, both in Lowell, Middlesex County, produced high-modulus graphite fibers used primarily by the aerospace industry.

Gypsum (Calcined).—Crude gypsum, shipped into the State from company-owned mines in other States and Nova Scotia, was calcined by USG Corp. at Charlestown near Boston. The calcined gypsum was made into wallboard and shipped throughout New England primarily for use in residential construction.

Lime.—Two companies manufactured lime in Berkshire County from locally quarried limestone. Markets for the lime included western New York and New England.

During the year, Pfizer Inc. completed its $13 million upgrading and expansion at its lime plant in Adams. The project, which began in July 1991, represented the largest single corporate investment at the Adams plant since Pfizer took it over in 1961. Over the past 10 years, Pfizer has invested more than $30 million at the facility. Also during the year, the company purchased two tracts of land adjacent to the Adams plant. In January, the company purchased 274 acres for use as a buffer zone at its current operations and for potential expansion in the years ahead. In May, 95 additional acres was purchased. The company indicated that portions of the latter property could be used for storage of byproducts from its limestone mining operations.

Peat.—Reed-sedge peat was produced by Sterling Peat Inc., Worcester County, and was used primarily for agricultural purposes. All of the material was sold in packaged form.

Perlite (Expanded).—Crude perlite, mined in New Mexico, was expanded by Whittemore Perlite Co. Inc. at a plant in Suffolk County. The expanded perlite was used for insulation, plaster aggregate, and as a horticultural medium.

Sand and Gravel.—Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

In 1991, construction sand and gravel was the second leading mineral commodity produced in terms of value, accounting for 35% of the State's total mineral value. In 1991, the estimated production and value of construction sand and gravel declined, 21% and 23%, respectively, from 1990 levels. The average unit value declined 12 cents from $4.02 f.o.b. in 1990 to $3.90 f.o.b. in 1991. More than 100 companies mined

TABLE 2

MASSACHUSETTS: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch): Riprap and jelly stone[2]	55	335	$6.09
Coarse aggregate, graded:			
Concrete aggregate, coarse	209	1,379	6.60
Bituminous aggregate, coarse	1,249	9,057	7.25
Bituminous surface-treatment aggregate	407	3,815	9.37
Railroad ballast	W	W	7.44
Fine aggregate (-3/8 inch):			
Stone sand, concrete	97	480	4.94
Stone sand, bituminous mix or seal	251	1,815	7.23
Screening, undesignated	87	630	7.24
Coarse and fine aggregates:			
Graded road base or subbase	57	383	6.72
Unpaved road surfacing	W	W	5.71
Terrazzo and exposed aggregate	W	W	1.17
Crusher run or fill or waste	69	563	8.15
Other construction materials[3]	380	6,319	16.63
Other miscellaneous uses[4]	1,537	13,853	9.01
Unspecified:[5]			
Actual	2,195	9,948	4.53
Estimated	538	2,784	5.17
Total	7,131	[6]51,362	7.20

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes dolomite, granite, limestone, miscellaneous stone, and traprock.
[2]Includes macadam and filter stone.
[3]Includes withheld amounts for coarse aggregate, graded, coarse and fine aggregates, and building products.
[4]Includes agricultural limestone, poultry grit and mineral food, lime manufacture, and other fillers or extenders.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.
[6]Data do not add to total shown because of independent rounding.

construction sand and gravel in 13 of the State's counties. There was no reported production for Suffolk County. Leading counties, in order of output, were Middlesex, Worcester, Norfolk, Bristol, and Hampden. The material was used mainly for concrete aggregate, road base and coverings, and fill.

In December, the Tyngsborough Board of Selectmen voted to reject a request from the V. H. Shea Corp. to expand its gravel and rock quarrying operations at the firm's 128-acre parcel in Groton. The board's vote against the permits ended a 6-month dispute between neighbors in the area and the Shea Corp. Although Shea has been operating at the site since 1967, a new zoning bylaw in 1987 changed the site from industrial to residential, which means mining cannot be performed on the property. The Shea Corp. is planning to take its case to court.

Industrial.—One company, Whitehead Bros. Co., Plymouth County, produced industrial sand primarily for use in molding and coremaking and in sandblasting.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Massachusetts crushed stone statistics are compiled by geographical districts as depicted in the State map. Table 3 presents end-use statistics for Massachusett's three districts.

Crushed.—Crushed stone was the State's leading mineral commodity, accounting for 46% of the State's total value. In 1991, production and value decreased 22% and 6%, respectively, from the estimated 1990 figures. In terms of output, 1991 production was almost 60% lower than the alltime high output of 17.5 million short tons produced in 1988. The 1991 output was close to the level of production in 1980.

A total of 16 companies operated 26 quarries in 9 counties. Leading counties, in order of output, were Berkshire, Middlesex, Hampden, and Bristol. Traprock (basalt) was mined at 17 quarries. These accounted for the majority of the stone produced. This was followed by granite (five quarries) and limestone (two quarries). Major uses for traprock and granite were for road

TABLE 3

MASSACHUSETTS: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	—	—	—	—	55	335
Coarse aggregates, graded[2]	—	—	W	W	W	W
Fine aggregates (-3/8 inch)[3]	W	W	W	W	364	2,612
Coarse and fine aggregates[4]	W	W	W	W	124	900
Other construction materials	226	5,539	518	2,432	1,992	16,177
Agricultural[5]	(6)	(6)	—	—	W	W
Chemical and metallurgical[7]	(6)	(6)	—	—	—	—
Special[8]	(6)	(6)	—	—	—	—
Other miscellaneous uses	1,119	10,635	—	—	—	—
Unspecified:[9]						
Actual	1,366	5,293	—	—	829	4,655
Estimated	—	—	173	1,118	365	1,666
Total[10]	2,711	21,467	692	3,550	3,728	26,345

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap and jetty stone, and filter stone.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[4]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run (select material or fill), and building products.
[5]Includes agricultural limestone and poultry grit and mineral food.
[6]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[7]Includes lime manufacture.
[8]Includes other fillers or extenders.
[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[10]Data may add not add to totals shown because of independent rounding.

TABLE 4

MASSACHUSETTS: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	2	W	W	$11.16	2	W	W	$12.01
Dolomite	1	W	W	1.13	1	W	W	12.16
Granite	5	2,812	$19,171	6.82	5	2,197	$17,464	7.95
Traprock	18	7,567	37,317	4.93	17	3,575	17,663	4.94
Sandstone	1	W	W	5.30	—	—	—	—
Miscellaneous stone	1	W	W	5.30	1	W	W	4.77
Total[1]	XX	10,379	67,768	6.53	XX	7,131	51,362	7.20

W Withheld to avoid disclosing company proprietary data, included with "Total." XX Not applicable.
[1]Data do not add to total shown because of independent rounding.

construction and concrete aggregate. Major limestone uses were for lime and cement manufacturing and as other fillers.

The town of Rockport, Essex County, was considering an option to pump water from two town-owned quarries to supplement the town's water supply. The State had imposed restrictions on the town's use of water after several years of short supply. Although the project was expected to be costly, the only alternative would be to build a dam estimated to cost more than $8 million. The dam project has been discussed and studied for the past two decades. The town's water supply committee hopes to postpone the dam building project until the year 2010. Through use of the quarries' water, the town expects that it would be able to supply sufficient water until that date.[8]

Dimension.—Massachusetts ranked fifth of the 34 States that reported dimension stone production. Dimension granite, used primarily for curbing, was quarried in Berkshire, Middlesex, and Plymouth Counties. Dimension marble was also quarried in Berkshire County and sold as rough blocks.

Vermiculite (Exfoliated).—W. R. Grace & Co. exfoliated imported vermiculite at its Easthampton plant in Hampshire County. Major uses were for insulation and for concrete and plaster aggregates.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related experience and has covered the mineral activities in Massachusetts for 7 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]State Geologist, Executive Office of Environmental Affairs, Boston, MA.

[3]Mining engineering. Industrial Minerals 1991, June 1992, p. 553.

[4]"Average number of workers" is a summary of the average number of persons working at individual mining establishments during periods (not necessarily continuous) of active operations.

[5]ConnStruction. The "Big Dig": Boston's Central Artery Project. V. 30, Issue 2, Summer 1991, pp. 10-11.

[6]American Metal Market. Recontek Construction of Massachusetts Plant Facing Opposition of 2 Groups. V. 99, No. 244, Dec. 20, 1991, p. 5.

[7]Business Week. Making Metal Without Making An Awful Mess. No. 3202, Mar. 11, 1991, p. 93.

[8]Gloucester Daily Times. Use of Quarries May Put Dam Project On Hold. Oct. 9, 1991, p. 17.

MASSACHUSETTS

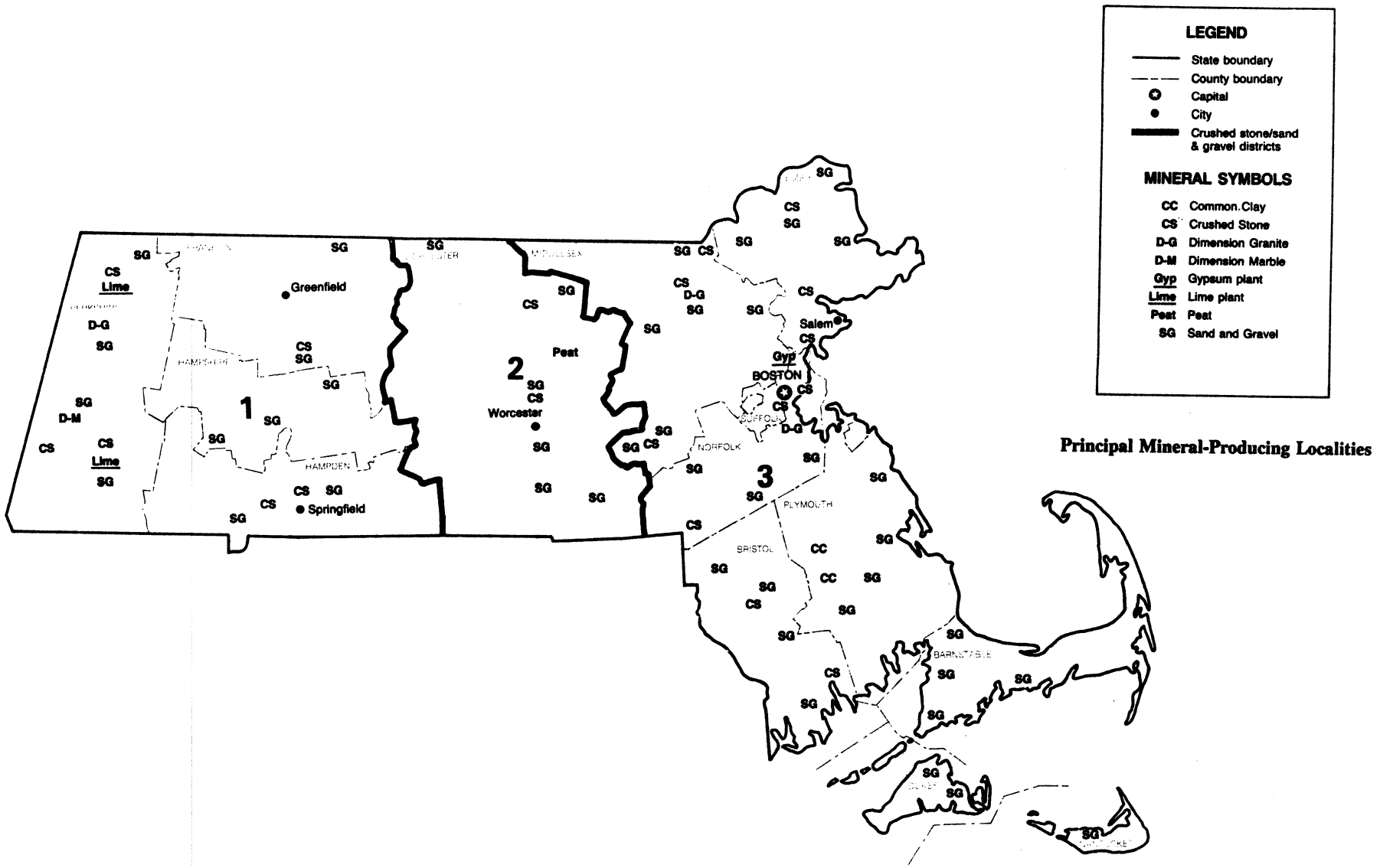


TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Abrasives (manufactured):			
Norton Co.	Box 15008 Worcester, MA 01615-0008	Plant	Worcester.
Clays:			
Stiles & Hart Brick Co.	Box 367 Bridgewater, MA 02324	Pit	Plymouth.
Graphite (synthetic):			
The Stackpole Fibers Co., Inc.	Foundry Industrial Park Lowell, MA 01852	Pit	Middlesex.
Textron Corp., Avco Specialty Materials Div.	1275 King St. Box 9000 Greenwich, CT 06836	Plant	Do.
Gypsum (calcined):			
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Suffolk.
Lime:			
Lee Lime Corp.[1]	Marble St. Lee, MA 01238	Plant and quarry	Berkshire.
Pfizer Inc.[1]	260 Columbia St. Adams, MA 01220	do.	Do.
Peat:			
Sterling Peat Inc.	64 Greenland Rd. Sterling, MA 01564	Bog	Worcester.
Perlite:			
Whittemore Perlite Co. Inc.	30 Glen St. Lawrence, MA 01843	Plant	Essex.
Sand and gravel (1990):			
Construction:			
Berkshire Concrete Co.	465 Chesire Rd. Pittsfield, MA 01201	Pits	Berkshire.
Emaral Corp.	Box 173 Millbury, MA 01527	Pit	Hampden, Middlesex, Worcester.
A. Graziano Inc.	71 Adams St. Braintree, MA 02184	Pit	Norfolk.
Heffron Materials	Box 176, 68 Winter St. Reading, MA 08164	Pit	Middlesex.
P. A. Landers Inc.	Box FF Hanover, MA 02339	Pit	Plymouth.
S. M. Lorusso & Sons Inc.	230 West St. Walpole, MA 02081	Pit	Norfolk.
Industrial:			
Whitehead Bros. Co. Inc.	Box 259, River Rd. Leesburg, NJ 08327	Pit	Do.
Stone:			
Crushed:			
Keating Materials Corp.	2140 Bridge St. Dracut, MA 01826	Quarries	Middlesex and Worcester.
John S. Lane & Son Inc.	730 East Mountain Rd. Westfield, MA 01085	do.	Berkshire, Hampden, Hampshire.
S. M. Lorusso & Sons Inc.	331 West St. Walpole, MA 02081	do.	Middlesex, Norfolk, Suffolk.

See footnotes at end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone—Continued:			
Crushed—Continued:			
Simeone Corp.	1185 Turnpike St. Stoughton, MA 02072	Quarries	Bristol and Norfolk.
Tilcon Inc.	Box 114 Acushnet, MA 02743	Quarry	Bristol.
Trimount Bituminous Products Co.	1935 Revere Beach Parkway Everett, MA 02149	Quarries	Essex.
Dimension:			
Fletcher Granite Co.	Groton Rd. West Chelmsford, MA 01863	Quarry	Middlesex.
LeMasurier Granite Quarry Inc.	Box 71, Ledge Rd. North Chelmsford, MA 01863	do.	Do.
Williams Stone Co. Inc.	Box 278 East Otis, MA 01029	do.	Berkshire.
Vermiculite (exfoliated):			
W. R. Grace & Co.	62-T Whittemore Ave. Cambridge, MA 02140	Plant	Hampshire.

[1]Also stone.

THE MINERAL INDUSTRY OF MICHIGAN

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Geological Survey Division, Michigan Department of Natural Resources, for collecting information on all nonfuel minerals.

By Robert H. Wood II[1] and Milton A. Gere, Jr.[2]

Michigan's 1991 nonfuel mineral production was valued at $1.5 billion, a 5% increase from the value established in 1990. Total value increases were reported for sales of clays, gypsum, lime, magnesium compounds, peat, salt, crushed stone, dimension stone, copper, iron ore, and iron oxide pigments. Total value decreases were reported for the sales of calcium chloride, cement, gemstones, industrial sand and gravel, iron and steel slag, potash, silver, and sulfur. Quantity produced decreased in nearly all of the mineral commodities except clays, copper, crude iron oxide pigments, dimension stone, iron ore, and sulfur. Substantial gains in estimated usable iron ore production, the largest contributor, accounted for most of the State's increase.

Michigan ranked fourth among all States in value of nonfuel minerals produced. The State had ranked eighth in 1990 because of the soft iron ore market and the 4-month strike in the State's iron mines. Michigan accounted for more than 4% of the Nation's nonfuel mineral value in 1991. It continued to be the leading producer of calcium chloride, crude iron oxide pigments, magnesium compounds, and peat; it ranked second in production of portland cement and iron ore and third in salt and industrial sand. Industrial minerals provided about two-thirds of the State's nonfuel mineral value.

EMPLOYMENT

The Michigan Employment Security Commission, Bureau of Research & Statistics, reported that Michigan's labor force totaled 4.54 million, slightly lower from that of 1990. The State's unemployment rate rose from 7.5% to 9.2%. A rate of 10.4%, compared with 8.9% in 1990, was posted in the Upper Peninsula where mining is an important occupation.

TABLE 1
NONFUEL MINERAL PRODUCTION IN MICHIGAN[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	255	$22,286	272	$23,880	e225	e$22,440
Portland	do.	5,449	253,324	5,906	263,607	e4,935	e222,075
Clays	metric tons	1,249,198	4,599	1,201,542	4,094	2,061,861	8,770
Gemstones		NA	10	NA	11	NA	10
Gypsum (crude)	thousand short tons	2,089	15,589	2,000	11,511	1,721	13,052
Iron ore (usable)	thousand metric tons	15,045	W	10,034	W	e12,741	W
Lime	thousand short tons	621	32,479	622	30,898	613	30,959
Peat	do.	286	6,082	280	6,264	249	6,442
Sand and gravel:							
Construction	do.	e48,000	e132,000	53,729	153,057	e44,800	e132,200
Industrial	do.	2,865	24,577	2,310	19,285	2,093	18,464
Stone (crushed)	do.	40,905	123,678	e43,100	e129,000	40,989	129,490
Combined value of calcium chloride (natural), copper, gold (1989), iron oxide pigments (crude), magnesium compounds, potash, salt, silver, stone (dimension), and values indicated by symbol W		XX	984,347	XX	796,516	XX	919,366
Total		XX	1,598,971	XX	1,438,123	XX	1,503,268

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Statewide, an average of 9,000 persons were engaged in mining, the same as that reported in 1990. Mining employment in the Upper Peninsula totaled 3,400 persons.

Average hourly pay for Michigan miners, including nonmetallic mining and oil and gas production industries, was $13.72, compared with $13.42 in 1990, and slightly lower than the average hourly pay of $14.18 reported for miners in the entire United States.[3]

REGULATORY ISSUES

The U.S. Environmental Protection Agency (EPA) continued studies of the Torch Lake Superfund site on the Keweenaw Peninsula in Houghton County. In October, EPA approved a contamination study of the copper tailings in Torch Lake and on the shoreline. The results of the study showed that the risk to public health posed by the contaminants is within the range generally acceptable to EPA. Nevertheless, EPA continued evaluating cleanup options to further reduce potential health risks and expected to propose a cleanup plan early next year. Another aspect of the Superfund program involved collecting and sampling the contents of 55-gallon drums found in the lake near Lake Linden, Torch Lake, and the shoreline. Results of the study have not been released. Torch Lake was added to the Superfund list in 1986 after large numbers of fish reportedly had tumors. It may never be determined if the elevated levels of arsenic, chromium, copper, lead, nickel, and zinc are naturally occurring or caused by the copper industry, which has used the lake as a depository for mining and milling wastes for about 125 years.

Detroit Coke Co. closed its Delray area and Jefferson Street coke plants in September following pressure from State and county agencies, as well as EPA. The company was being fined $5,000 per day by the Wayne County Air Pollution Control Commission since missing an August 1 deadline for installing smokestack pollution equipment. Detroit Coke was a major supplier to National Steel's Great Lakes division in Ecorse.

EXPLORATION ACTIVITIES

In May, the Michigan Department of Natural Resources (DNR), through its Real Estate Div., conducted its annual metallic minerals lease sale, offering 91,925 acres of State-owned land in Delta, Dickinson, Iron, Marquette, and Menominee Counties. Bids on 15,951 acres were received. Successful bidders were Callahan Mining Corp. (7,364 acres), Crystal Exploration Inc. (5,198 acres), Exmin Corp. (1,018 acres), BHP-Utah International (868 acres), Alexander Fagotti (840 acres), Peter Hayes (423 acres), and Jack Everett (160 acres). Bonus bids totaled $34,299.21. The highest bid per acre was $13.00 and the lowest was $1.00, with an average bid of $2.15 per acre. The combination of bonus bids and first-year rental payments ($3 per acre) were expected to produce $82,152.21 in revenue for the Michigan Natural Resources Trust Fund. Most of the 15,951 acres covered by the bids was in Dickinson County (6,400 acres); other counties involved were Iron (3,594 acres), Marquette (2,251 acres), and Menominee (3,706 acres). None of the Delta County acreage offered in the sale was leased. Statewide, lease sale results were up considerably from those of 1990, when there were only three successful bidders, 4,838 acres leased, bonuses of $9,063.58, and first-year revenues of $23,577.58.

Copper, diamonds, and gold were the primary targets of exploration programs continuing in the Upper Peninsula. The DNR reported that 8 companies performed exploratory drilling of 62 holes on State and private mineral leases in the Upper Peninsula, totaling approximately 7,963 feet, considerably less than the 18,400 feet drilled in 1990.

Callahan Mining Corp. commenced sale of assets associated with its Ropes underground gold mine (closed 1989) in Marquette County. The company continued to pursue an exploration program for gold and other minerals in the Upper Peninsula through joint ventures funded by Western Mining Corp. (U.S.A.). Western, a subsidiary of Western Mining Corp. Ltd. of Australia, can earn up to 50% of Callahan's interest in the properties included under each venture managed by Callahan. One venture involved drilling on the Silver Creek property within the Marquette County greenstone belt. Another involved property acquisition and exploration 100 miles southwest of Marquette. Callahan also will manage gold exploration on leases obtained on the Champion Iron Mine property near Champion, in Marquette County.

Crystal Exploration Inc., a wholly owned subsidiary of the Australian company Crystal Mining NL, continued its diamond exploration program in Michigan's Upper Peninsula. Crystal Exploration has expended more than $2 million in search of diamonds and has reported finding 10 kimberlite pipes between Iron Mountain and Marquette.

Great Lakes Minerals, of Toronto, Ontario, Canada, acquired the right to purchase all the shares of Keweenaw Copper Co. Inc., owners of 50% interest in Michigan Mining & Manufacturing and Michigan Copper, in exchange for 550,000 shares of Great Lakes. Michigan Mining holds the Lake Superior Land Co. mineral lease that contains the 543-S chalcocite copper deposit as well as several properties with reportedly excellent exploration potential. Mining was scheduled to begin next year on the 543-S deposit near Gratiot Lake in Keweenaw County. About 40 jobs were expected to be created from the 300- to 500-ton-per-day operation. The 543-S deposit hosts probable reserves of 3 million short tons of 2.9% copper and 1.3 million short tons of 4% copper at depths ranging up to 500 feet below the surface.

Great Lakes Minerals announced an option and joint venture with Wheaton River Minerals (Canada) to explore its G-2 depository that reportedly contains 454,000 tons of 3.49% copper in the form of chalcocite.

Late in the year, Noranda Exploration Inc. (Canada) and Great Lakes Minerals announced an agreement where Noranda

agreed to spend $4 million over 4 years to explore almost 42,000 acres of Great Lakes Minerals' leased lands in the Keweenaw Peninsula. Noranda will end up with a 60% interest in the lands included in the agreement. The 543-S project, the G-2 area, and several others are excluded from this agreement.

Exploration for oil and gas continued in the Michigan Basin in the Lower Peninsula. There were 1,213 drilling permits issued for oil and gas wells. By yearend, 632 holes were drilled, resulting in 506 gas wells, 30 oil wells, and 96 dry holes. The Antrim gas play accounted for 493 of the gas wells drilled.

LEGISLATION AND GOVERNMENT PROGRAMS

Final rules were approved by the State to implement the 1988 Michigan Mining and Resources Development Act (Act 188). This legislation will allow for grants and loans to be made for projects involving new technologies, products, etc., that will aid the State's forest and mineral resource industries.

In March, U.S. Geological Survey representatives presented the Geological Survey Division, Michigan DNR, a framed copy of the "final" topographic map of the State at the Second Symposium on Michigan Geology. Topographic mapping, which began in 1902, was completed in Michigan in 1990, creating about 1,250, 7.5-minute quadrangles. Topographic maps form the base for geologic maps that are valuable tools for use in mineral exploration.

Central Michigan University's geology department, Mount Pleasant, received a $105,254 grant from the Michigan Research Excellence Fund to investigate the potential for mining precious metals in parts of Dickinson and Iron Counties. Faculty and students were in the process of making detailed geologic, geochemical, and geophysical maps. Efforts have been concentrated in the Peavy Pond area in Iron County where studies have found fairly high concentrations of cobalt and nickel. A mining industry oversight team was scheduled for May 1992 to determine whether mining would be economically feasible.

A researcher at Michigan Technological University (MTU) was studying more efficient ways to remove dissolved heavy metals from industrial wastes under an $82,300 grant from the U.S. Bureau of Mines Generic Minerals Technology program. Under the 2-year project, it was planned to test column flotation techniques and reagents to recover valuable minerals that are lost using current wastewater treatment methods that rely on filtration and settling.

The DNR, Geological Survey Division (GSD), maintained its Geological Core and Sample Repository at Marquette. This "rock library" contained drill core and cuttings from throughout most of the State, with the greater part of the collection originating from mineral exploration drilling in the western part of the Upper Peninsula. By appointment, the materials were open to public use for geological research by industry, government, and academia. Additions during 1991 included core from 43 drill holes consisting of 1,545 boxes of core representing about 14,367 feet of drilling from 10 counties. Two additional cuttings libraries are maintained by GSD. Cuttings from hundreds of selected oil and gas wells were maintained by the Subsurface and Petroleum Geology Unit in Lansing. Water well cuttings from selected Upper Peninsula water wells were maintained by GSD at DNR's Escanaba District Office. Records for thousands of oil and gas wells and logs for water wells in Michigan were maintained in GSD's Lansing office. Copies of all Upper Peninsula water well logs also were maintained at the Escanaba District Office.

The Gerald E. Eddy Geology Center, in the Waterloo State Recreation Area in Washtenaw County, continued to be a cooperative effort of DNR's Geological Survey and Parks Divisions. The center has interpretative displays featuring the geology and mineral resources of the State and hiking trails that offer an explanation of the geology in the immediate area.

The U.S. Forest Service announced in December that a "seed money" grant for a building stone initiative was given to a Michigan group. This was part of the Forest Service's Rural Development Program, "...for field projects designed to foster rural economic diversification opportunities presented by building stone." The Ottawa National Forest team, which received the grant, consisted of four members, one each from the Ottawa National Forest, Ironwood, MI; the Forest Service Northeastern Area, State and Private Forest Office, St. Paul, MN; the Department of Mining Engineering, MTU; and the GSD. The grant would be used at MTU to help identify and delineate rock deposits with a potential to be developed into sources of building stone. This renewed activity by MTU was started in the early 1970's to encourage a building stone industry and create more jobs in Michigan.

Michigan's abundant graphitic slate deposits continued to be investigated for commercial utilization. The Mineral Technology Research Group, Department of Mining Engineering, MTU, led the process of evaluating the slate resources and the laboratory studies to beneficiate the materials. The work was sponsored by several companies and GSD. Studies show the graphitic slate could be used as a substitute for shale in the manufacturing of portland cement.

In another study of graphitic slate, PelleTech Corp., Negaunee, performed a laboratory-scale experiment that reportedly made silicon carbide by a cupola firing of pellets made of Michigan graphitic slate. The silicarb produced could be used in steelmaking and other metallurgical processes.

MTU received a Michigan Research Excellence Fund grant to study the use of bioleaching to remove phosphorus from Michigan iron ore. This study may lead to increasing Michigan's iron ore reserves, which could promote job preservation and possible expansion of the iron ore industry.

Members of MTU's Department of Geological Engineering, Geology and Geophysics, continued the Ishpeming Greenstone Belt mapping project started

several years earlier. The 1991 phase included the mapping of the Negaunee N.W. Quadrangle and was sponsored in part by USGS and the Michigan GSD. Additionally, a study of thermal modeling of the Midcontinent Rift System and the related copper deposits was begun. This research was sponsored by the Petroleum Research Fund of the American Chemical Society.

The Upper Peninsula Chapter, Society of Mining, Metallurgy and Exploration Inc. of American Institute of Mining Engineers (AIME), approved and initiated the MINE Fund. This fund would provide loan-scholarships to students in mineral-related areas at MTU and was intended to attract and keep students in the mineral-related programs.

The A.E. Seaman Mineralogical Museum at MTU, Houghton, continued to perform mineral education outreach activities by providing mineral displays at several major rock and mineral hobby shows throughout the United States. The museum is internationally known for its fine displays. In 1990, both houses of the State legislature gave the museum the official title "The Mineralogical Museum of Michigan."

FUELS

According to the Independent Petroleum Association of America, Michigan ranked 16th in crude oil and 10th in natural gas production in 1991. The State produced 17,652,162 barrels of oil (42 gallons each) and 189,496 million cubic feet of gas.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Bromine.—Michigan and Arkansas were the only two States producing bromine in 1991. In Michigan, bromine-enriched brines occur in the Devonian Sylvania Formation. Small amounts of unpurified bromine were produced as a byproduct from Dow Chemical Co.'s well brine operation near Ludington, Mason County. All of Michigan's unpurified bromine product was reprocessed in Arkansas before being used or sold to consumers.

Calcium Chloride.—Michigan continued to lead the Nation in calcium chloride production, far outranking California, the only other producing State. Output and value declined only slightly from 1990 levels. Dow Chemical Co. produced calcium chloride pellets and flake at its well brine operation near Ludington, Mason County, and Wilkinson Chemical Corp. marketed calcium chloride solution from its operation in Lapeer County. Calcium chloride was used for melting snow and ice from streets and highways, for dust control, road base stabilization, thawing coal and other bulk materials, concrete set acceleration, and other miscellaneous uses.

Cement.—Portland and masonry cement sales declined an estimated 16% and 6%, respectively, over those of 1990. Estimated quantities of portland and masonry cement produced also declined from previous years' reported amounts by 16% and 17%, respectively. Michigan increased to second rank among the 38 States producing portland cement, but slipped to fifth among the 33 masonry-cement-producing States. Among the nonfuel minerals produced in Michigan in 1991, only iron ore contributed more to the total State value of mineral production. The estimated average price of Michigan's portland cement was $45 per short ton and masonry cement was about $100 per short ton.

Michigan had five cement plants. Lafarge Corp. and Medusa Cement Co. operated dry-process plants; Holnam Inc. and St. Mary's Peerless Cement Co. operated wet-process plants; and Essroc Materials Inc. (formerly Aetna Cement Corp.) operated a grinding plant only. Gray portland cement was produced at each of the plants. Holnam was the only company not producing masonry cement; however, the company was the only producer of portland pozzolan cement.

Lafarge commissioned a new grinding-system modernization and signed a $2.4 million agreement with GE Power Generation to modify a steam turbine for its Alpena plant. The new grinding system replaced six ball mills with three that will produce a total of 425 tons of cement per hour. A proposed heat recovery boiler, attached to Lafarge's cement kiln, will power the steam turbine. The project was expected to be completed early next year.

Holnam began a $5 million office expansion in Dundee Township. Expansion and renovation became necessary when Dundee Cement Co. and Ideal Basic Industries of Denver were merged into Holnam Inc., and Northwestern States Portland Cement Co. and United Cement Co. were acquired.

Clays.—Michigan ranked fourth in common clay output among the 43 producing States, surpassing production reported in Alabama, California, and Georgia. Production and attendant value increased about 72% and 114%, respectively, compared with 1990 figures. Clay was produced by five companies from five pits in four counties. Most of the tonnage was captive production by cement companies; the remainder was for use in pottery and brick manufacture. Michigan hosted the largest manufacture of clay pots in the United States (about 44 million last year), F.W. Ritter and Sons, of South Rockwood in southern Wayne County. A year's production required clay extraction from only 1 to 2 acres of land from the 280-acre former farmland purchased by the company.

Gemstones.—The value of gemstones and mineral specimens collected by mineral dealers, rockhounds, and other hobbyists was estimated to have decreased 9% in 1991. Gemstones and mineral specimens common to Michigan include agates, ankerite, chlorastrolite, domeykite, jasper, laumontite, native copper, Petoskey stones (fossilized coral), prehnite, Kona dolomite, and various iron minerals. Lake Superior beaches, old mine dumps, and gravel pits are

commonly the sources of materials collected.

Crystal Exploration Inc. continued into the fourth year on its diamond exploration program in Michigan's Upper Peninsula. In May, the company purchased 14 more State mineral leases (5,198 acres) to continue exploration. Crystal Exploration Inc. has found about 10 kimberlite pipes between Iron Mountain and Marquette and spent more than $2 million in search of diamonds. Small diamonds have been found in some of the kimberlite pipes. Exmin Corp. maintained some exploration leases in Michigan also.

Gypsum.—Output of crude gypsum decreased by 14%; however, an increase in the average price resulted in a 13% raise in total value. Lower gypsum production dropped Michigan into fourth place, below Indiana, among the 20 producing States. The State has two important gypsum-producing areas. Domtar Gypsum Inc. and Georgia-Pacific Corp. operated underground mines near Grand Rapids in Kent County, and Michigan Gypsum Co., Lafarge Corp., and USG Corp. operated open pit mines in Iosco County.

Domtar Gypsum, Georgia-Pacific, and Lafarge all operated calcining plants at or near the mine sites. Gypsum rock from USG's Alabaster Mine in Iosco County was calcined at its Detroit plant in Wayne County or shipped to other States for processing. Calcined production from the four plants totaled about 653,000 short tons valued at about $12.4 million, placing Michigan ninth among the 28 States where calcining plants operated. Gypsum is commonly used in cement, wallboard, and other building products in addition to use as agricultural fertilizer, in dental castings and toothpaste, and as a filler in food products, glass, and plastics.

Lime.—Michigan ranked 10th of 32 States in lime production. Output dropped slightly, 0.2%, from that of 1990, but total value increased about 1.4%. Five companies reported production of quicklime from eight plants in seven counties. Wayne County led the State's lime production. Marblehead Lime Co. produced both quicklime and hydrated lime. Lime was used in steelmaking, sugar refining, and water treatment.

Western Lime & Cement Co. decided against construction of a lime plant in Gladstone. Although economic conditions related to changes in the market for its product were stated as the reasons for not proceeding, Gladstone residents had intensely protested the proposed plant.

Magnesium Compounds.—Michigan continued to lead the Nation in production of magnesium compounds, far outranking California, the next largest producer among the six producing States. A small increase in total value helped offset the slight decline in total output reported in 1990. Three companies produced magnesium compounds from well brines in Manistee and Mason Counties in the west-central part of the State. Compounds produced included caustic-calcined magnesia, magnesium carbonate, magnesium hydroxide, and refractory magnesia.

Peat.—Michigan again led the Nation in peat sales, ranking first among 19 producing States in 1991 and supplying almost one-third of the U.S. total. Eleven companies sold 249,000 short tons of peat from bogs in 10 counties. Although the production declined about 11% from the 1990 level, an increase in value resulted in a 3% growth in total sales value. Most of the U.S. producer sales were for general soil improvement and horticulture use. Peat was used for turf maintenance and greens construction at golf courses, as an ingredient in potting soils, for mushroom beds, for vegetable growing, as an earthworm culture, and by nurseries. Reed-sedge was the predominant type of peat harvested, followed by humus and sphagnum.

Perlite (Expanded).—Michigan ranked 14th among the 33 States that expanded perlite. Crude perlite from Harborlite Corp.'s mine in Arizona was expanded at the company's Vicksburg plant in Kalamazoo County. Although the production decreased about 8% from the 1990 level, an increase in value resulted in a 2% growth in total sales value. The expanded product was marketed for use in filter aids.

Potassium Salts.—For the second full year, Kalium Chemicals Ltd. operated its Hersey pilot plant facility in southwestern Osceola County. Total output declined slightly from that of 1990. Potash was produced by solution mining of a 2,400-meter-deep ore body. The 36,000-metric-ton-per-year test facility was constructed to demonstrate a technical ability to extract and refine potash from the Michigan Basin.

Salt.—Michigan ranked third among 10 producing States. Sales decreased about 3% in quantity and increased 3% in value. Salt was solution-mined by Akzo Salt Inc. in Manistee and St. Clair Counties and by Morton International Inc. in Manistee County. Salt was recovered from the brines using a vacuum pan process. Morton International Inc. has completed four new wells in the past 2 years, and Akzo Salt Inc. was completing work on two new wells in Manistee County. Salt was sold for a variety of uses, including animal feed, chemical-industrial processing, highway deicing, human consumption, and water treatment.

Sand and Gravel.—Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1990 and estimates for 1989 and 1991.

Tonnage and value of construction sand and gravel produced in 1991 was estimated to have decreased 17% and 14%, respectively, from 1990's reported figures. Construction sand and gravel accounted for about 9% of the State's nonfuel mineral value; only iron ore and portland cement contributed more.

TABLE 2
MICHIGAN: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	W	W	2.23
Riprap and jetty stone	206	1,182	5.74
Filter stone	246	1,014	4.12
Coarse aggregate, graded:			
Concrete aggregate, coarse	2,256	8,569	3.80
Bituminous aggregate, coarse	1,381	5,693	4.12
Railroad ballast	133	611	4.60
Fine aggregate (-3/8 inch):			
Stone sand, concrete	230	614	2.67
Stone sand, bituminous mix or seal	207	362	1.75
Screening, undesignated	111	375	3.38
Coarse and fine aggregates:			
Graded road base or subbase	3,536	12,087	3.42
Unpaved road surfacing	841	3,614	4.30
Crusher run or fill or waste	16	133	8.31
Other construction materials[2]	50	225	4.50
Agricultural: Agricultural limestone[3]	159	923	5.81
Chemical and metallurgical:			
Cement manufacture	5,810	10,915	1.88
Lime manufacture	W	W	3.88
Flux stone	1,906	7,362	3.86
Special: Other fillers or extenders	W	W	1.50
Other miscellaneous uses[4]	3,411	11,516	3.38
Unspecified:[5]			
Actual	19,836	62,767	3.16
Estimated	654	1,528	2.34
Total	40,989	129,489	3.16

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes dolomite, limestone, marble, marl, miscellaneous stone, sandstone, and traprock.
[2]Includes withheld amounts for coarse aggregate (+1 inch).
[3]Includes poultry grit and mineral food, and other agricultural uses.
[4]Includes withheld amounts for chemical and metallurgical, and special.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.

Industrial.—Michigan ranked third behind California and Illinois among 37 States with reported industrial sand and gravel production. Production continued on its downward slide to the lowest level in many years, down 9% in quantity and 4% in value compared with 1990 figures. Coastal dunes along Lake Michigan were the main source of the industrial sand. Seven companies reported output from 14 operations in 11 counties. Each of the companies sold sand for foundry applications, a use that consumed most of the production. The remainder was sold for glassmaking, fiberglass manufacture, sandblasting, refractories, traction sand, and other miscellaneous uses. The leading counties, in terms of value, of production were Muskegon, Van Buren, Ottawa, Wayne, and Wexford.

Slag, Iron and Steel.—Michigan ranked fourth among 28 States processing iron and steel slag in 1991. Only Ohio, Pennsylvania, and Indiana, respectively, reported greater sales. Two companies processed iron and steel slag from steel mills in Wayne County and electric arc furnaces in Jackson and Monroe Counties. The material was marketed mainly for road base material, with lesser amounts for a variety of other uses. Sales decreased 13% in quantity and 19% in value.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1990 and actual data for 1989 and 1991. Table 4 provides production and end-use data for crushed stone from each of the State's three districts depicted in the State map.

Crushed.—Total output of crushed stone decreased about 5% to 41 million short tons in 1991, nearly the same as that in 1989. Attendant value showed a small increase, slightly over the record high of $129 million estimated in 1990. Limestone-dolomite constituted most of the crushed stone sales, with marl, sandstone, traprock, marble, and quartzite accounting for virtually all of the remainder. Michigan ranked 13th among the 49 states producing crushed stone from 38 quarries, some of which are among the Nation's largest.

Pfizer Specialty Minerals Inc., a subsidiary of Pfizer Inc., bought and planned to reopen the Port Inland Limestone quarry at Gulliver in Schoolcraft County. Formally operated by Inland Lime & Stone Co., the quarry became idle in December 1989 after almost 60 years of operation. Its closure was related to union workers' refusal to vote on a contract proposal from St. Mary's Cement Co. of Ontario, which wanted to buy the operation. The new owners have rebuilt the plant and planned to resume full operations by April 1992. Due to the automated equipment being installed by Pfizer, the new plant will require just one-third of the 190 formerly employed by Inland.

Monroe Township continued fighting the France Stone Co. request for rezoning of 200 acres in that township from

TABLE 3

MICHIGAN: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	W	W	W	W	238	1,349
Coarse aggregates, graded[2]	W	W	W	W	1,723	8,489
Fine aggregates (-3/8 inch)[3]	W	W	W	W	261	629
Coarse and fine aggregates[4]	61	179	1,545	4,253	2,788	11,401
Other construction materials	559	1,432	2,009	6,566	30	180
Agricultural[5]	(6)	(6)	—	—	(6)	(6)
Chemical and metallurgical[7]	(6)	(6)	8,290	21,752	(6)	(6)
Special[8]	—	—	—	—	(6)	(6)
Other miscellaneous uses	908	3,235	—	—	2,088	5,728
Unspecified:[9]						
Actual	3,228	11,252	16,261	49,777	346	1,738
Estimated	314	345	—	—	340	1,183
Total[10]	5,070	16,444	28,105	82,348	7,815	30,697

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap and jetty stone, and filter stone.
[2]Includes concrete aggregate, coarse, bituminous aggregate, coarse, and railroad ballast.
[3]Includes stone sand, concrete, stone sand, bituminous mix or seal, and screening, undesignated.
[4]Includes graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[5]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[6]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[7]Includes cement manufacture, lime manufacture, and flux stone.
[8]Includes other fillers or extenders.
[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[10]Data may not add to totals shown because of independent rounding.

agricultural to heavy industrial as a preliminary step in opening a new limestone quarry. Cost of the quarry suit, more than $100,000 in legal fees this year, will be recovered by an increase in the tax rate. The case was expected to go to trial in May 1992.

Holnam Inc. entered into an agreement with the three townships (Milan, London, and Holnam) surrounding its Holnam cement plant to provide crushed stone at a discounted price.

In July, Michigan Limestone Operations' Calcite Plant ended a 3-week layoff of 140 people. About 16 people will remain on layoff indefinitely owing to reductions in operations related to the recession. In operation for 77 years, Michigan Limestone Operations' Calcite Plant quarry (5 miles long, 1 1/4 miles wide, and 260 feet deep) at Rogers City, Presque Isle County, is reportedly the world's largest quarry.

A Belleville construction firm requested a permit to open a limestone quarry in Berlin Township next to the Rockwood Stone Co. quarry. The 90-acre parcel was zoned agricultural requiring a special use permit by the township.

Dimension.—Reported production of dimension stone increased sharply from 1990's estimated amount. Of the two companies that were active during 1991, Jude Stone Quarry Co. quarried sandstone for curbing near Napoleon in Jackson County, and Inwood Stone Products Co. produced dolomite in Schoolcraft County for use as veneer.

Sulfur (Recovered).—Two companies recovered byproduct sulfur at petroleum refineries in Manistee and Wayne Counties. Sales increased 18% in quantity and decreased 3% in value over those reported for 1990.

Metals

Copper and Silver.—Michigan continued to rank fifth among 12 States in copper production and ninth among 16 States in silver production. Virtually all of the output was from Copper Range Co.'s White Pine Mine, smelter, and refinery complex in Ontonagon County. Copper Range is owned by Metall Mining Co., a Canadian-based subsidiary of Metallgesellschaft A.G. of the Federal Republic of Germany. Production of copper, in terms of recoverable metal, was about 11% higher than that in 1990, the highest since 1985 when Copper Range reopened its White Pine Mine. Reported silver production declined about 3%. Copper prices averaged $1.09 per pound in 1991, compared with $1.23 per pound in 1990. Silver prices dropped for the fourth consecutive year to $4.04 per troy ounce, compared with the 1990 average of $4.82.

TABLE 4
MICHIGAN: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	27	35,385	$104,558	$2.95	25	36,203	$113,675	$3.14
Dolomite	3	4,544	14,185	3.12	3	4,503	14,743	3.27
Marble	1	W	25	W	1	W	W	31.83
Calcareous marl	2	12	28	2.33	3	16	52	3.25
Traprock	1	24	69	2.88	4	14	36	2.57
Sandstone and quartzite	2	W	W	11.46	1	W	346	W
Miscellaneous stone	1	W	W	1.00	1	W	W	1.10
Total[1]	XX	40,905	123,678	3.02	XX	40,989	129,490	3.16

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

Metall Mining continued work aimed at modernizing its Copper Range facility to increase production and lower costs. In August, the No. 4 mill section was restarted and included new cleaner and recleaner circuits designed to improve concentrate grade from 28.5% to 31.5%. Copper concentrates from other mines, including Bingham Canyon in Utah and Morenci in Arizona, were processed in the smelter on a toll basis. Approximately 1,119 people were employed at the facility.

Great Lakes Minerals planned to start mining chalcocite copper at the 543-S site in 1992. Great Lakes Minerals has plans for four other sites in Keweenaw County near Gratiot Lake as well.

The opening of the Centennial copper mine in Houghton County near Kearsarge remained on hold. American Chemet Corp., a Peninsula Copper Industries Inc. (PCI) shareholder, filed a $1.1 million lawsuit against PCI's president, MICHCAN Copper Co., and Michigan Mining & Manufacturing Inc. over the Centennial project.

Red Metal Explorations Inc., of Hancock, produced a limited amount of copper, silver, and other minerals from the Caledonia Mine, Ontonagon County, primarily for mineral collections. The Caledonia Mine has been worked off and on since the mid-1800's.

The Quincy Mine Hoist Association Inc., Hancock, restored the 1894 hoist house at the Quincy copper mine and made it into a visitor center. At one time, the Quincy Mine was the deepest known mine in the world. The No. 2 shaft extended to 9,300 feet deep on the incline. The large steam hoist, used at the time the mine was active, is a tourist attraction the nonprofit association operates during the summer months.

Iron Ore.—Michigan continued to rank second behind Minnesota in shipments of iron ore, the State's leading nonfuel mineral commodity in terms of value. Shipments in 1991 totaled 12.7 million metric tons, an increase of about 27% over the 10 million tons shipped in 1990; however, a decrease from shipments made in 1988 and 1989. A 4-month strike reduced production in Michigan mines in 1990. Michigan furnished 22% of the Nation's total iron ore in 1991, compared with 18% in 1990.

Cleveland-Cliffs Inc. (CCI) reported in its 1991 annual report to stockholders that 7.6 million long tons of pellets was produced during the year at the Empire Mine, nearly up to its rated annual capacity of 8 million long tons. CCI also stated that 4.7 million long tons of pellets was produced at the Tilden Mine, which had a rated annual capacity of 6.7 million long tons. Magnetite ore was mined at the Empire Mine. For the second full year, iron ore pellets from both hematite and magnetite were produced at the Tilden Mine, the world's first operation capable of producing iron ore pellets from both magnetite and hematite ore. A new area, Section 20, was being developed at the Empire Mine to assist in blending the ores required for constant plant feed. The Empire Mine Partnership was owned 40% by Inland Steel, 25% by CCI, 25% by LTV Steel, and 10% by Wheeling-Pittsburg Steel Corp.

About 85% of the Michigan ore was hauled by rail to Escanaba or Marquette ports and then transported by lake vessels to lower lake ports for delivery to blast and steel furnaces. The remainder was shipped entirely by rail to consumers, mostly to USX Corp.'s Fairfield steelworks near Bessemer, AL. First ore cargoes of the 1991 navigation season left the Lake Superior and Ishpeming Railroad Co. Presque Isle dock in Marquette on March 30, and the Chicago & Northwestern Railroad (C&NW) dock in Escanaba on March 12. Approximately 5 to 6 million long tons of ore was shipped from each of the ports before closing January 1, 1992, and January 11, 1992, respectively.

Michigan ranked first among the five States reporting shipments of crude iron oxide pigments. Quantity and value of iron oxide sales increased about 9% and 10%, respectively, over those of 1990. All shipments were by CCI from a stockpile at its Mather Mine in Marquette County.

Iron and Steel.—Michigan mills produced 7 million short tons of raw steel

TABLE 5

MICHIGAN: USABLE IRON ORE[1] PRODUCED (DIRECT SHIPPING OF ALL FORMS OF CONCENTRATES AND AGGLOMERATES), BY RANGE

(Thousand metric tons, gross weight, unless otherwise specified)

Year	Marquette Range	Menominee Range (Michigan part)	Gogebic Range (Michigan part)	Total		Iron content (percent)
				Gross weight		
				Ore[2]	Iron content	
1854-1985	573,851	[3]321,307	[4]253,631	1,148,788	NA	NA
1986	10,727	—	—	10,727	6,911	64.43
1987	12,491	—	—	12,491	7,956	63.69
1988	14,589	—	—	14,589	9,063	62.12
1989	15,611	—	—	15,611	9,778	62.64
1990	9,468	—	—	9,468	5,881	62.12
1991	12,645	—	—	12,645	7,829	61.91
Total[2]	649,382	[5]321,307	[5]253,631	1,224,319	NA	NA

NA Not available.
[1]Exclusive after 1905 of iron ore containing 5% or more manganese.
[2]Data may not add to totals shown because of independent rounding.
[3]No production after 1981.
[4]No production after 1979.
[5]Distribution by range partly estimated before 1906.

in 1991, about 13.6% less than the 8.1 million short tons produced in 1990, according to the American Iron and Steel Institute. The four Michigan steel mills provided almost 8% of the 87.9 million tons produced nationwide. The State ranked fifth in production, following Indiana, Ohio, Pennsylvania, and Illinois. Most of the steel produced at Michigan mills was used by the automobile industry.

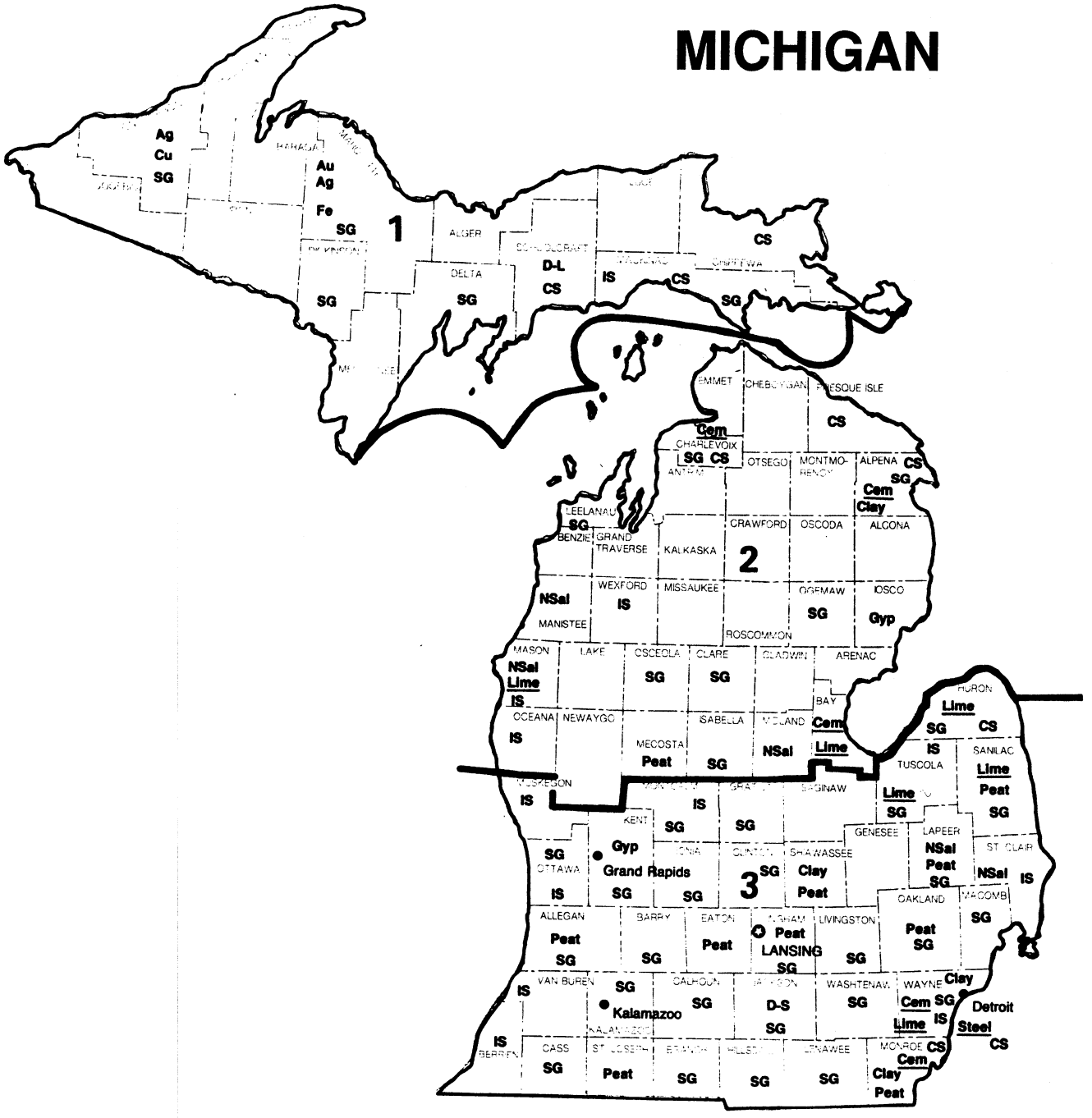
McLouth Steel, which operated mills in Trenton and Gibraltar, laid off between 400 and 500 hourly and salaried workers in an effort to weather the recession, reducing the employee-owned company's work force to about 1,550.

At year's end, North Star Steel Co.'s (a unit of Cargill Inc.) plans to increase production at its Monroe mill were delayed until a determination on the effect on air quality was resolved by Michigan's Air Pollution Control Commission. Officials from the State Department of Natural Resources recommended denial of the company's request to operate the mill's furnace and ladle refining station longer hours. The Monroe mill employed about 540.

[1]State Mineral Officer, U.S. Bureau of Mines, Denver, CO. He has 15 years of mineral-related government experience. The author gratefully acknowledges assistance in preparation of the chapter given by Pat LaTour, editorial assistant.

[2]Regional geologist, Geological Survey Division, Michigan Department of Natural Resources, Marquette, MI.

MICHIGAN



LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Au	Gold
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper
D-L	Dimension Limestone
D-S	Dimension Sandstone
Fe	Iron
Gyp	Gypsum
IS	Industrial Sand
Lime	Lime plant
NSal	Natural Salines
Peat	Peat
SG	Sand and Gravel
Steel	Iron and Steel plant

Principal Mineral-Producing Localities

TABLE 6
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Essroc Materials Inc., a subsidiary of Societe des Ciments Francais	Box 80 Essexville, MI 48732	Grinding plant	Bay.
Holnam Inc., Dundee Div., a subsidiary of Holderbank Financiere Glaris SA[1 2]	6211 Ann Arbor Rd. Dundee, MI 48131	Quarry, clay pit, plant	Monroe.
Lafarge Corp., Great Lakes Region[1 2 3]	4000 Town Center Suite 200 Southfield, MI 48075	do.	Alpena.
Medusa Cement Co., a division of Medusa Corp.[1 2]	Box 5668 Cleveland, OH 44101	do.	Charlevoix.
St. Mary's Peerless Cement Co., a division of St. Mary's Cement Ltd.	9333 Dearborn St. Detroit, MI 48209	Plant	Wayne.
Clays:			
F. W. Ritter Sons Co.	12670 North Dixie Hwy. South Rockwood, MI 48179	Clay pit and plant	Monroe.
U.S. Brick Inc., Michigan Div., a subsidiary of Canada Brick Co.	3820 Serr Rd. Corunna, MI 48817	do.	Shiawassee.
Copper:			
Copper Range Co.[4]	Box 100 White Pine, MI 49971	Underground mine, concentrator, smelter, refinery	Ontonagon.
Gypsum:			
Domtar Gypsum Inc.	Box 1670 Grand Rapids, MI 49504	Underground mine and plant	Kent.
Georgia-Pacific Corp.	133 Peachtree St., NE Atlanta, GA 30303	do.	Do.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	Open pit mine Plant	Iosco. Wayne.
Iron ore:			
Cleveland-Cliffs Iron Co.[5]	504 Spruce St. Ishpeming, MI 49849	Open pit mines and plants	Marquette.
Iron and steel:			
McLouth Steel Products Corp.	1650 West Jefferson Trenton, MI 48183	Plant	Wayne.
National Steel Corp., Great Lakes Steel Div.	1 Quality Dr. Ecorse, MI 48229	do.	Do.
Rouge Steel Co.	3001 Miller Rd. Dearborn, MI 48121	do.	Do.
Lime:			
Detroit Lime Co., a subsidiary of Edward C. Levy Co.	8800 Dix Hwy. Dearborn, MI 48823	do.	Do.
The Dow Chemical Co., Lime Div.	South Madison St. Ludington, MI 49431	do.	Mason.
Marblehead Lime Co., a division of General Dynamics Corp.	222 North LaSalle St. Chicago, IL 60601	Plants	Wayne.
Michigan Sugar Co.	Box 1348 Saginaw, MI 48605	do.	Huron, Saginaw, Sanilac, Tuscola.
Monitor Sugar Co.	2600 South Euclid St. Bay City, MI 48706	Plant	Bay.
Peat:			
Al-Par Peat Co.	5900 Henderson Rd. Elsie, MI 48831	Bog and plant	Shiawassee.
Douglas Farms	0-998 Chicago Dr. Jenison, MI 49428	do.	Allegan.

See footnotes at end of table.

TABLE 6—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Peat—Continued:			
Fletcher & Rickard	25800 Haas Rd. New Hudson, MI 48165	Bog and plant.	Oakland.
Hyponex Corp.	14111 Scottslawn Rd. Marysville, OH 43031	Bogs and plants	Lapeer and Shiawassee.
Michigan Peat Co.	Box 980129 Houston, TX 77006	do.	Sanilac.
Perlite (expanded):			
Harborlite Corp.	Box 458 Escondido, CA 92025	Plant	Kalamazoo.
Potassium salts:			
Kalium Chemicals Ltd.	11461 South 135th St. Hersey, MI 48640	Solution mine and plant	Osceola.
Salines (natural):			
The Dow Chemical Co.[6 7]	2020 Dow Center Midland, MI 48640	Brine wells and plant	Mason.
Martin Marietta Corp., Magnesia Specialties Div.[7]	Executive Plaza II Hunt Valley, MD 21030	do.	Manistee.
Morton International Inc.[7]	110 North Wacker Dr. Chicago, IL 60606	do.	Do.
Wilkinson Chemical Corp.[6]	8290 Lapeer Rd. Mayville, MI 48744	do.	Lapeer.
Salt:			
Akzo Salt Inc.	916 South Riverside St. Clair, MI 48079	Brine wells and plants	Manistee and St. Clair.
Morton International Inc.	110 North Wacker Dr. Chicago, IL 60606	Brine wells and plant	Manistee.
Sand and gravel:			
Construction:			
CSR America Inc.	67500 Mound Rd. Romeo, MI 48065	Pits and plants	Kalamazoo, Livingston, Macomb, Oakland.
Grand Rapids Gravel Co.	2700 28th St., SW Grand Rapids, MI 49509	do.	Kent and Ottawa.
Holloway Sand & Gravel Co. Inc.	29250 Wixom Rd. Wixom, MI 48096	do.	Oakland and Washtenaw.
Hubscher & Son Inc.	Box 411 Mt. Pleasant, MI 48804	do.	Clare, Gogebic, Gratiot, Isabella.
Edward C. Levy Co. Lyon Sand & Gravel Co.	4780 South Hill New Hudson, MI 48165	Pit and plant	Oakland.
Portable Aggregates Producers	1401 Souter Blvd. Troy, MI 48084	Pits and plants	Do.
Bill Smith Sand & Gravel Inc.	Box 23 Otsego, MI 49078	do.	Allegan and Cass.
Spartan Aggregates Inc.	3931 East Holt Rd. Holt, MI 48842	do.	Ingham and Tuscola.
Tri-City Aggregates Inc.	1401 Souter Blvd. Holly, MI 48442	do.	Oakland.
Whitaker & Gooding Co.	5800 Cherry Hill Rd. Ypsilanti, MI 48197	do.	Lapeer, Oakland, Washtenaw.
Industrial:			
Cheyenne Sand Corp., a subsidiary of Construction Aggregates Corp.	Box 6 Ferrysburg, MI 49409	do.	Ottawa.

See footnotes at end of table.

TABLE 6—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued:			
Industrial—Continued:			
Manley Bros. of Indiana Inc.	Box 538 Chesterton, IN 46304	Pits and plants	Berrien and Van Buren.
Nugent Sand Co. Inc.	Box 1209 Muskegon, MI 49443	do.	Muskegon.
Sargent Sand Co.	Box 6280 Saginaw, MI 48603	do.	Mason, Tuscola, Wexford.
Slag (iron and steel):			
International Mill Service Co.	1818 Market St. Philadelphia, PA 19103	Plants	Jackson and Monroe.
Edward C. Levy Co.	8800 Dix Ave. Detroit, MI 48209	do.	Wayne.
Stone:			
Crushed:			
Limestone-dolomite:			
Beazer USA	1850 Koppers Bldg. Pittsburgh, PA 15219	Quarry and plant	Monroe.
Crane Co.	757 Third Ave. New York, NY 10017	Quarry	Charlevoix.
Michigan Mineral Associates	1035 Calcite Road Rogers City, MI 49779	do.	Mackinac and Presque Isle.
Presque Isle Corp.	Box 426 Alpena, MI 49707	Quarry and plant	Presque Isle.
Stoneco Inc., a division of S. E. Johnson Co.	Box 29A Maumee, OH 43537	Quarries and plants	Monroe.
Marl:			
Poehlman & Son	Route 2 Cassopolis, MI 49031	Pit	Cass.
Quartzite:			
A. Lindberg & Sons Inc.	500 Mather Ave. Ishpeming, MI 49849	Quarry and plant	Marquette.
Traprock:			
George Hocking Construction Co.	Box 488 South Range, MI 49963	do.	Houghton.
Dimension:			
Limestone-dolomite:			
Inwood Stone Products Co.	Box 24 Cooks, MI 49817	do.	Schoolcraft.
Sandstone:			
Jude Stone Quarry Co.	338 Austin Rd. Napoleon, MI 49261	do.	Jackson.
Sulfur (recovered):			
Marathon Oil Co.	1300 South Fort St. Detroit, MI 48217	Elemental sulfur recovered as a byproduct of oil refining	Wayne.
Shell Western E&P Inc.	Box 1523 Houston, TX 77251	do.	Manistee.

[1]Also clays.
[2]Also crushed limestone.
[3]Also gypsum.
[4]Also silver.
[5]Also crude iron oxide pigments.
[6]Calcium chloride.
[7]Magnesium compounds.

THE MINERAL INDUSTRY OF MINNESOTA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Minnesota Geological and Natural History Survey for collecting information on all nonfuel minerals.

By Robert H. Wood II[1]

Minnesota's mineral production reported to the U.S. Bureau of Mines in 1991, valued at about $1.3 billion, represented the lowest value reported for the State since 1988. A drop in production of more than 12% from that of the previous year was a reflection of decreased sales reported in nearly all of the State's mineral commodities. Lime, clays, and gemstones were the only mineral commodities with reported increases in production and sales during the year. Reduced sales dropped Minnesota from sixth to seventh rank nationally in the value of nonfuel mineral production. The State contributed about 4.2% of the total U.S. mineral value in 1991.

In order of value, iron ore, construction sand and gravel, and crushed stone were Minnesota's three leading mineral commodities in 1991. Iron ore, the only metallic mineral commodity with reported production in the State, accounted for almost 90% of the State's total mineral value during the year. Construction sand and gravel and crushed stone collectively contributed about 7% of the State's total mineral production value.

Minnesota continued to lead the Nation in production of iron ore, contributing more than 75% of the total U.S. iron ore production. Of nonmetallic mineral commodities produced in the State, peat ranked 5th among 19 States reporting production; dimension stone, 7th of 34; industrial sand and gravel, 10th of 37; lime, 25th of 32; crushed stone, 31st of 49; and clay, 38th of 43.

TRENDS AND DEVELOPMENTS

Inland Steel Mining Co. opened its new Laurentian Mine. Construction on the $20 million open pit taconite mine near Gilbert began in 1990. Crude ore from the Laurentian Mine was processed at the company's Minorca taconite plant in Virginia, Minnesota along with ore from the company's Minorca pit.

LTV Steel Mining Co. closed the McKinley Extension (Donara Mine) owing to ore reserve exhaustion. The McKinley Extension was the last of the large natural iron ore properties operating in the State. Existing crude ore and concentrate stockpiles were expected to be blended with ore from the Connie Mine and shipped over the next 2 years.

Conbuilt Iron Corp. was seeking to form a consortium of corporations to build a direct-reduction iron ore mill in Duluth. The company would use a German-invented Corex process that turns iron ore into pig iron. Conbuilt's plans were for an 800,000-ton-per-year plant that would cost about $180 million. Although the plant would not create large

TABLE 1
NONFUEL MINERAL PRODUCTION IN MINNESOTA[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gemstones		NA	$42	NA	$46	NA	$62
Iron ore (usable)	thousand metric tons	41,044	1,223,909	45,139	1,308,920	e42,966	e1,157,920
Peat	thousand short tons	33	1,415	48	2,972	35	1,910
Sand and gravel (construction)	do.	e33,700	e82,600	33,869	77,502	e24,500	e58,800
Stone:							
Crushed	do.	8,760	30,218	e9,100	e31,900	8,378	30,624
Dimension	short tons	44,605	16,031	e60,195	e20,836	45,795	13,962
Combined value of clays (common, kaolin), lime, and sand and gravel (industrial)		XX	22,022	XX	27,746	XX	25,607
Total		XX	1,376,237	XX	1,469,922	XX	1,288,885

eEstimated. NA Not available. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

numbers of jobs, it should increase the demand for taconite and help stabilize the industry, which was competing with recycled scrap steel.

M E International, a Minneapolis-based manufacturer of wear parts for mining equipment, started up a new foundry in St. Cloud. The new plant was planned to have an annual capacity to produce 7,000 tons of liners for rod mills, ball mills, and gyratory crushers. The plant was designed for possible expansion to increase capacity to 18,000 tons if future market conditions improve.

USG Corp. missed a $105 million principal and $40 million interest payment due the first part of the year. The company missed the payment because it was in the process of developing plans for restructuring a $2.26 billion long-term debt. USG has been squeezed by the slumping construction market and recapitalization was needed to avoid a hostile takeover during 1988.

EMPLOYMENT

According to the Minnesota Department of Jobs and Training, Research and Statistics Office, employment in the State's mining industry averaged 7,900 workers during the year, a decrease of 200 workers compared with data released in 1990. Decreased activity in the State's construction industry, indicated by lower sales in the construction materials, probably accounted for the decrease in the number of workers reported in mining. The average number of workers employed in the metal mining sector was 6,300, the same as that in 1990. The average hourly earnings for all mine workers was $15.21, a $0.79 increase over that of the previous year. Metal mine workers had average hourly wages of $15.95, nearly a $1.00 increase.

During the 7 million employee-hours worked in 1991 at mining operations, there was 1 fatality at a sand and gravel operation, 158 injuries resulting in lost workdays, and 59 injuries resulting in no workdays lost reported by the U.S. Department of Labor. At mills and preparation plants associated with mining operations, an additional 165 injuries to workers resulted in lost workdays and 92 injuries resulted in no lost workdays. A total of 6.3 million employee-hours was worked at the mills and plants during the year.

REGULATORY ISSUES

Administrative orders permanently limiting Koch Refining Co.'s releases of sulfur dioxide at its Rosemont facility were approved by the Minnesota Pollution Control Agency (MPCA) Citizens Board in March. Koch agreed to make improvements at its oil refinery and sulfuric acid plant to comply with newly imposed limits on sulfur dioxide emissions.

North Star Steel Co. and USX Corp. agreed to pay financial penalties to the State for repeated incidents of air pollution. In May, MPCA agreed to accept $84,000 from North Star for violations at its steel mill in St. Paul and $192,000 from USX for violations at its Minntac taconite plant near Mountain Iron. North Star failed to control dust from its plant, and emissions escaped from the plant's electric arc furnaces. USX violated air pollution rules when it installed burners and burned wood waste without obtaining a permit. Both companies agreed to install pollution control equipment.

Environmentalists sued MPCA in an attempt to postpone the opening of LTV Steel Co.'s coal-fired North Shore powerplant. The environmental groups alleged that the plant at Schroeder would violate sulfur dioxide emissions and the State's acid rain standards. MPCA had granted LTV an air emission permit in July. In September, a three-judge panel denied the environmental groups' request for a stay of the permit for the Taconite Harbor plant. The 225-megawatt powerplant had been idle since June 1982 when LTV determined it could buy cheaper electricity from Minnesota Power for its taconite mine and ore-processing plant in Hoyt Lakes.

EXPLORATION ACTIVITIES

To attract more interest in mineral exploration in the State, the Minnesota Department of Natural Resources (DNR) began a new permit procedure, referred to as a Regional Geologic Reconnaissance Authorization (RGRA). A 1-year RGRA permit will allow mapping, geophysical and geochemical surveys, and limited drilling activities (through glacial overburden and up to 20 feet in bedrock) on State lands without obtaining a mineral lease. Permitees would not control the land or have preferential treatment in obtaining a mineral lease and, within 10 days after expiration of the permit, are required to submit at least 25% of all drill samples and data generated as a result of the authorization. In January, Newmont Mining Co. acquired one of the first RGRA's issued for proposed work in northern Itasca County and southern Koochiching County. Four RGRA's were issued during the year.

In October, the DNR Minerals Division offered leases on about 1 million acres of State land in conjunction with the eighth annual Current Minerals Activities Forum. Lands in portions of Beltrami, Itasca, Koochiching, Lake, Lake of the Woods, Marshall, Morrison, Roseau, St. Louis, and Todd Counties were offered for lease. Bids were received from 4 companies on 59 units covering a total of 24,500 acres. Phelps Dodge Exploration East Inc. submitted bids on 28 units, Newmont Exploration Inc. on 18, North Bay Exploration on 12, and American Shield Co. submitted 1. Bids were submitted on units in Beltrami, Itasca, Koochiching, Lake of the Woods, and St. Louis Counties. DNR reported there were 138 State metallic mineral leases, covering 52,093 acres, in effect at the end of 1991.

According to DNR, in 1991, there were 195 exploration holes drilled on State and private lands for a total of 42,140 feet. Drilling projects were conducted in eight counties during the year: Noranda and Newmont in Beltrami County; Newmont and National Steel Pellet Co. in Itasca County; Newmont

and Exmin in Koochiching County; Exmin in Mille Lacs and Morrison Counties; Cominco American Inc. and Noranda in Norman County; Northern Con-Agg Inc., NRRI-OCHS, and U.S. Borax in Redwood County; and American Shield, Exmin, Hibbing Taconite Co., and Nerco Exploration Co. in St. Louis County.

Exploration for precious and base metals was primarily in the ancient greenstone terrains in the northern part of the State and in the Duluth Complex (mafic-ultramafic rocks) in northeastern Minnesota. Taconite development drilling was centered in St. Louis and Itasca Counties. One company reportedly conducted exploratory drilling for diamond-bearing kimberlite in several counties in the central and northern part of the State. In the southern part of the State, kaolin clay deposits were drilled in Redwood County.

LEGISLATION AND GOVERNMENT PROGRAMS

Two bills indirectly affecting the mining industry were enacted into law in 1991. Senate file 837 extended time restrictions on public access to mineral exploration data generated from exploration on public and private land. Public access to data generated on public land was extended from 90 days to 1 year. Data from private lands will become public only after the mineral lease is no longer in force, up to a 5-year limit. Senate file 962 revised State mineral leasing procedures and methods of computing royalties.

On June 30, the Minnesota Mineral Resources Institute at the Minneapolis campus of the University of Minnesota was closed. The action followed budget deficits and changing attitudes on the University's direction. The 78 years of basic research activity at the Institute focused largely on iron ore research, which included development of taconite processing technology.

The Minerals Division of DNR published four reports on mineral resources during the year. A dimension stone inventory, which began in 1989, was published for the northern part of the State. Dimension stone discovered during the inventory led to a sale of stone at three locations in the Superior National Forest. DNR also published reports on metallic mineral potential that identified occurrences with high potential for copper, zinc, nickel, and gold deposits in an Archean greenstone belt in Lake of the Woods County.

During the year, DNR was in the process of compiling a digital index on the cores and data available in the Hibbing DNR office library. During the past 2 years, DNR added 343 drill cores and data from two complete exploration programs to the library.

Five geologic maps of Late Cretaceous age rocks in southwestern Minnesota were published by the State Geological Survey. It was theorized that rock units in the area could host economic deposits of manganese. The maps were intended to serve as a framework for mineral exploration in the area.

Results of research conducted at the Natural Resources Research Institute (NRRI) at the University of Minnesota, Duluth, disclosed that the substitution of lime-dolomite hydrate for raw flux in fluxed taconite pellets would reduce the energy for flux production by 50%. Studies on temperature control during various stages of taconite processing may lead to greater efficiency and increased productivity. A dry magnetic cobbing method developed by NRRI researchers for low-grade taconite waste rock enabled a local contractor to increase production and produce taconite crude in addition to his usual products, railroad ballast and blast furnace trim.

Minnesota is working through the Iron Ore Cooperative Research Program, with matching industry and U.S. Bureau of Mines funds, on projects designed to improve the metallurgical properties of iron ore pellets, reduce processing costs, and modify processing methods. Projects completed during the year included production of iron ore concentrates containing only 3% silica; identification of a production saving method utilizing dry cobbing of rod mill feed; in-plant testing of the Lasentec particle-size analyzer in conjunction with concentrate filter operations; digital image analysis of particle size in primary crusher feed and pit run ore; and in-plant testing of carbon addition to taconite pellets.

The U.S. Bureau of Mines Twin Cities Research Center (TCRC) conducted research under various cooperative agreements with State agencies and private industry on a variety of mining and mineral-related projects. As part of an ongoing project, researchers studied the diamond drill core from two holes (one in the Cuyuna Range and the other in the Emily district) to evaluate whether in situ mining techniques can be used to economically recover low-grade manganese resources found in the State. Drilling indicated that most of the manganese minerals (manganite, cryptomelane, and hollandite) were found to occur in pods and lenses ranging between 1.5 meters to 18 meters thick with a manganese content ranging between 10% and 50%. Core leaching tests showed that, although the initial permeability of the core was low, permeability increased as manganese was leached.

In another activity at TCRC, an on-line, computer-vision-based system was developed to determine size distribution, particle shapes, brightness, and contrast of flowing materials. Better quality pellets and reduced operating costs can be achieved through an accurate control of the ball size and moisture content. The system was installed on a discharge belt of an agglomeration balling drum in a Minnesota taconite pelletizing plant.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Minnesota was the leading iron ore producer in the Nation, contributing more than 75% of the total U.S. iron ore shipments in 1991. In terms of value, iron ore accounted for almost 90% of the State's total mineral value during the year. According to figures compiled by

TABLE 2
MINNESOTA: PRODUCTION AND SHIPMENTS OF USABLE IRON ORE[1]

(Thousand metric tons, gross weight, unless otherwise specified)

Year	Production				Shipments			
	Natural ore and concentrates	Pellets	Total[2]	Iron content (percent)	Natural ore and concentrates	Pellets	Total[2]	Proportion of pellets to total ore (percent)
1986	1,179	26,297	27,476	64.07	1,367	27,875	29,242	95.33
1987	1,516	32,748	34,264	64.22	1,663	32,610	34,273	95.15
1988	825	40,624	41,449	63.95	760	39,974	40,734	98.13
1989	613	40,758	41,370	63.84	613	40,432	41,044	98.51
1990	535	44,625	45,160	r63.69	498	44,642	45,140	98.90
1991	789	42,203	42,991	63.75	829	42,137	42,966	98.07

rRevised.
[1]Exclusive of ore containing 5% or more manganese.
[2]Data may not add to totals shown because of independent rounding.

the Minnesota Iron Mining Association, the State's taconite operations generated more than $1 billion in economic activity and paid more than $95 million in State and local taxes during 1991. Reduced demand and transaction prices during the year were reflected by the decrease in shipments of iron ore, down almost 5% in quantity and 12% in value compared with 1990 figures. Production was from seven taconite operations and one natural iron ore mine in the Mesabi range in northeastern Minnesota.

During the year, Eveleth Mines was in the process of undergoing the largest construction project since its expansion in 1975. The $7.5 million project, started in August, was expected to be completed early next year. When completed, the crusher capacity at the North Star Mine would be expanded from 38,000 to 60,000 tons per day, allowing the company to mine its best and cheapest ores (those with the lowest stripping ratio). The 60% increased crusher capacity also would allow Eveleth to move all of its operations to the Thunderbird North Mine and close Thunderbird South.

In October and November, Eveleth Mines shut down operations for 6 weeks to decrease production because of sagging demand for iron ore and for scheduled repairs. About 465 workers at the Eveleth mining operation were affected by the shutdown. Although none of the other six mining companies announced fall cuts in response to a lower demand in the Nation's steel industry, LTV Steel Mining Co. shut down for 30 days in June to decrease its annual iron ore production by 0.7 million tons.

In May, Inland Steel Mining Co.'s new Laurentian Mine near Gilbert became the first significant taconite property to open in the central part of the Mesabi range in more than 10 years. Construction on the $20 million open pit mine began in September 1990. Crude ore from the Laurentian Mine is trucked about 6 miles for processing at the company's existing pellet plant at the Minorca Mine near Virginia. Up to a 33% magnetic iron content was reported at the Laurentian Mine, compared with 21% at the Minorca Mine. Ore reserves at the company's Minorca Mine are expected to be exhausted in about 2 years; reserves at the Laurentian Mine are estimated to last about 40 years.

In September, LTV Steel Mining Co. closed the reserve-depleted McKinley Extension (originally the Donora ore body) near Hoyt Lakes. The one-half-mile-long, 490-foot-deep pit was the last of the large operating natural iron ore mines in North America. Natural iron ore has been mined in Minnesota since ore was first shipped from the Soudan Mine near Lake Vermilion in 1884. Now only taconite, a lower grade ore that requires extensive processing, is being mined in the State. The company planned to blend the remaining stockpiled ore and concentrate with ore from the Connie Mine (a small operation with no plant). LTV planned to ship the remaining processed ore over the next 2 years, before permanently closing and dismantling the beneficiation plant.

In May, U.S. Steel Corp. reached an agreement with the MPCA to install a $12 million scrubber system in its Minntac taconite plant at Mountain Iron. The Minnesota Environmental Protection Agency required installation of the new system to limit the amount of dust created during the process of converting iron ore into pellets. The company was required to complete work on the system by March 1993.

Industrial Minerals

Clays.—Common clay production in the State during 1991 increased slightly in value and quantity compared with 1990 figures. The quantity of kaolin clay, mined only in Redwood County, remained about the same as last year's level, although a substantial increase in the attendant value was reported. Two firms operating pits in the southern part of the State accounted for the entire annual output.

In April, the Redwood County Board granted Minnesota Valley Minerals Inc. (MVM), a Mankato-based mining

company, a conditional use permit to mine kaolin in Swedes Township north of Belview. Permit conditions limit annual production to 75,000 short tons and open pit excavation to a depth of 862 feet above sea level (elevation of the mine site is 905 feet). Some of the kaolin will be marketed for use as a cement additive and some for use as pottery clay. Eventually, MVM would like to expand operations to include a processing plant in Belview and use the material as a filler in livestock feed. MVM estimated a mine life in excess of 25 years on the 31-acre mine site.

The Redwood County Board granted Nova Natural Resources Inc. a mining permit to expand its kaolin operation in Horner Township. The permit allows Nova to mine 20 feet deeper (down to 860 feet) on the present site and expand its operation from 35 acres to almost 70 acres. The new permit would increase the amount of kaolin available for mining by 58,000 tons per acre.

Gemstones.—The estimated value of gemstones produced in Minnesota increased 35% over 1990's estimated value. A precise value could not be determined for gem material collected by rock hounds, mineral collectors, and other hobbyists, and no commercial gemstone mining operations were reported in Minnesota during the year. Lapidary materials found in the State included thomsonite, jasper, catlinite, silkstone, binghamite, and Lake Superior agates, in addition to a variety of mineral and fossil specimens.

Lime.—Lime production in Minnesota rose about 4% in quantity and 5% in value compared with 1990 figures. Two sugar-beet processing companies, which consumed their own lime output, accounted for all of the State's production. Limestone used to manufacture the lime was obtained from out-of-State sources.

Peat.—Annual peat sales decreased about 27% in quantity and 36% in value compared with 1990 figures. The average unit value for all types of peat produced in the State decreased from about $62 per short ton in 1990 to $55 per short ton. Peat was harvested by nine companies in seven Minnesota counties. Most of the peat harvested in Minnesota was of the sphagnum variety; the remainder was principally reed-sedge and a small amount of hypnum. The greatest use for the State's peat production was for general soil improvement.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This annual report contains estimates for 1989 and 1991 and actual data for 1990.

Minnesota's estimated construction sand and gravel production decreased about 28% in quantity and 24% in value compared with actual data reported in 1990. The average unit value of the State's sand and gravel production increased from $2.29 per short ton in 1990 to an estimated $2.40 per short ton.

Controversy continued over construction sand and gravel operations throughout the year. Sand and gravel mining permits for Washington County, May Township, and the city of Maple Grove were approved by local governments. Permits were denied for new operations in New Scandia Township, Monticello Township, and in the community of Shoreview.

Industrial.—Output and value of industrial sand decreased about 24% and 16%, respectively, from data compiled in 1990. Two companies, with operations in Le Sueur, Scott, and Washington Counties, reported production of industrial sand in 1991.

The Le Sueur County Commissioners granted UNIMIN Corp. permission to expand its silica sand operations in the townships of Kasota and Ottawa. Le Sueur County Commissioners also approved UNIMIN's required annual report, which was used to verify whether the company was in compliance with county-imposed regulations. UNIMIN's request to expand hours and reduce the required bonding amount also was approved.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This annual report contains actual data for 1989 and 1991 and estimates for 1990.

Crushed.—In 1991, crushed stone production decreased 8% in quantity and 4% in value from the Bureau's 1990 estimates. An increase of $0.21 in the average unit value to $3.66 was not enough to offset a greater decline in the State's reported production. Limestone constituted most of the crushed stone sales, accounting for more than 78% of the total crushed and broken stone sales in the State.

Dimension.—Dimension stone output decreased in production and value by 24% and 33%, respectively, from 1990 estimates. Granite and limestone continued to be the principal types of dimension stone quarried in the State.

During the year, DNR completed and published the results of a reconnaissance-level dimension stone inventory of crystalline rocks on government-administrated lands in six northeastern Minnesota counties. Approximately 250 outcroppings were evaluated during the 2-year study. Joint spacing, color, texture, deleterious minerals, and size of extractable blocks were the criteria used in the evaluation. Field investigations identified 12 sites, including 2 inactive quarries, that have potential for dimension stone development.[2] The potential sites were offered for lease and Cold Springs Granite Co., headquartered in St. Cloud, was awarded an exploration contract in October 1991 on three sites. The three sites are about 3 miles south of Crane Lake, 12 miles southeast of Ely, and 4 miles east of Isabella. Depending on favorable test results, the company planned to open quarries at all three sites.

TABLE 3

MINNESOTA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	W	W	$6.01
Riprap and jetty stone	85	414	4.87
Filter stone	120	515	4.29
Coarse aggregate, graded:			
Concrete aggregate, coarse	334	1,331	3.99
Bituminous aggregate, coarse	279	1,272	4.56
Bituminous surface-treatment aggregate	131	506	3.87
Railroad ballast	652	3,242	4.97
Fine aggregate (-3/8 inch): Stone sand, bituminous mix or seal[2]	197	937	4.76
Coarse and fine aggregates:			
Graded road base or subbase	1,890	6,918	3.66
Unpaved road surfacing	315	924	2.93
Terrazzo and exposed aggregate	W	W	5.14
Crusher run or fill or waste	312	318	1.02
Other construction materials[3]	606	3,138	5.18
Agricultural: Agricultural limestone[4]	193	712	3.69
Chemical and metallurgical: Lime manufacture	W	W	4.00
Special: Asphalt fillers or extenders	W	W	2.35
Other miscellaneous uses[5]	247	532	2.15
Unspecified:[6]			
Actual	2,025	7,146	3.53
Estimated	991	2,717	2.74
Total[7]	8,378	30,624	3.66

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes dolomite, granite, limestone, quartzite, and traprock.
[2]Includes screening, undesignated.
[3]Includes withheld amounts for coarse aggregate (+1 inch), and coarse and fine aggregates.
[4]Includes poultry grit and mineral food.
[5]Includes withheld amounts for chemical and metallurgical, special, and other specified uses not listed.
[6]Includes production reported without a breakdown by use and estimates for nonrespondents.
[7]Data may not add to totals shown because of independent rounding.

Other Industrial Minerals.—Raw materials for producing expanded perlite and sulfur produced in Minnesota were obtained from out-of-State sources. Perlite was expanded at the USG Interiors, Inc. acoustical products plant in Cloquet. The reported quantity and value of the expanded material produced remained at the same level as in the 2 previous years.

Sulfur was recovered by Koch Refining Co. at its refinery in Pine Bend and by Ashland Petroleum Co. at its refinery in St. Paul Park. Recovered sulfur during 1991 decreased 8% in quantity and 15% in value compared with 1990 figures.

[1]State Mineral Officer, U.S. Bureau of Mines, Denver, CO. He has 15 years of mineral-related work with the Government. Assistance in the preparation of the chapter was given by Pat LaTour, editorial assistant.

[2]Oberhelman, M. Dimension Stone Inventory of Northern Minnesota. Minerals Division, Minnesota Department of Natural Resources Report 289, 1991, 34 pp.

TABLE 4

MINNESOTA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	—	—	W	W	W	W
Coarse aggregates, graded[2]	145	490	W	W	W	W
Fine aggregates (-3/8 inch)[3]	—	—	W	W	W	W
Coarse and fine aggregates[4]	W	W	W	W	—	—
Other construction materials	122	492	13	111	800	3,722
Agricultural[5]	W	W	—	—	W	W
Chemical and metallurgical[6]	—	—	—	—	—	—
Special[7]	—	—	—	—	—	—
Other miscellaneous uses	—	—	—	—	—	—
Unspecified:[9]						
Actual	100	316	—	—	—	—
Estimated	—	—	—	—	320	528
Total[10]	368	1,298	13	111	1,120	4,250

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	W	W	155	686	W	W
Coarse aggregates, graded[2]	W	W	333	1,267	177	809
Fine aggregates (-3/8 inch)[3]	W	W	W	W	—	—
Coarse and fine aggregates[4]	260	927	1,703	5,281	569	2,154
Other construction materials	419	2,219	105	583	156	934
Agricultural[5]	W	W	84	230	(8)	(8)
Chemical and metallurgical[6]	—	—	—	—	(8)	(8)
Special[7]	—	—	(8)	(8)	—	—
Other miscellaneous uses	—	—	247	529	73	328
Unspecified:[9]						
Actual	209	793	—	—	1,700	5,984
Estimated	212	869	127	441	348	931
Total[10]	1,099	4,808	2,754	9,016	3,024	11,141

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."

[1]Includes macadam, riprap and jetty stone, and filter stone.

[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.

[3]Includes stone sand (bituminous mix or seal) and undesignated.

[4]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run (select material or fill).

[5]Includes agricultural limestone, poultry grit and mineral food.

[6]Include lime manufacture.

[7]Includes asphalt fillers or extenders.

[8]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."

[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.

[10]Data may not add to totals shown because of independent rounding.

TABLE 5

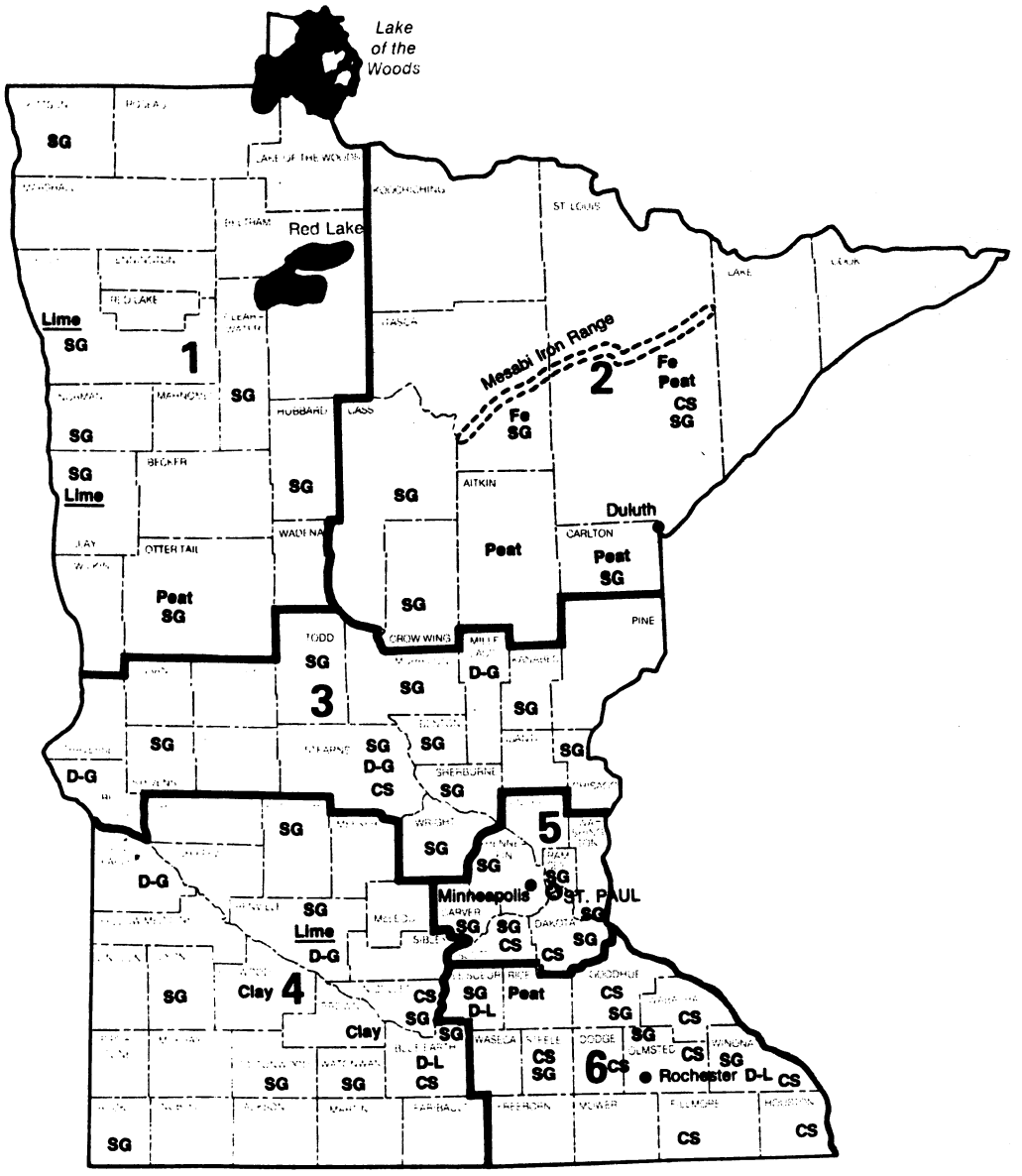
MINNESOTA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	36	6,781	$22,866	$3.37	45	6,806	$24,005	$3.53
Dolomite	3	W	W	3.01	1	W	W	3.00
Granite	4	1,765	6,536	3.70	3	W	W	3.81
Traprock	2	10	82	8.20	1	W	W	9.25
Quartzite	—	—	—	—	1	W	W	5.96
Miscellaneous stone	1	W	W	4.50	—	—	—	—
Total[1]	XX	8,760	30,218	3.45	XX	8,378	30,624	3.66

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.

[1]Data may not add to totals shown because of independent rounding

MINNESOTA



LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Clay	Clay
CS	Crushed Stone
D-G	Dimension Granite
D-L	Dimension Limestone
Fe	Iron
Lime	Lime plant
Peat	Peat
SG	Sand and Gravel

Concentration of mineral operations

Principal Mineral-Producing Localities

TABLE 6
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
Northwestern States Portland Cement Co.	Box 1008 Mason City, IA 50401	Pit	Redwood.
Ochs Brick & Tile Co.	Box 106 Springfield, MN 56087	Pit and plant	Brown.
Do.	do.	Pit	Redwood.
Iron ore:			
Cyprus Northshore Mining Corp.	10 Outer Dr. Silver Bay, MN 55614	Mine and primary crusher Concentrator and agglomerator	St. Louis. Lake.
Inland Steel Mining Co. Minorca Mine and Plant	30 West Monroe St. Chicago, IL 60603	Mine, concentrator, agglomerator	St. Louis.
LTV Steel Co., Northwest Ore Div. McKinley Extension	Box 196 Aurora, MN 55706	Mine and concentrator	Do.
National Steel Pellet Co.	Box 217 Keewatin, MN 55753	Mine, concentrator, agglomerator	Itasca and St. Louis.
Oglebay Norton Co. Eveleth Mines	1100 Superior Ave. Cleveland, OH 44114	do.	St. Louis.
Pickands Mather & Co. (a subsidiary of Cleveland-Cliffs Inc.):			
Hibbing Taconite Co.	Box 900 Hoyt Lakes, MN 55750	do.	Do.
LTV Steel Mining Co.	do.	do.	Do.
USX Corp., Minnesota Ore Operations Minntac	Box 417 Mountain Iron, MN 55768	do.	Do.
Lime:			
American Crystal Sugar Co.	101 North 3d St. Moorhead, MN 56560	Plants	Clay and Polk.
Southern Minnesota Sugar Co-op.	Box 500 Renville, MN 56284	Plant	Renville.
Peat:			
Aitkin Agri-Peat	Fleming Route, Box 35 Aitkin, MN 56431	Bog and plant	Aitkin.
Davidson Peat Co.	Route 3, Box 6 Kenyon, MN 55946	Bog	Rice.
Michigan Peat Co.	Box 980129 Houston, TX 77098	Bog and plant	Carlton.
Minnesota Sphagnum Inc.	Box 58 Goodhart, MI 49737	do.	St. Louis.
Peatrex Ltd.	10162 93d Ave. North Maple Grove, MN 55369	do.	Carlton.
Perlite (expanded):			
USG Interiors Inc., a subsidiary of USG Corp.	Arch St. Cloquet, MN 55720	Plant	Do.
Sand and gravel:			
Construction:			
Barton Contracting Co.	10633 89th Ave. North Maple Grove, MN 55369	Pits and plants	Hennepin and Washington.
Cemstone Products Co.	2025 Centre Pointe Blvd. Suite 300 Mendota Heights, MN 55120	Pit and plant	Washington.

TABLE 6—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued:			
Construction—Continued:			
Fairway Construction Co.	Box 426 Hector, MN 55342	Pits and plants	Meeker and Renville.
Fischer Construction Co. Inc.	6801 West 150th St. Apple Valley, MN 55124	do.	Dakota.
C. S. McCrossan Inc.	7865 Jefferson Hwy. Maple Grove, MN 55369	do.	Dakota and Hennepin.
Northwestern Aggregates, Model Stone	400 West 61st St. Minneapolis, MN 55419	Pit and plant	Dakota.
J. L. Shiely Co.	1101 North Snelling Ave. St. Paul, MN 55108	Pits and plants	Dakota, Hennepin, Washington.
Industrial:			
Twin City Silica Ltd.	499 Cottage Grove Dr. Woodbury, MN 55125	Pit and plant	Washington.
UNIMIN Corp.	258 Elm St. New Canaan, CT 06840	Pits and plants	Le Sueur and Scott.
Slag, iron and steel:			
International Mill Service Co.	1818 Market St. Philadelphia, PA 19103	Plant	Washington.
Stone:			
Crushed:			
Granite:			
Meridian Aggregates Co.	Box 69 St. Cloud, MN 56301	Quarries and plants	Stearns and Yellow Medicine.
Limestone and dolomite:			
Bryan Rock Products Inc.	Box 215 Shakopee, MN 55379	do.	Scott and Washington.
Edward Kraemer & Sons Inc.	1020 West Cliff Rd. Burnsville, MN 55337	Quarry and plant	Dakota.
Mathy Construction Co., Patterson Quarries Div.	Route 3, Box 15 St. Charles, MN 55972	Quarries and plants	Fillmore, Houston, Olmsted, Wabasha, Winona.
Roverud Construction Inc.	601 Highway 44E. Box 606 Spring Grove, MN 55974	do.	Houston and Fillmore.
J. L. Shiely Co.	1101 North Snelling Ave. St. Paul, MN 55108	do.	Scott and Washington.
Quartzite:			
New Ulm Quartzite Quarries Inc.	Route 5, Box 21 New Ulm, MN 56073	Quarry and plant	Nicollet.
Traprock (basalt):			
Del Zotto Construction Co.	2300 Commonwealth Ave. Duluth, MN 55806	do.	St. Louis.
Dimension:			
Granite:			
Cold Spring Granite Co.	Cold Spring, MN 56320	Quarries	Big Stone, Mille Lacs, Renville.
Do.	do.	Quarries and plant	Stearns.
Limestone:			
Biesanz Stone Co. Inc.	Box 768 Winona, MN 55987	do.	Winona.
Minnesota Quarries Inc.	Box 1358 Mankato, MN 56002	do.	Blue Earth.

TABLE 6—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone—Continued:			
Dimension—Continued:			
Limestone—Continued:			
Vetter Stone Co.	Route 5, Box 41 Mankato, MN 56001	Quarries and plant	Blue Earth and Le Sueur.
Sulfur (recovered):			
Ashland Petroleum Co., a division of Ashland Oil Inc.	Box 391 Ashland, KY 41101	Elemental sulfur recovered as a byproduct of oil refining	Washington.
Koch Refining Co., a division of Koch Industries Inc.	Box 2302 Wichita, KS 67201	do.	Dakota.

THE MINERAL INDUSTRY OF MISSISSIPPI

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Office of Geology, Mississippi Department of Environmental Quality, for collecting information on all nonfuel minerals.

By Doss H. White, Jr.,[1] S. Cragin Knox,[2] and Michael B. E. Bograd[3]

In 1991, Mississippi's nonfuel mineral value was $102 million, $10 million less than that reported in 1990, the record year for mineral value. The decline was due to the effects of the nationwide recession, which had a strong, negative impact on Mississippi's construction industry, the primary customer for much of the State's mineral output. Demand for two of the three major construction minerals mined or manufactured instate, cement and sand and gravel, fell more than $15 million while sales of the third, stone, rose by only $1.1 million. The decline in mineral demand and sales did not affect the State's ranking of 42d in U.S. mineral value.

TRENDS AND DEVELOPMENTS

Over the past 20 years, Mississippi's mineral value has varied from $36 million in 1971 and 1973 to a record high of $112 million in 1990. During this period, mineral value, in 5-year intervals, was as follows: 1971—$36 million; 1976—$70 million, (a $34 million increase); 1981—$91 million, (a $21 million increase); 1986—$101 million (a $10 million increase); and 1991—$102 million (a $1 million increase).

The above data illustrate that although mineral sales have risen during the past 20 years, the increases are becoming smaller and the trend in 1991 has reversed.

Approximately one-third of the State's mineral sales is derived from sand and gravel, which historically has been a high-volume, low unit price commodity. As previously noted, much of Mississippi's mineral output of cement, sand and gravel, and crushed stone is used in the construction industry. Any event or series of events such as a regional or nationwide recession affecting construction also impacted the demand for and sales of much of the State's mineral commodities.

Developments during 1991 included the change of ownership of the ball clay operation near Crenshaw[4] and the move of a Louisiana iron company into Mississippi.[5] Chevron Oil Co.'s 530,000-short-ton-per-year ammonia plant at Pascagoula was dismantled and rumored to be destined for Pakistan. Mississippi Chemical Corp. (MCC) was constructing a 200,000-short-ton-per-year nitric acid plant at Yazoo City. The facility was scheduled to come on-stream in late 1992. The company produced ammonia, nitric acid, ammonium nitrate, urea, and urea-ammonium nitrate solutions at other Yazoo City facilities.

MCC was unable to locate a buyer for its repossessed diammonium phosphate plant at Pascagoula. The company planned to restart the plant using imported Moroccan phosphate rock in late 1992.

The Department of Energy placed the salt dome near Richton on the list of sites to be considered for the planned additions

TABLE 1
NONFUEL MINERAL PRODUCTION IN MISSISSIPPI[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	short tons	899,373	$23,573	817,828	$16,196	1,172,213	$34,382
Gemstones		NA	5	NA	1	NA	1
Sand and gravel (construction)	thousand short tons	e15,600	e51,500	13,032	45,817	e9,900	e33,000
Stone (crushed)	do.	1,069	3,994	e1,400	e5,500	1,632	6,603
Combined value of cement [masonry (1989-90), portland], clays [ball, fuller's earth (1990), kaolin (1991)], and sand and gravel (industrial)		XX	28,539	XX	44,799	XX	27,873
Total		XX	107,611	XX	112,313	XX	101,859

eEstimated. NA Not available. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.

to the Strategic Petroleum Reserve storage facilities.[6]

EMPLOYMENT

Mining employment in the nonfuel sector during 1991 decreased by 400 workers or 6.7%. Employment in the oil and gas extraction sector decreased by 500 workers or 9.3%.[7]

REGULATORY ISSUES

The search for a site to bury hazardous wastes narrowed from 417 to 8, 5 of which are on Mississippi State University (MSU) lands. All 12,000 acres of the MSU property is underlain by the Selma Chalk, an impervious formation of calcium carbonate that would help inhibit any waste flow escaping from a landfill. In neighboring Alabama, the hazardous waste disposal site at Emelle, operated by Chemical Waste Management Inc., is in the Selma Chalk.

During the year, the State's scrap metal companies, citing low level radiation, began rejecting loads of scrap. The radioactivity was associated primarily with scrap metal from oilfield-related facilities in Mississippi and Louisiana.[8] Steel mills, the major customer for scrap metal, tightened their guidelines for scrap purchases.

EXPLORATION ACTIVITIES

Clay County was awarded a Federal grant to drill an exploratory hole through one or more coalbeds underlying the county. The hole would help determine the possibility of establishing a coalbed methane extraction industry. Plantation Petroleum Corp. was picked to drill the $181,000 hole north of West Point.

LEGISLATION AND GOVERNMENT PROGRAMS

The Mississippi Legislature passed two bills, signed into law by the Governor, that were of interest to the State's mineral industry. House bill 812 required the Commission on Environmental Quality (CEQ) to consider the following factors when imposing penalties: willfulness of the violation, damage to any natural resources, cost of restoration, economic benefit of noncompliance, seriousness of violation, and past performance history. House bill 1269 clarified regulation of the disposal of oilfield exploration and production waste. The CEQ would regulate commercial disposal. The State Oil and Gas Board would regulate on-site disposal and all Class II underground injection wells.

The Mississippi Department of Economic and Community Development (DECD) provided a $70,000 grant to a Louisiana company to drill a methane test hole in Clay County. The moneys were given to DECD by the Federal Government from price-overcharge funds collected when oil prices were regulated.

The Mississippi Office of Geology continued research into the geology and mineral resources of Mississippi; regulatory responsibilities for surface mining also continued. The Surface Geology Division continued mapping the Wilcox Group and its contacts with the underlying Midway and overlying Claiborne groups; results will be applied to a planned revision of the State geologic map. The study area has current and potential interest for lignite, brick clays, and kaolinitic clays. The Surface Geology and Environmental Geology divisions cooperated in obtaining a 530-foot continuous core through the Eocene Yazoo Clay. The core's mineralogy and micropaleontology are being studied by a variety of researchers. The Energy and Coastal Geology Division staff published several articles in petroleum trade journals and in Mississippi Geology. The Coastal Geology Section acquired field data along the coast and barrier islands to document coastal erosion, sediment transport, and framework geology.

The Mining and Reclamation Division continued to enforce the Mississippi Surface Mining and Reclamation Act of 1977 by issuing permits, inspecting permitted areas and complaints, overseeing reclamation, and enforcing orders. During calendar year 1991, 926 inspections were performed, 63 permits and 102 notices of exempt operations were issued, and 141.1 acres was reclaimed with resulting bond releases. At yearend, the State had on file 418 mining permits covering a total of 10,718 acres.

The Mississippi Mineral Resources Institute (MMRI) received its basic support from a direct appropriation by the State of Mississippi and from the U.S. Bureau of Mines. Additional support was generated through grants and contracts from State and Federal agencies and private industry. During fiscal year 1990-91 (July 1990-June 1991), 14 grants involving 16 principal investigators were funded. Final reports were placed on open file and were available for distribution for a nominal cost to cover photocopying and mailing.

Several of the projects were on the State's nonfuel mineral resources. Among these were (1) Mineral Resource Potential of the Jackson Dome, (2) Exploration for Heavy Minerals in Ancient Strand Line Sands of Mississippi, (3) Assessment of Mississippi Clays, (4) Engineering Geologic Evaluation of Surface and Near-Surface Clay Resources in South-Central Mississippi, (5) Boracite Group Minerals Associated with Subsurface Evaporite Formations in East-Central Mississippi and West-Central Alabama, and (6) Geologic and Economic Feasibilities of Selected Clay, Sand and Gravel, Heavy Mineral, and Associated Deposits in Mississippi.

The MMRI staff were involved with several projects, including (1) helping State governments secure natural gas as economically as possible, (2) locating ground water reserves for the city of Corinth, (3) serving on the committee to locate a hazardous waste disposal site, and (4) assuming the lead role in a task force to address fossil energy exploration and development research.[9]

Tennessee-Tombigbee Waterway Authority officials announced that mineral products ranked second through fifth in tonnage among the cargos shipped through the Tennessee-Tombigbee Waterway, which flows through northeastern Mississippi. Wood chips ranked first, followed by crushed stone,

asphalt, coal, and "fuel." The "Tenn-Tom" has averaged shipping 5 million tons of cargo annually. In 1991, a new contract between an Alabama steam plant and a western Kentucky coal producer increased shipments by 1 million tons of coal annually, a 20% increase in the waterway tonnage.[10]

U.S. Bureau of Mines personnel at the Intermountain Field Operations Center in Denver, CO, reviewed Environmental Impact Statements (EIS) pertaining to federally funded projects in Mississippi. The EIS reviews were to determine that mineral resources or mineral mining and/or processing facilities were not impacted negatively by the project(s).

The U.S. Army Corps of Engineers issued the required permits for the Lowndes County Port Authority to dredge a 2,800-foot gravel bar, southeast of the port in the old Tombigbee River channel. Removal of the bar will speed development of a barge fleeting area that will hold up to 100 barges. A port spokesperson noted that the bar removal and fleeting area development was all that was needed to complete the port facilities.[11]

The U.S. Department of Energy (DOE) placed the salt dome near Richton on the Strategic Petroleum Reserve storage facility list. The dome, one of the largest of the 550 gulf coast salt domes, is 8 miles long and 2 1/2 miles wide at its widest point. If selected, 15 storage caverns capable of holding 10 million barrels each would be developed in the dome's central area. The storage site would be connected by pipeline to a marine loading facility at Pascagoula.[12]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

During 1991, 418 industrial mineral operations were licensed by the State. The majority, 84%, was sand and gravel operations; the remaining 16% was for clays and crushed stone.

Cement.—Holnam Inc. completed its first full year of operations of the former United Cement portland cement plant at Artesia in Lowndes County. The facility, designed to use the wet process, used locally mined chalk and sand, iron mill scale from Alabama, and gypsum from Spain for cement manufacture. The chalk, sand, and scale were blended into a slurry, which was injected into a 14- by 500-foot, coal-fired kiln. The resulting clinker was ground with gypsum to produce a grey portland cement. The material was marketed throughout a nine-State area. The gypsum and coal were trucked from the Lowndes County port on the Tennessee-Tombigbee Waterway. The plant's output was estimated to have decreased 11% and value declined 8%.

Clays.—Mississippi ranked 11th among the 44 States with clay production. For the first time, clays were the leading mineral commodity, valuewise, produced instate; sales accounted for approximately 33% of the total mineral value. Output of common clay, ball clay, and fuller's earth totaled 1.2 million tons valued at $34.4 million, a slight increase over the tonnage and value reported for 1990. One firm reported the production of a small tonnage of kaolin. Based on the geology of this deposit this material should be classified as common clay.

Ball Clay.—Two firms, Kentucky-Tennessee Clay Co., a subsidiary of Hecla Mining Co., and United Clays Inc., a subsidiary of Watts Blake Bearne & Co. PLC, mined and processed ball clay in northwestern Mississippi near the community of Sledge.

Processing included drying, grinding, and bagging. Kentucky-Tennessee sold their output primarily to the tile and asphalt filler markets, and United Clay produced a product for the fiberglass and ceramic fixtures markets. Output and value increased slightly over those reported in 1991.

Bentonite.—Sales by Mississippi's three bentonite producers ranked the State third among the 11 States with bentonite production. Only Wyoming and Montana reported higher sales and production. Both conventional and acid-activated processing were used; two of the four acid-activated bentonite plants in North and Central America were in Mississippi. Output and value, 210,000 metric tons and $6.8 million, fell 79,000 metric tons and almost $7 million below the 1990 levels of 289,000 metric tons and $13.6 million.

The three producers, Applied Industrial Minerals Corp. (AIMCOR), American Colloid Co., and Engelhard Corp., operated surface mines in the east-central part of the State. Two of the firms purchased and processed Arizona bentonite.

AIMCOR mined and processed calcium bentonite at a property near Aberdeen in Monroe County. The deposit was mined with scrapers and draglines; the crude bentonite was air dried, shredded, sized, and bagged. Sales were to the foundry industry as a mold binder and to the animal feed industry for a pelletizing medium.

The Aberdeen area was also the site of American Colloid Co.'s mine and processing plant. Locally mined clays were processed by conventional methods, drying, shredding, sizing, and packaging. Mississippi- and Arizona-mined bentonites were also processed using the acidulation process to produce a product for specialty clay sales. The clays were treated with sulfuric acid, washed, dried, sized, and bagged. Mississippi acid-treated bentonite was sold to the vegetable oil industry as a filter to remove impurities. Acid-treated Arizona bentonite was sold to the desiccant industry.

Engelhard Corp. operated a processing plant in Jackson and mines in Monroe and Smith Counties. Both Mississippi and Arizona bentonites were processed at the Jackson facility using conventional and acid activation methods. The conventionally processed Arizona clays were marketed for desiccant applications, and the acid-activated clays were sold to the vegetable oil and petrochemical industry.

Common Clay.—Production of common clay was reported by 9 companies operating 13 pits. Production, 638,000 metric tons, exceeded the previous year's production by 110,000 metric tons. Value increased from $2.6 million in 1990 to $6.6 million in 1991.

Boydstun Lumber Co., Louisville, mined and marketed clay to brick companies in Alabama, Louisiana, and Mississippi. Seven brick companies were active during the year; one purchased clay from Boydstun, and six operated mines instate. Two firms supplemented Mississippi clay production with clay from Alabama mines. One firm mined clay for the manufacture of lightweight aggregate at a plant in Jackson.

Fuller's Earth.—Oil-Dri Production Co. Inc. and AIMCOR mined and processed fuller's earth, a high-absorbency clay, in north-central Mississippi. The mines and plants were in the Ripley-Blue Mountain area of Tippah County. Production totaled 313,000 metric tons valued at $21 million. This was an increase in both tonnage and value over that reported for 1990.

Both companies operated surface mines and trucked the raw clay to processing plants where it was shredded, air dried, calcined, sized, and bagged. Oil-Dri's output was marketed primarily as an industrial waste absorbent and agricultural products carrier. AIMCOR's production was sold as a pet and industrial waste absorbent and agricultural products carrier.

Sand and Gravel.—Sales of construction and industrial sand and gravel accounted for approximately one-third of the State's mineral value. Production and value fell below that reported in 1990 as a result of a downturn in construction activity and demand for mold/core and sandblasting applications.

Construction.—Production of construction sand and gravel is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This report contains estimates for 1989 and 1991 and actual data for 1990.

The estimated production of construction sand and gravel, 9.9 million short tons, was 3.1 million short tons below the tonnage reported by industry in 1990. Value declined $2.8 million below the 1990 sales.

In the last year that a full industry canvass was obtained, production was reported by 68 firms operating 117 mines in 36 counties. The industry operated 45 stationary and 35 portable processing plants. Three counties, Copiah, DeSoto, and Itawamba, produced more than 1 million tons. The major end uses reported were for concrete aggregate, asphaltic concrete, and road base/cover.

Industrial.—Huey Stockstill Inc., Pearl River County, and Tri-Sands Inc., Tishomingo County, reported industrial sand output and sales. Output and value declined 7% from that reported in 1990.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This report contains actual data for 1989 and 1991 and estimates for 1990.

Production and value, 1.6 million short tons valued at $6.6 million, exceeded the 1990 estimate by 200,000 short tons and $1.1 million.

Production was reported by five firms from, in descending order of tonnage, Lowndes, Tishomingo, Clay, Smith, and Noxubee Counties. Four of the companies produced Cretaceous chalk and the fifth produced a Paleozoic limestone. Holnam Inc., the leading producer, mined chalk for use in cement manufacture. The second leading producer, Vulcan Materials Co., mined limestone for traditional aggregate applications. The other three companies mined chalk for agricultural applications.

Sulfur (Recovered).—Five firms recovered sulfur from refineries in Clarke, Jackson, Lamar, and Rankin Counties. Output totaled 695,000 metric tons valued at $47 million. This was a decrease of 8,000 metric tons and $1.4 million.

Other Industrial Minerals.—Table 1 in this chapter contains data on mineral commodities mined in the State. A number of other mineral commodities were shipped into Mississippi and were used for plant feed and/or manufactured into a higher value product.

Anhydrous ammonia was produced by Mississippi Chemical Corp. at its Yazoo City plant. Natural gas feedstock was the raw material used in ammonia manufacture.

TABLE 2

MISSISSIPPI: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate: Other construction materials[2]	708	2,696	$3.81
Agricultural: Agricultural limestone	57	346	6.07
Unspecified:[3]			
Actual	850	3,502	4.12
Estimated	17	59	3.47
Total	1,632	6,603	4.05

[1]Includes limestone.
[2]Includes riprap and jetty stone, concrete aggregate, coarse, bituminous aggregate, coarse, bituminous surface-treatment aggregate, railroad ballast, stone sand, concrete, stone sand, bituminous mix or seal, graded road base or subbase, and crushed run or fill or waste.
[3]Includes production reported without a breakdown by use and estimates for nonrespondents.

TABLE 3
MISSISSIPPI: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	7	1,069	$3,994	$3.74	5	1,632	$6,603	$4.05

Cobalt, manganese oxide, and iron oxide pigments were shipped into the State by several brick companies as a coloring agent. The materials were obtained from suppliers in Georgia and Texas. Barite mined in Georgia was also purchased by several of the brick companies for use in the brickmaking process.

Ilmenite and synthetic rutile were shipped into the State by E. I. du Pont de Nemours & Co., DeLisle, and Kerr-McGee Chemical Corp., Hamilton. The titanium minerals were used in the manufacture of titanium dioxide pigments. The DeLisle plant obtained ilmenite from Australia. Work began in June on three tanks to hold 15,000 tons of ilmenite each at the Port of Gulfport. These tanks, and an existing 50,000-ton tank, will be used to store ore for the DeLisle plant. The synthetic rutile was obtained from a Kerr-McGee plant in Alabama.

Lime was shipped into a plant at Vicksburg by Falco Lime Inc. The material, marketed for a soil stabilization agent to pulp and paper mills and water-treatment plants, was obtained from a Missouri firm. Falco Lime also marketed calcium carbonate and kiln dust.

Perlite, a volcanic rock, was expanded by Mansville Products Corp. at a plant in Natchez and by USG Interiors Inc. at Greenville. Mississippi maintained its first place ranking in expanded perlite output. Sales were to the formed products, roof, and insulation board industries.

Rock salt, shipped into the State by KemaNord Inc., Columbus, was used to manufacture sodium chlorate. The salt was purchased from a mining company in Louisiana. The end product was sold to paper mills for pulp bleaching.

Stone (dimension) was shipped into the State by a number of stone companies for cemetery monument and architectural applications. Granite and marble were the major stone types marketed.

Metals

Mississippi's metal industry processed both metallic ores and scrap.

Iron and Steel.—Birmingham Steel Corp. operated a 210,000-short-ton-melting-capacity minimill at Flowood near Jackson. The company continued to evaluate plans to upgrade the facility's furnace, caster, and rolling mill.

At yearend, Bethlehem Steel Co. and National Steel Co. were considering a site in Mississippi, along with sites in the south-central and Southwest United States, for a new $100 million galvanized sheet steel plant.

Manganese.—Electrolytic manganese metal was produced at a Kerr-McGee Chemical Corp. plant in Hamilton. Manganese ore, imported from west Africa, was used to produce a metal for the aluminum industry, the principal market for the Hamilton plant output.

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[1]State Mineral Officer, U.S. Bureau of Mines, Tuscaloosa, AL. He has 31 years of mineral-related industry and government experience and has covered the mineral activities in Mississippi since 1989. Assistance in the preparation of the chapter was given by Maylene E. Hubbard, editorial assistant.

[2]Director, Mississippi Office of Geology, Jackson, MS.

[3]Geologist, Mississippi Office of Geology, Jackson, MS.

[4]Industrial Minerals (London). Hecla Buys Indusmin Feldspar Mines. No. 281, Feb. 1991, p. 13.

[5]Picayune Item. New Industry Opens in Picayune. Dec. 22, 1991.

[6]Richton Dispatch. Richton Salt Dome Suitable for Oil Storage. Nov. 28, 1991.

[7]Mississippi Labor Market, Mississippi Employment Security Commission. V. 43, No. 2 Supplement, Mar. 1992, p. 2.

[8]Natchez Democrat. Radiation in Fields Affects Businesses. Feb. 2, 1991.

[9]The Mississippi Mineral Resources Institute. Annual Report. FY 1990-1991.

[10]West Point Times Leader. Officials See Good Year for Tenn-Tom Waterway. Mar. 19, 1991.

[11]Vicksburg Evening Post. Dredge Permit Signed for Columbus Port. Jan. 31, 1991.

[12]Richton Dispatch. Richton Salt Dome Suitable for Oil Storage. Nov. 28, 1991.

MISSISSIPPI

LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Agr Li	Agricultural Lime
BC	Ball Clay
Bent	Bentonite
CC	Common Clay
Cem	Cement plant
CS	Crushed Stone
Ful	Fuller's earth
Lime	Lime plant
SG	Sand and Gravel

Principal Mineral-Producing Localities

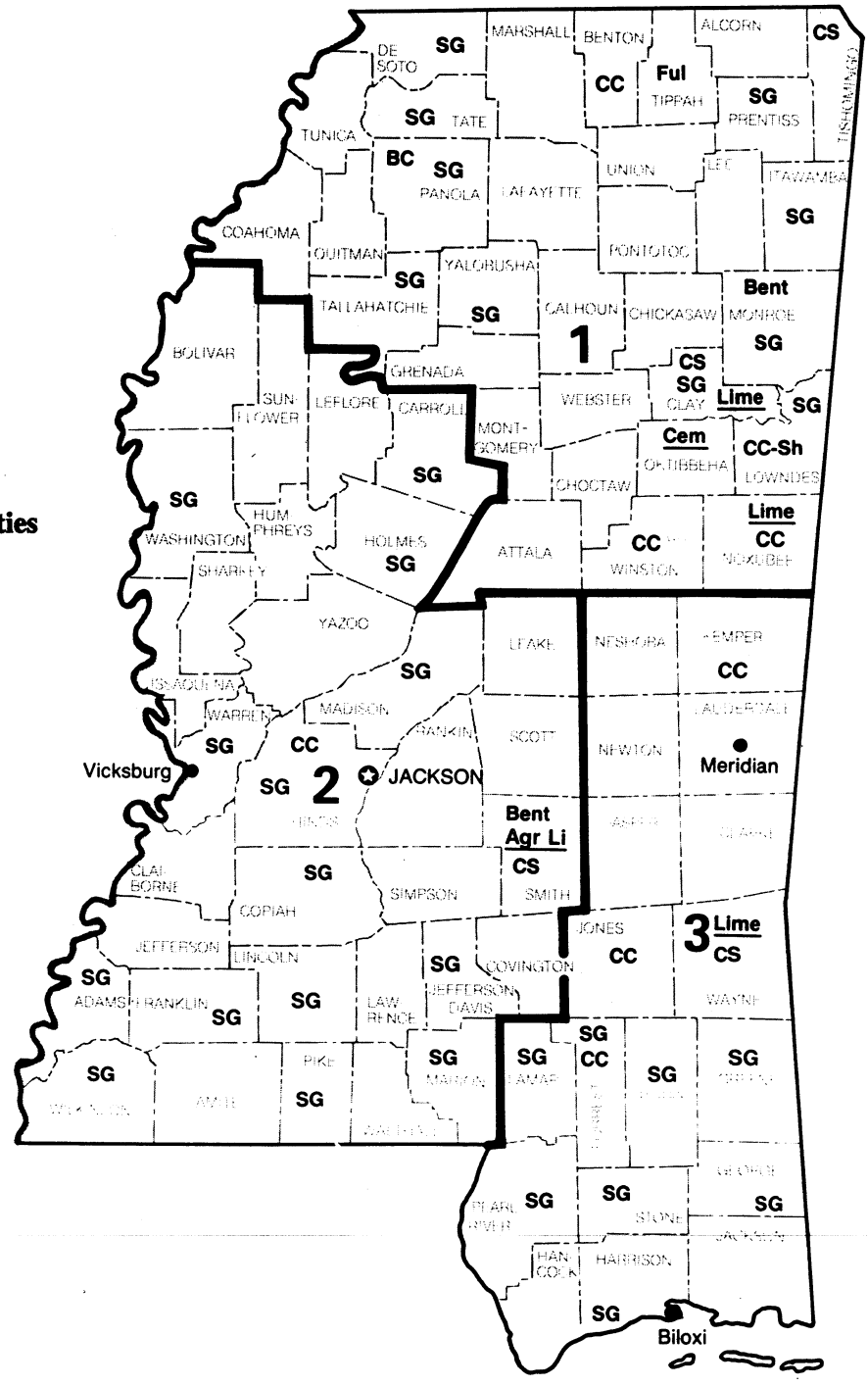

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
United Cement Co.	Box 185 Artesia, MS 39736	Plant	Lowndes.
Clays:			
Ball:			
Kentucky-Tennessee Clay Co.	Box 449 Mayfield, KY 42066	Mine and plant	Panola and Quitman.
Bentonite:			
Applied Industrial Minerals Corp.	Route 4, Box 366 Aberdeen, MS 39730	do.	Monroe
American Colloid Co.	Drawer 608 Aberdeen, MS 39730	do.	Do.
Engelhard Corp.	Box 8337 Jackson, MS 39204	do.	Monroe, Smith, Hinds.
Common:			
Boydston Lumber Co.	Box 207 Louisville, MS 39339	Mine	Winston.
Columbus Brick Co. Inc.	Box 866 Columbus, MS 39703	Mine and plant	Clay and Lowndes.
Delta Brick Div., Boral Bricks Inc.	Box 431 Macon, MS 39341	do.	Kemper, Noxubee, Jones, Winston.
Tri-State Brick & Tile Co. Inc.	Box 31768 Jackson, MS 39206	do.	Hinds.
Fuller's earth:			
Applied Industrial Minerals Corp.	Box 37 Blue Mountain, MS 38610	do.	Tippah.
Oil-Dry Production Co. Inc.	Box 476 Ripley, MS 38633	do.	Do.
Sand and gravel:			
Construction:			
American Sand & Gravel Co.	Box 272 Hattiesburg, MS 39401	Mines and plant	Forrest, Jones, Lamar, Pearl River, Perry.
Blain Sand & Gravel Co.	Box 278 Mount Olive, MS 39119	Mines and plants	Various.
J. J. Ferguson S & G Co.	Box 660 Greenwood, MS 38930	do.	Carroll and Holmes.
Industrial:			
Tri-Sands Inc.	Route 1, Box 17 Trafford, MS 35172	Mine and plant	Tishomingo.
Stone (crushed):			
Vulcan Materials Co.	Box 418 Iuka, MS 38852	Quarry and plant	Do.
Limeco Inc.	Route 1, Box 431 West Point, MS 39773	do.	Clay.
United Cement Co.	Box 185 Artesia, MS 39736	do.	Lowndes.

THE MINERAL INDUSTRY OF MISSOURI

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Missouri Department of Natural Resources, Division of Geology and Land Surveys, for collecting information on all nonfuel minerals.

By Jeanne Zelten[1] and Ardel Rueff[2]

The value of nonfuel mineral production in Missouri reported to the U.S. Bureau of Mines for 1991 was more than $880 million. This was a decrease of nearly $225 million, or almost 20%, below that reported in 1990. The value of the three leading mineral commodities, lead, portland cement, and crushed stone, decreased almost $160 million from the 1990 total, a decrease of almost 20%. Missouri ranked 12th nationally in production of nonfuel minerals. The State ranked first in the production of lead, lime, and fire clay; second in crude iron oxide pigments; and third in the production of barite, fuller's earth, and finished iron oxide pigments.

TRENDS AND DEVELOPMENTS

Environmental opposition to exploratory drilling, as well as to both new and expanded mining, continued throughout the State.

Mark Twain National Forest's Supervisor upheld a decision to allow access to forest lands for exploratory drilling for lead. In 1990, The Doe Run Co. proposed to drill up to 20 exploratory holes south of Winona in the Eleven Point District of the forest. Five appeals over the approval were made by environmental groups, including the Local Committee for a Lead-Free Ozarks, the Sierra Club, and the Coalition for the Environment. Concern centered on possible pollution of the water supply, nearby springs, and Wild and Scenic Rivers; destruction of the national forest environment; and the presumption that exploration would be followed by lead mining. In the mid-1980's, Doe Run had initially requested permission to drill up to 250 exploratory holes on 119,000 acres in Mark Twain National Forest. An Environmental Analysis, completed January 1991, resulted in a Finding of No Significant Impact (FONSI) by the U.S. Forest Service. The FONSI is consent from the Forest Service to the Bureau of Land Management, which administers

TABLE 1
NONFUEL MINERAL PRODUCTION IN MISSOURI[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	4,922	$182,005	4,481	$180,090	e4,276	e$171,040
Clays[2]	metric tons	1,479,898	14,665	1,347,558	12,864	2,001,537	11,060
Iron ore (usable)	thousand metric tons	1,060	W	1,002	W	e224	W
Lead[3]	metric tons	366,931	318,320	r380,781	r386,345	351,995	259,841
Sand and gravel:							
Construction	thousand short tons	e10,000	e32,500	9,243	25,097	e7,400	e20,100
Industrial	do.	750	9,972	W	W	W	W
Silver[3]	metric tons	53	9,456	r42	r6,434	35	4,483
Stone (crushed)	thousand short tons	51,754	171,848	e53,100	e190,900	47,938	167,233
Zinc[3]	metric tons	50,790	91,885	48,864	80,355	42,506	49,453
Combined value of barite, cement (masonry), clays (fuller's earth), copper, gemstones, iron oxide pigments (crude), lime, stone (dimension), and values indicated by symbol W		XX	219,236	XX	r220,555	XX	197,141
Total		XX	1,049,887	XX	r1,102,640	XX	880,351

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.

[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2]Excludes certain clays; kind and value included with "Combined value" figure.

[3]Recoverable content of ores, etc.

mineral leasing on Federal land, to drill on the national forest. Permission to drill was granted April 8, on the condition that Doe Run use certain practices to prevent ground and water pollution. The company has an estimated 10 to 20 years of ore reserves left in its mines near Viburnum. It would take from 10 to 15 years to complete studies, permitting, and planning for a new mine. The company has been mining in the forest for more than 35 years. Further opposition was anticipated if lead deposits were discovered.

Renewed interest was shown in the Mississippi Valley type mineralization near the Viburnum Trend. Leasing for exploration increased over that of previous years. Considerable emphasis was placed on the regional setting of known deposits.

The city of Olathe, in Johnson County, proposed to construct an asphalt plant near Johnson County Industrial Airport. The city wanted to annex approximately 87 acres about one-half mile east of the airport. No objection was raised by the Airport Commission. Last year, the Airport Commission opposed a plan by Holland Corp. for a 160-acre mining operation near the airport. The Olathe City Council refused to rezone the property and was sued by the company. The quarry was opposed because of concerns that flying debris might hit planes coming in to land.

Innovative methods of landfill reclamation were demonstrated in Fred Weber's North Quarry, 20 miles northwest of St. Louis, St. Louis County. The operation produced more than 1 million short tons of aggregate per year, and also disposed of more than 25% of the trash from the St. Louis metropolitan area. In 1974, the company started a solid waste municipal landfill in a 200-foot-deep mined-out section of the quarry. The landfill was one of the largest in Missouri. In 1981, the company began recovering methane from the landfill. The methane was used to supplement natural gas in firing an aggregate dryer and hot-oil heaters in an asphalt plant. During the winter, the gas also was used to heat an on-site commercial greenhouse.

Missouri Mining Co. applied for a permit for a solid waste landfill about 3½ miles northwest of Queen City, in Schuyler County. The permit was denied by the Missouri Department of Natural Resources (DNR) because the company did not adequately study ground water at the proposed landfill site. The company appealed the decision.

Gravel operations along several rivers, in Cedar, Dallas, Greene, Miller, St. Clair, and Webster Counties, were shut down or moved because of the presence of the Niangua Darter, a fish protected by the Endangered Species Act.

W. A. Ellis Construction Co. applied for rezoning (from agricultural to heavy industrial) of about 250 acres of land to expand its quarry operations. The application covered land adjacent to the company's Missouri Rock Quarry, east of Liberty in Clay County. After extensive opposition and appeals by residents, Ellis withdrew the application in November.

Les Mitchell applied to the Lafayette County Planning and Zoning Commissioners to rezone, to heavy manufacturing, a 159-acre tract of land southwest of Bates City, Lafayette County. The tract included his present quarry operation, which had run out of rock. Mitchell wanted to add a portable batch plant to the site in order to receive a State contract to produce asphalt for use on the area's roads. Residents opposed the rezoning, citing greater traffic risks and other concerns. The commission approved a Conditional Use Permit, which allowed mining operations to continue in an area adjacent to the present quarry. The permit was for the life of the mineral. Mitchell's quarry was the only rock source in the county.

Expansion of the Central Stone Co. limestone operation in Ralls County was protested by local residents because of noise, road damage, blasting, and a variety of environmental concerns.

EMPLOYMENT

Employment in Missouri's nonfuel mining industry in 1991 averaged 4,700, a 7.8% decrease from the 5,200 employed in 1990.[3] An average of 908 workers were employed at underground mines, 1,752 at surface operations, and 2,709 at mills and preparation plants.[4] In addition, an average of 312 coal miners employed at surface mines was a decrease of about 10% from the 347 employed in 1990.[5]

In the mineral-dependent construction industry, the annual average number of employees was about 88,100, a decrease of about 9.8% from the 97,700 average for 1990. Employment in the stone, clay, and glass products sectors decreased to 10,400 by December, down 700 workers from the 11,100 employed in December 1990. In the primary metal products sector, employees numbered about 12,200 in December, about 100 fewer than in December 1990.[6]

According to the U.S. Department of Labor, injuries resulting in lost workdays reported from more than 4.7 million hours worked in nonfuel surface and underground mines in 1991 totaled 115 (28 from underground mines, 87 from surface operations). Included were 80 injuries with no lost workdays (33 from underground mines, 47 from surface operations) and 1 fatality (surface operation). During nearly 5.4 million hours worked at mills and preparation plants, an additional 146 injuries, which resulted in lost workdays, and 134 injuries, in which no days were lost, occurred. In addition, surface coal mines reported 30 injuries resulting in lost workdays and 5 injuries with no days lost during 911,422 hours worked. Five injuries resulting in lost workdays were reported during more than 76,000 hours worked at coal plants.[7]

REGULATORY ISSUES

In addition to more stringent environmental regulations and the national trend toward recycling, the need for recycling batteries was expected to intensify in Missouri because of a new State law, which became effective January 1, mandating that automobile batteries could no longer be placed in landfills. Because the majority of lead

consumed in the world is secondary lead, recycling became the growth sector of the lead industry.

The U.S. Department of Defense removed more than 350 barrels of depleted uranium from a warehouse in De Soto, western Johnson County. After unsuccessful efforts to force Chemical Commodities Inc. to dispose of its uranium, the Environmental Protection Agency (EPA) turned to the Department of Defense. Environmental law dictates that any party that ever owned a hazardous material, including the Government, retains responsibility forever. The Defense Department sold the uranium as surplus to Chemical Commodities 26 years ago. The Agency removed the uranium drums from the building, sampled the contents, and repackaged the material for disposal elsewhere. The warehouse floor and earth beneath the building were tested for contamination. Tainted flooring and soil were removed and disposed of offsite.

LEGISLATION AND GOVERNMENT PROGRAMS

House bill 108, signed by the Governor in July, authorized the State to join the Interstate Mining Compact (IMC) and to participate in various conservation efforts related to mining. The IMC was organized to ensure that mining is pursued while at the same time protecting and restoring land, water, and other affected resources. Under the IMC, the Interstate Mining Commission, consisting of one voting member from each State, was established to carry out the provisions of the bill, resolve disputes between member States, and submit an annual report to the Governors and legislators of member States. House bill 108 also created within the DNR the Mining Practices Advisory Council to advise the State's Interstate Mining Commission member and make recommendations to the Governor.

House bill 759 did not pass, but could have had a severe impact on the lead mining industry in the State. The bill would have levied a severance tax on all lead mined in Missouri in an amount equal to 5% of the value at the first point of sale. There also would be a tax on recycled lead. The taxes would be in addition to all other applicable taxes imposed. Proceeds from the taxes would be deposited into the State general revenue account to pay for removing lead paint in older housing.

Senate bill 45, signed by the Governor in August, authorized the DNR to impose administrative penalties for violations of environmental laws and programs, consistent with penalties identified in the Federal Resource Conservation and Recovery Act. This act concerns pollution, health hazards, and public nuisances of land, waters, or air pertaining to solid and hazardous wastes, surface and underground mining, air and water quality, and underground storage tanks.

House resolution 321 would have eliminated the House Mines and Mining Committee from the list of standing committees in the House and incorporated it into the Energy and Environment Committee. This would have been a crippling blow to the mining industry. An amendment retaining the Mines and Mining Committee was later approved in the House.

House bill 403 created the Land Survey Advisory Committee to advise the Director of the DNR on issues concerning the regulations needed to carry out the Department's functions and duties.

House bill 727 would have established a mine map repository in the DNR Division of Geology and Land Survey. The repository would have contained mine maps of all closed underground mines and mineral rights ownership maps for all active underground mines in the State. The maps would be open for examination by all interested parties. The bill was expected to be reintroduced early in the next session and was expected to pass.

Senate bills 199 and 221 required that abandoned core drill holes, water wells, or other holes drilled in the earth be filled and sealed according to specific procedures. The purpose was to help protect ground water supplies and enhance safety. The Missouri Limestone Producers Association recommended the use of quarry screenings for filling the hole and a layer of watertight clay for capping it. The bill also required drillers to pass an examination prior to issuance of a permit.

Senate bill 421 redefined hazardous waste violations and increased fines to a maximum of $25,000 per day. Suit can be filed in any county where such violations occur, and time limitations for the prosecution of hazardous waste violations will begin when the DNR first becomes aware of evidence of such an event.

Missouri's new solid waste management law, Senate bill 530, took effect January 1, 1991, and required long-range regional planning to reduce the amount of waste created and disposed of in landfills. Local governments and citizens organized solid waste planning systems suited to their regional needs and preferences. Financial assistance would be funded by a fee levied on each ton of solid waste disposed of in a landfill. The new law required recycling of such items as tires, motor oil, large appliances, and batteries.

The DNR developed a funding proposal to be placed on the 1992 election ballot. A 3% severance tax would be levied on all minerals mined in the State and a 1% product fee would be imposed on the value of stone and other industrial minerals used in manufacturing and construction. Fees for pollution discharges into the air and water, fees on water usage, and other fees also were included. The tax and fees were part of a $131 million proposal to support several DNR programs.

The Missouri Division of Geology and Land Survey and the U.S. Geological Survey (USGS) completed the third year of a joint evaluation of Precambrian iron ore deposits for possible Olympic Dam-type deposits. Mapping at the Pea Ridge Mine was completed, and the map will be published by the USGS. Logging of 100,000 feet of core from Cominco American Inc.'s Boss-Bixby deposit and from the Camels Hump deposit was begun. Exploration for and interest in

this type of deposit decreased somewhat in 1991, owing primarily to depressed economic conditions. As many as five companies conducted geochemical or geophysical surveys or drilling, mostly on private lands.

The USGS and the State Geological Surveys of Illinois, Indiana, Kentucky, and Missouri jointly appraised the mineral resource potential of the Paducah 1° x 2° quadrangle, which overlies parts of all four States, as part of the Conterminous United States Mineral Assessment Program (CUSMAP). In addition to mineral resources, bedrock and surficial geology maps, geophysics, and other maps were produced. Results were to be published in 1992. The Rolla, Springfield, Harrison, and Joplin 2° quadrangles previously were completed under the CUSMAP program. The Paducah project was the first of the five Missouri CUSMAP's to have a completely digitized data base and to utilize Geographic Information System technology in regional resource assessment. Other cooperative projects with the USGS included mapping bedrock geology of three 7½ minute quadrangles in the St. Louis-Memphis corridor as part of the Cooperative Geologic Mapping Program.

The U.S. Bureau of Mines Rolla Research Center investigated the potential for the recovery of rare-earth elements and other valuable minerals from Missouri iron mines. This was a continuation of a previous study to recover rare earths from breccia pipes at the Pea Ridge Mine. Barium, copper, gold, silver, and tin were identified in the ores and are possible byproducts. The new project addressed the recovery of rare earths from the iron oxide ore body, tailings, and mine waters at Pea Ridge and other iron ore deposits in southeastern Missouri. Other Rolla Research activities related to Missouri mining included purification of wastewater from mines and the treatment of abandoned tailings, especially in the Old Lead Belt in southeastern Missouri.

The School of Mines and Metallurgy at the University of Missouri-Rolla began a program providing upperclassmen a quarry-engineering emphasis. Courses in the departments of metallurgical, mining, geological, and civil engineering would be technical electives in existing mining engineering curriculums. Members of the National Stone Association and the National Aggregates Association agreed to employ selected students desiring to explore opportunities in the aggregates industry during the summer prior to their senior year. It was hoped that this would encourage permanent employment in the industry.

Under the State Mining and Mineral Resources Research Institute Program Act (Public Law 98-409), the U.S. Bureau of Mines awarded a basic allotment grant of $148,000 to the University of Missouri-Rolla. The monies were used to perform basic and applied research related to the State's mineral resources and for the general benefit of the Nation's mineral industry. Under stipulations of the act, the State was required to match this grant on a 2:1 basis.

The School of Mines and Metallurgy at the University of Missouri-Rolla received a $150,000 grant, to be paid over 5 years, from ASARCO Incorporated for the establishment of the Asarco Endowment Fund. The fund will be used for undergraduate scholarships and faculty support.

After years of negotiations, the Greer Spring Acquisition and Protection Act of 1991 authorized the Federal Government to purchase Greer Spring. Congress appropriated $3.6 million for the purchase of 6,900 acres along the Eleven Point River. The land was appraised at $4.5 million, but the owner reduced the price and the Anheuser-Busch Foundation, which once tried to purchase the spring to bottle its water, contributed funds. Mining would be prohibited, and timbering would be limited to salvaging fallen trees and protecting the forest. Access for recreational uses would be allowed. The 6,900 acres would be split into two separate tracts and controlled by the Forest Service. Almost 2,800 acres would be added to the Eleven Point Wild and Scenic River corridor, and a special management area would be established for the remaining 4,100 acres.

Toward yearend, the Division of Geology and Land Survey program was threatened with elimination as a result of proposed budget cuts by the Missouri General Assembly. A letter-writing campaign and widespread intervention by industry demonstrated public support for the agency. The matter was expected to be resolved early in 1992.

The Division of Geology and Land Survey continued with the placement of first order control monuments, using the geodetic positioning satellite. Projects continued in St. Louis, Kansas City, St. Charles, Rolla, Springfield, Joplin, and other areas of the State. A mark maintenance program, in cooperation with the National Geodetic Survey, also was started. The program will provide maintenance of all horizontal and vertical control stations in the State.

The first Midcontinent Industrial Minerals Workshop was organized by the Division of Geology and Land Survey, cohosted with the USGS and the U.S. Bureau of Mines, and held in St. Louis. The purpose was to address land use planning and the environmental aspects of rebuilding the infrastructure of the region through planned development. More than 100 city planners, resource managers, land reclamation specialists, industry representatives, and legal experts attended the 2-day meeting. Similar meetings were anticipated for the future.

EPA experimented with solutions to clean up areas contaminated with polychlorinated biphenyls (PCB's). One technique involved adding lime, although further investigation was necessary. Sites with major PCB contamination in the State were the Missouri Electric Works in Cape Girardeau and the Conservation Chemical Co. in Kansas City.

FUELS

Coal, oil, and gas were produced in Missouri in 1991, primarily for use as fuels.

In 1991, a total of about 2.3 million short tons of high volatile bituminous coal was produced from surface mines in Barton, Bates, Ralls, Randolph, and Vernon Counties. Production decreased

about 11.5% from the 1990 production of about 2.6 million short tons. In 1990, coal was produced from four mines. Annual coal production in Missouri has decreased steadily from a high of more than 6.7 million short tons in 1984. Most of the coal was used to supply 48 coal-fired electric generating units in the State.[8]

Coal occurs in Pennsylvanian formations in the northern and western regions of the State. Eastern Missouri is supplied from nearby Illinois coalfields.

Riedel Energy Inc. of Portland, OR, requested that more than 1,000 acres in Monroe County be rezoned, from agricultural to commercial, for the purpose of strip-mining coal. The high-sulfur coal was blended with Illinois coal to reduce the sulfur content. Most of the coal was sold to utility companies for electric power production. The company also requested to have 1,245 acres in Monroe County rezoned. Riedel was mining 426 acres in Ralls County, had an office in Hannibal, and was considering expansion of operations into Marion County.

Assessment of coalbed methane potential in the Forest City Basin, in the northwestern corner of the State, continued. A research proposal received favorable support from the State legislature. Continuing work under the National Coal Resources Data System included digitization of data for two 7½-minute quadrangles.

Marketed natural gas production was 15 million cubic feet in 1991, up from the 7 million cubic feet produced in 1990. Production of crude oil in 1991 was 150,000 barrels.[9] Crude petroleum production in 1990 was 146,000 barrels.[10]

One new field wildcat, a dry hole 240 feet deep, was drilled in 1991. In 1990, new field wildcats included one oil well and seven dry holes. Development in 1991 included 21 oil wells, compared with 2 oil and 2 gas wells in 1990. A new field was discovered in Bates County, in Pennsylvanian strata, 450 feet deep. The number of gas and gas condensate wells producing at the end of the year was six, down two from that of 1990.

Most oilfields and gasfields are in the western part of the State. Areas of interest for future exploration include the Forest City Basin in the northwestern corner of the State, the Lincoln Fold area in the northeastern corner, and the Mississippi Embayment area in the southeastern corner.

REVIEW BY NONFUEL MINERAL COMMODITIES

A variety of industrial minerals and metals were mined, manufactured, or recovered as byproducts in 1991. Missouri's industrial mineral sector accounted for well over one-half of the State's nonfuel mineral value produced. Lead and zinc constituted about 35%.

Industrial Minerals

Passage in November of the $151 billion Intermodal Surface Transportation Efficiency Act, with its 6-year Federal highway funding provisions, was expected to contribute to increased aggregate production in 1992. States must provide matching funds, 80% Federal and 20% State, to receive Federal highway funding. The bill will provide $183 million more per year for Missouri, a 73% increase over what it received on the average in the past 5 years. Significant improvements in roads and highways were anticipated and could lead to significant increases in aggregate consumption. Cement consumption in the State was expected to increase 5% to 6% in 1992. The increase was attributed to anticipated increases in highway work as well as in commercial and residential building.

Growth in the lime and limestone industry was enhanced by the Clean Air Act Amendments and other environmental legislation, which required the installation of stack scrubbers at coal-fired powerplants. Lime and pulverized limestone are used in the scrubbers to remove sulfur oxides from stack gases. As the required scrubbers are installed and plants are brought into compliance with the new regulations, the demand for lime and limestone is expected to increase over the next several years. Other areas of continued growth in usage included water treatment, to achieve proper pH balances, and the treatment of hazardous wastes.

Environmental and zoning regulations were cited as the primary reasons for making it increasingly difficult for the construction aggregates industry to expand existing quarries and to develop new quarry operations. As operations must move farther from market areas, transportation costs increase, ultimately affecting aggregate prices and competition.

A number of construction projects in Kansas City began in 1991 and were expected to continue throughout the 1990's, providing much-needed business to the construction industry and mineral producers supplying the area. Included are expansions at the city's convention center, the Kansas City International Airport, the zoo, flood control and beautification work, housing, and a variety of business and recreational projects.

Permit-authorized construction in 1991 totaled about $1,780 million. The number of residential single- and multi-family units was 17,661, and the value of nonresidential construction was $596.3 million. Nonbuilding construction, including highways, totaled $34 million.[11]

Barite.—Missouri ranked third of five States producing barite, and producers accounted for approximately 2.5% of the national tonnage and for about 3% of the value. Reported production and value were 52% and 74%, respectively, below those reported in 1990. Barite is a barium sulfate mineral used primarily as an oil-well-drilling mud additive to control gas pressure. Chemical-grade barite was used as a pigment and filler in paint and rubber manufacture and as a glass flux. Other uses were the preparation of barium compounds; as fillers and extenders in inks, paper, textiles, asbestos, and linoleum products; and as ballast in the tires of heavy construction equipment.

Baroid Drilling Fluids Inc., a division of NL Petroleum Services Inc., reported production from a surface mine in Washington County. The barite was crushed and ground at the company's two plants for use as fillers, extenders, and well-drilling muds. The company is the third largest domestic producer, with mines in Missouri and Nevada. Rich barite deposits occur across the central part of the State, primarily in karst structures. The deposits usually are less than 200 feet in diameter. Weathering of these deposits formed residual barite deposits. In Washington County, the blanketlike, residual deposits average 10 to 15 feet in thickness and cover wide areas.

Cement.—Portland and masonry cements constituted the second leading mineral commodity produced in the State, accounting for nearly 20% of Missouri's 1991 mineral value. The State retained its fifth place ranking in portland cement production among the 38 portland cement-producing States. Portland cement production and value, estimated at almost 4.3 million short tons valued at about $171 million, was 205,000 short tons and $9 million below the figures reported by the cement industry in 1990. The decline was due to the recession and a drop in housing construction. Masonry cement production and value decreased about 6%.

Cement plant locations are determined by the availability of raw materials (limestone, clay or shale, and sandstone) near river and rail transportation, which provide access to the Mississippi-Missouri-Ohio Rivers markets. Major sales were to ready-mix plants (72.4%), concrete products manufacturers (12.1%), and highway contractors (9.2%). Masonry cement was used in bricklaying and other masonry applications.

Continental Cement Co. of Hannibal, in Marion County, produced portland and masonry cement by wet-process methods. Holnam Inc., Dundee Div., of Clarksville, Pike County, produced portland and pozzolan cement by wet-process methods. Portland and masonry cement were produced by dry-process methods by Lone Star Industries Inc. of Cape Girardeau, Cape Girardeau County, and by Lafarge Corp., in Sugar Creek, Jackson County. River Cement Co. of Festus, Jefferson County, produced portland cement by dry-process methods.

Clays.—Missouri ranked fifth among the 44 States reporting clay and shale production. Fire clay, common clay, and fuller's earth were mined.

Among seven States producing fire clay, Missouri ranked first. Six companies reported production of 276,189 metric tons valued at almost $5.5 million from 30 pits in 7 counties. Sales were to the refractories industry. Fire clays, the common name for refractory clays, are resistant to high temperatures without any change other than dehydration. They are the most valuable clays produced and are found as filled sink and bedded deposits in the east-central and southeastern parts of the State. Uses included refractory brick, high-temperature-resistant mortar, crucibles, zinc retorts and condensers, and miscellaneous uses in foundries and steelworks.

The State ranked ninth of 43 States producing common clay. Reported production, 2,001,537 metric tons valued at more than $11 million, accounted for a major portion of the total clay and shale tonnage. Common clay was mined by 11 companies operating 10 pits in 7 counties. The leading counties, Pike, Stoddard, and Ralls, accounted for almost 92% of the total. Principal products manufactured from clay and shale included common brick and tile, pottery, fillers, lightweight aggregates, and a raw material used in the manufacture of cement. These clays are present principally in the western and northern parts of the State in Pennsylvanian, Devonian, and Middle Ordovician formations.

Golden Cat Corp. purchased the Southern Clay Div. of Edward Lowe Industries Inc., including four mining and manufacturing operations, one of which was near Oran, Scott County. Production levels remained constant, and the company opened another clay mine near Avery, Hickory County, to supply the Oran plant. The plant manufactured granules for pesticide use in agriculture and for use as oil and grease absorbents.

The State ranked fifth among 10 States with fuller's earth production. One company reported production from two pits in Stoddard County. Sales were mainly to the absorbent industry for such applications as pet litter, oil absorbents, pesticide carriers, and in animal feeds.

Lime.—In 1991, the State ranked first among the 32 lime-producing States. Two companies, Ash Grove Cement Co. in Springfield, Greene County, and Mississippi Lime Co. in St. Genevieve, St. Genevieve County, reported production of both quicklime and hydrated lime. Resco Products Inc. in Bonne Terre, St. Francois County, reported production of quicklime. Lime sales were to the water-treatment industry, for oil refining, and for the manufacture of paper and steel. Mississippi Lime Co. was the top lime-producing plant in the country.

Lime is manufactured by heating or calcining limestone or dolomite in a kiln at high temperatures to drive off carbon dioxide. The resulting product is quicklime. Hydrated lime, the more stable form, is produced when water is added to the quicklime. Lime is used as a soil conditioner, as plant food, for soil stabilization, neutralization of acid mine and industrial wastewaters, and treatment of coal-fired plant stack gases to reduce sulfur dioxide emission. It is widely used as a flux and as a basic chemical. Most stone suitable for the manufacture of lime is found in the Ordovician Plattin Formation and the Mississippian Burlington and Keokuk Limestones.

Sand and Gravel.—Both construction and industrial sand and gravel were mined in Missouri during 1991.

Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates.

This chapter contains actual data for 1990 and estimates for 1989 and 1991.

The value of construction sand and gravel ranked fifth among the industrial minerals produced in Missouri in 1991. According to State records, 116 companies produced sand and gravel during the year. Construction sand and gravel is found as alluvial deposits along rivers, streams, and their floodplains, especially along the Mississippi and Missouri Rivers. Material also is dredged from these rivers. Terrace deposits are found in the southeastern corner, and glacial deposits are found in the northwestern part of the State. The principal uses were as aggregate in concrete mortar, plaster, in asphalt paving materials, as ballast on railroads and highways, and as a filler.

Industrial.—Missouri ranked 13th among the 37 States with industrial sand and gravel production. Industrial sand production was reported by three companies operating four mines in two counties. Production decreased 0.6% and value decreased almost 4% below that reported in 1990.

Industrial sand was produced along the Mississippi and Missouri Rivers in the eastern part of the State, from the Ordovician St. Peter Sandstone. The principal use was as glass sand. Minor uses included abrasives, flux, refractory material, ceramics, chemical uses, filter media, engine sand, and other special industrial purposes.

Stone.—Both crushed and dimension stone were produced in Missouri during 1991. Stone was the third leading industrial mineral produced, accounting for about 19% of the State's total nonfuel mineral value. Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1990 and actual data for 1989 and 1991. Missouri crushed stone statistics are compiled by geographical districts as depicted on the State map. Tables 2, 3, and 4 present end-use data for this commodity in the eight Missouri districts.

Limestone and dolomite overlie more than 60% of the State. Igneous rocks, primarily felsite and granite, are exposed in the St. Francois Mountains of southeastern Missouri. Sandstone is widely distributed, but most deposits are thin and of low quality.

The utilization of a stone deposit is determined by the quality of the stone, demand, available transportation, and availability of the deposit. For some aggregate uses and for dimension stone, physical characteristics are significant. For some chemical and other specialized uses, chemical composition is important. If specific physical or chemical characteristics are not important, haulage distances, local demand, and availability are the determining factors.

Abandoned quarries have been used for waste disposal, a lake development, an athletic field, and homesites. Underground workings have been converted into office, warehouse, and factory space.

Crushed.—The value of crushed stone production, $167.2 million, was $23.7 million below that reported by industry in 1990. Production decreased from an estimated 53.1 million short tons in 1990 to 47.9 million short tons reported for 1991.

In 1991, crushed stone production was reported by 117 companies operating 184 quarries in 67 counties. Limestone, dolomite, granite, and sandstone were produced. Three counties, Jefferson, St. Genevieve, and St. Louis, accounted for almost 30% of the total production. Major uses were for graded roadbase, concrete aggregate, and riprap-jetty stone. Other uses included unpaved road surface, cement manufacture, bituminous aggregate, agricultural liming, and treatment of coal-fired plant stack gases to reduce sulfur dioxide emission.

Central Stone Co.'s new limestone quarry, in Ralls County, opened in April despite resistance from local residents. Protests centered on noise, road damage, and blasting. There were numerous complaints after the quarry opened. Central sought permit approval from the U.S. Army Corps of Engineers to construct a docking facility on the Mississippi River to load quarry products onto barges, to construct a levee around the mining area, and to work on Fools Creek, which runs through the quarry site. The company wanted to rechannel 1,000 feet of Fools Creek to mine limestone south of the creek. The Corps decided the program was in compliance with the Endangered Species Act, even though the project area included a bed of mussels so rare that the State declared it a sanctuary. Several of the 32 species of mussels are rare and endangered. Saverton residents filed suit against Central Stone Co., EPA, and the U.S. Army Corps of Engineers for discharging pollutants into the Mississippi River. Residents said the quarry damaged a wetlands area and a bald eagle roosting site and that a road across Fools Creek was in violation of wetland regulations. Residents feared more problems if Central received permission to expand its operation. The company purchased the 189 acres, 11 miles south of Hannibal, 9 years ago.

Barber & Sons Wholesale Tobacco Co.'s quarry won approval from the Jackson County Board of Zoning and Adjustment in April to expand limestone mining operations in Lee's Summit, near Lake Lotawana, despite opposition from hundreds of nearby residents and county employees. After mining the property, Barber & Son planned to transform it into as much as 6 million square feet of underground storage space. Crushed limestone from the existing quarry was used for construction and road building, and the company provided all of the county's gravel for the previous 2 years by bidding less than other rock producers in the area.

R & J Quarries opened a limestone and gravel operation in Versailles, Morgan County. The company hoped to sell to Morgan County and local individuals at a more reasonable price than material hauled from elsewhere. The same property was a quarry 20 years ago when Highway 5 was constructed.

TABLE 2

MISSOURI: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	743	2,833	$3.81
Riprap and jetty stone	4,029	11,433	2.84
Filter stone	322	1,067	3.31
Other coarse aggregate	146	534	3.67
Coarse aggregate, graded:			
Concrete aggregate, coarse	3,334	11,986	3.60
Bituminous aggregate, coarse	1,894	7,207	3.81
Bituminous surface-treatment aggregate	1,499	5,722	3.82
Railroad ballast	878	3,136	3.57
Other graded coarse aggregate	21	73	3.50
Fine aggregate (-3/8 inch):			
Stone sand, concrete	155	652	4.19
Stone sand, bituminous mix or seal	323	1,191	3.69
Screening, undesignated	1,035	3,606	3.48
Other fine aggregates	4	15	3.50
Coarse and fine aggregates:			
Graded road base or subbase	8,069	29,468	3.65
Unpaved road surfacing	2,472	9,669	3.91
Terrazzo and exposed aggregate	1	4	3.73
Crusher run or fill or waste	431	2,692	6.25
Other construction materials[2]	852	3,424	4.02
Agricultural: Agricultural limestone[3]	1,241	4,540	3.66
Chemical and metallurgical: Cement manufacture[4]	5,324	11,347	2.14
Special:			
Asphalt fillers or extenders	W	W	4.48
Other fillers or extenders	W	W	2.65
Other miscellaneous uses[5]	59	342	5.80
Unspecified:[6]			
Actual	8,762	34,754	3.97
Estimated	6,344	21,538	3.40
Total	47,938	167,233	3.49

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[1]Includes dolomite, granite, limestone, limestone and dolomite, miscellaneous stone, and traprock.
[2]Includes pipe bedding and roofing granules.
[3]Includes poultry grit and mineral food.
[4]Includes lime manufacture, dead-burned dolomite manufacture, and chemical stone.
[5]Includes withheld amounts for special and other specified uses not listed.
[6]Includes production reported without a breakdown by use and estimates for nonrespondents.

Dimension.—Two companies reported production of dimension stone in 1991. Missouri Red Granite Quarries Inc., Iron County, mined granite, and Beavers Stone Co., Camden County, mined sandstone. Both companies produced both rough and monument stone.

Missouri Red Granite Quarries Inc. operated a quarry on approximately 1,060 acres, about 4 miles north of Ironton, Iron County. Most of the granite was used for markers and monuments; some was used for buildings both in and out of State. Granite blocks were trucked from the quarry to Mount Airy, NC. The blocks were fabricated, cut and polished, and made into panels, small blocks, and other shapes. The finished pieces were trucked from North Carolina to St. Louis, MO, and other markets; more blocks were picked up from the quarry and trucked to North Carolina. The company attempted to interest the building industry in again using more "Missouri Red."

Another company, Graniteville Stone Products Co., began operations in November at an old granite quarry near Ironton, Iron County, mining Missouri Red granite. Quarrying started at the edge of an old pit, but operations were moved to the top of the hill where the granite was of better quality. Bad weather at yearend inhibited production, which already comprised about a dozen blocks of granite. Much of the granite was to be shipped to Georgia for sale. Eventually the company planned to install equipment at Graniteville to cut granite tile for floors and other decorative uses for sale to the building industry. The company applied for a $140,000 grant from the county commission to assist the new business.

Other Industrial Minerals.—Several industrial minerals, shipped into Missouri or produced as byproducts of other industries, either were sold as recovered or processed into higher value products.

Tripoli, a microcrystalline form of high-purity silica, occurs in deposits up to 12 feet thick in the Mississippian Boone formation. American Tripoli Inc., a subsidiary of NYCO Mineral and the Canadian Pacific Railroad, mined and processed tripoli quarried near Peoria, in Ottawa County, on the Oklahoma side of the border. The tripoli was transported to drying sheds at the company's mill in Seneca, Newton County, MO, to be crushed and processed. The processed material was used in buffing and polishing compounds, in concrete, and as a paint filler. The company spent $200,000 on improvements, including a new drying shed, and plans to install a new crusher next year.

Perlite was expanded by Georgia-Pacific Corp., in Crawford County, and by Brouk Co., in St. Louis County. The

TABLE 3

MISSOURI: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregates (+1 1/2 inch)[1]	479	1,914	W	W	64	250	W	W
Coarse aggregates, graded[2]	221	1,131	W	W	580	2,064	673	2,807
Fine aggregates (-3/8 inch)[3]	W	W	W	W	119	467	124	398
Coarse and fine aggregates[4]	W	W	W	W	1,399	7,470	1,305	4,466
Other construction materials	301	1,391	425	1,523	64	701	92	277
Agricultural[5]	94	370	(6)	(6)	(6)	(6)	81	218
Chemical and metallurgical[7]	—	—	(6)	(6)	(6)	(6)	—	—
Special[8]	—	—	—	—	—	—	—	—
Other miscellaneous uses	—	—	905	2,197	920	814	—	—
Unspecified:[9]								
Actual	1,077	6,135	205	587	1,976	8,935	773	2,822
Estimated	335	1,149	1,090	2,399	678	2,817	261	951
Total[10]	2,508	12,090	2,625	6,706	5,800	23,518	3,308	11,938

	District 5		District 6		District 7		District 8	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregates (+1 1/2 inch)[1]	454	1,592	64	266	W	W	3,961	11,096
Coarse aggregates, graded[2]	2,859	9,860	1,446	5,864	309	1,097	1,474	5,062
Fine aggregates (-3/8 inch)[3]	803	2,836	247	960	W	W	194	717
Coarse and fine aggregates[4]	4,257	15,365	1,415	5,578	276	1,072	1,794	5,699
Other construction materials	72	257	253	1,003	47	168	437	1,361
Agricultural[5]	(6)	(6)	(6)	(6)	92	357	(6)	(6)
Chemical and metallurgical[7]	(6)	(6)	(6)	(6)	—	—	(6)	(6)
Special[8]	—	—	(6)	(6)	—	—	—	—
Other miscellaneous uses	3,246	7,109	677	2,935	—	—	608	2,228
Unspecified:[9]								
Actual	2,037	8,638	8	37	459	1,540	2,228	6,061
Estimated	2,477	8,735	1,015	3,654	55	182	433	1,651
Total[10]	16,206	54,392	5,124	20,298	1,237	4,415	11,129	33,875

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap and jetty stone, filter stone, and other coarse aggregate.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), railroad ballast, other fine aggregate, and other graded coarse aggregate.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), and fine aggregate (screening-undesignated).
[4]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run (select material and fill), and pipe bedding.
[5]Includes agricultural limestone and poultry grit and mineral food.
[6]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[7]Includes cement manufacture, lime manufacture, dead-burned dolomite, and chemical stone for alkali works.
[8]Includes asphalt fillers or extenders and other extenders and fillers.
[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[10]Data may not add to totals shown because of independent rounding.

material was used in acoustic tile, concrete aggregate, cavity fill, and fillers. Brouk Co. also exfoliated vermiculite at its St. Louis plant. The vermiculite was used for refractory block and pool base. The St. Louis plant can produce up to 12,000 tons per year of both perlite and vermiculite.

A variety of gemstones, minerals, and fossils were collected by amateur collectors and professionals, both for private collections and for commercial sales. The materials were sold as specimens and formed into a variety of decorative items. Rock and mineral specimens included crystals of galena, sphalerite, chalcopyrite, dolomite, calcite, amethyst, quartz, and manganese. Ore minerals collected included galena, sphalerite, chalcopyrite, calcite, marcasite, silver, copper, tungsten,

TABLE 4
MISSOURI: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone[1]	207	47,978	$159,490	$3.32	163	44,698	$155,631	$3.48
Dolomite	11	1,159	3,979	3.43	15	1,652	6,221	3.77
Granite	2	W	W	2.63	2	W	W	3.38
Traprock	1	W	W	3.41	1	100	373	3.73
Sandstone	11	610	2,019	3.31	2	W	W	W
Miscellaneous stone	1	334	1,926	5.77	1	18	43	2.39
Total[2]	XX	51,754	171,848	3.32	XX	47,938	167,233	3.49

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Includes "Limestone/dolomite," reported with no distinction between the two.
[2]Data may not add to totals shown because of independent rounding.

nickel, and iron. Also collected were quartz and calcite lined geodes.

Precipitated calcium carbonate was produced by Mississippi Lime Co. at its plant in St. Genevieve County. Olivine, mined in Norway by A/S Olivine, was shipped to New Orleans, transferred to barges and moved up the Mississippi River to St. Louis, and trucked about 70 miles to the Pea Ridge Iron Ore Co. Inc.'s pelletizing plant in Washington County. The olivine was used as a binder in making iron ore pellets. Slag, a byproduct of steelmaking, was processed by Heckett Div. of Harsco Corp., Jackson County, and sold for use as a concrete aggregate, for fill, railroad ballast, and road base. Stone, primarily granite and marble, was shipped into the State and fabricated into monuments and used for architectural applications. Lee Fertilizer in Camden Point, Platte County, transported fertilizer by barges and trucks to a variety of markets.

A. P. Green Industries Inc. of Mexico, Audrain County, was a leading manufacturer and distributor of refractory products. The company also manufactured industrial lime products used in the production of steel, aluminum, and paper, and for road stabilization and water purification.

Metals

The metals sector of Missouri's mineral industry accounted for about 38% of the 1991 mineral value. The State continued as the leader among the 11 lead-producing States, contributing 75.5% of the total domestic lead production. Missouri ranked fourth among the 10 iron ore-producing States.

The State received mineral revenues, distributed to States by the Minerals Management Service and the Bureau of Land Management for onshore mineral leases on Federal lands, totaling $3,310,457 in 1991. This was a decrease of $3,605,483 from 1990 distributions of $6,915,940. Royalties were received for copper ($440,813), lead ($2,106,367), and zinc ($763,277).[12]

Copper, Lead, Silver, and Zinc.— Missouri was first of 11 States producing lead, fourth of 12 States producing zinc, sixth of 12 States producing copper, and eighth of 16 States producing silver in 1991. Reported production and value of lead decreased 7.5% and almost 33%, respectively, from the 1990 reported values. Zinc production and value also decreased, 13% and 38%, respectively, from those of 1990. Reported silver production and value decreased 16.5% and 30% below 1990 totals. Copper production and value also decreased substantially. Total value of lead produced in the State in 1991 was 348,000 metric tons valued at $256,861,000. This was 75% of U.S. production and 10% of world production.

Three important lead and zinc mining districts in Missouri are the Southeast Missouri lead district, which includes the Viburnum Trend and the Old Lead Belt; the Central Missouri district; and the Southwest district, which includes the Tri-State zinc-lead district of Kansas, Oklahoma, and Missouri. Copper and silver occur in the ore, but values are variable.

Three nonferrous metal producers, The Doe Run Co., Asarco and Cominco American Inc.-Dresser Industries, were active in the Southeast Missouri lead district. Lead was the primary metal mined; copper, silver, and zinc were recovered as byproducts during lead recovery. Mineralization occurred along the flanks of the St. Francois Mountains in the Cambrian Bonneterre Formation.

Lead was used mainly for batteries. Other uses included ammunition, collapsible tubes, cable covering, caulking, solder, foil, pigments, plumbing, and radiation shielding. Most of the lead used in batteries is later recovered and reused.

Zinc ores mined in Missouri were used for alloys, galvanizing, zinc oxide, and other metallurgical applications. Some zinc is processed at the American Zinc Co. smelter at Monsanto, IL, and at the AMAX Lead and Zinc Div. smelter at Blackwell, OK.

Copper is used in coins, electrical applications, brass manufacture, copper

tubing, alloys, and for various chemical uses.

Silver is used in the manufacture of photographic materials, sterling silverware, solder and brazing alloys, jewelry, optical goods, novelties, chemicals, various medicinal uses, and for dental amalgams.

The Doe Run Co., a subsidiary of Fluor Corp. of Irvine, CA, is North America's largest and only fully integrated producer of refined lead metal. Exploration and development efforts at the company's mines successfully added 2 million short tons to ore reserves during the year.

Doe Run completed construction and startup of a new, environmentally state-of-the-art lead recycling plant. Located at the idle Buick primary smelter site near Boss, Dent County, the Buick Resource Recovery Facility was designed to produce 60,000 short tons of finished lead annually from used lead-acid automobile batteries, used industrial batteries, and other lead-bearing materials. The $38 million facility was expected to increase Doe Run's production of refined lead from a capacity of 235,000 short tons to nearly 300,000 short tons per year. The increase was roughly one-fourth as much as the annual production from the company's primary smelter in Herculaneum. The new facility employs state-of-the-art industrial processes and waste management practices to ensure environmental protection, producing two-thirds less waste than conventional secondary plants. Nearly every part of each battery is recycled. Plastic cases are sent elsewhere for recycling, with all other battery parts recycled on-site. Battery acid is converted to sodium sulfate for laundry detergent and for use in the glass and paper industries. Construction began in May 1990, the facility was operational since July 1991, and lead production began in September. Full startup was achieved October 7, establishing Doe Run as the only significant U.S. supplier of both primary and secondary lead products. Doe Run was the first company to install such a sophisticated process in the United States.

In April, Doe Run cut its production of refined lead by 25% (60,000 short tons) and employment by 25% (260 workers) at its mining and milling divisions. Two of its six lead mines, the No. 28 Mine at Viburnum and the Brushy Creek Mine south of Viburnum, were temporarily closed, and one of two furnaces at the Herculaneum smelter was temporarily shut down. The company had been producing primary lead at its annual capacity of about 235,000 short tons and cut back to about 175,000 short tons. The reduction, aimed at lowering costs and matching lead production with lead market demand, was in response to a worldwide surplus and general U.S. economic recession. Slow automobile sales and a mild winter, combined with unusually high lead exports from the former Soviet republics, contributed to rising industrywide inventories and low lead prices.

In September, Doe Run's Fletcher mine and mill operation at Viburnum was awarded the 1990 Sentinels of Safety award, the Nation's most prestigious mine safety award, in the Underground Mine Division. The Fletcher operations won the award for completing 110,704 hours without an injury resulting in loss of a day's work. The award marks the third time that Fletcher has won in this category. Doe Run has won the award eight times, more than any other company in the United States.

Asarco produced lead from its Sweetwater and West Fork mine and mill complexes. The company reached an agreement on a new contract with union representatives at the Glover lead smelting and refining plant. The agreement will run until early 1994.

Cominco American Inc. sold one-half of its one-half share in the Magmont Mine to Asarco. Lead, zinc, and copper ore reserves at the mine were expected to be depleted within the next several years. Although exploration did not result in additional reserves, more ore will be removed from pillars than was originally anticipated. The company continued planning for shutdown of the mine.

Iron Ore and Iron Oxide Pigments.— Missouri ranked fourth of 10 States producing iron ore in 1991. The State ranked first of 5 States producing crude iron oxide pigments and third of 12 States producing finished iron oxide pigments. Production was from St. Louis and Washington Counties. St. Louis County produced synthetic black, brown, red, and yellow iron oxides, and Washington County produced magnetite. Reported iron ore production and value decreased dramatically in 1991, while reported crude and finished iron oxide pigment production increased substantially. Because of the recession in the steel industry, North American iron ore operations experienced decreases in production and shipments for the second consecutive year at a level below the 10-year high reached in 1989.

Three types of iron ore deposits have been mined in Missouri: filled-sink hematite deposits, brown iron ore (limonite) deposits, and Precambrian hematite and magnetite deposits. Sink and limonite deposits are smaller, lower grade, and less uniform than the Precambrian deposits and therefore not as good for pellets. Precambrian iron ore deposits have been mined and prospected primarily in the southeastern part of the State, in the core area of the Ozark uplift in Iron County.

Pea Ridge Iron Ore Co., owned by Big River Minerals Corp., was the Nation's only underground iron producer. The company produced specialty iron oxides for use in coal preparation, ferritic magnet production, and chemical manufacturing and iron ore pellets for the steel industry at its mine and processing facilities near Sullivan, Washington County. The pellet plant closed in 1991 but production was expected to resume in 1992.

Heavy-media magnetite was recovered as a coproduct at the Pea Ridge plant. The magnetite was sold to coal washing plants. Sales of a product containing 69.7% iron and 0.21% silica for ferrite permanent magnet manufacture continued.

Pea Ridge produced both crude and finished iron oxide pigments, and Columbia Chemical Co., of St. Louis,

produced finished pigments. Pigment sales were for use in the manufacture of paint and coatings, electronics, rubber, plastics, ceramics, polishing compounds, and as a source of iron in glassmaking.

Other Metals.—Missouri ranked seventh of 14 States producing aluminum in 1991. Noranda Aluminum Inc., a subsidiary of Noranda Mines Ltd. of Toronto, Canada, operated the State's only aluminum reduction plant in New Madrid County. Bauxite was transported by barges along the Mississippi River from the Port of New Orleans to the 204,000-metric-ton plant. Primary aluminum and electrical conductors were produced.

Armco Inc. operated its Midwestern Steel Div. at Kansas City, Jackson County. The facility produced carbon wire rods and grinding media.

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[1]State Mineral Officer, U.S. Bureau of Mines, Denver, CO. She has 14 years of mineral-related industry and government experience. Assistance in the preparation of the chapter was given by Pat LaTour, editorial assistant.

[2]Geologist, Missouri Department of Natural Resources, Division of Geology and Land Survey, Rolla, MO.

[3]University of Missouri-Columbia, B&PA Research Center. Statistical Abstract for Missouri 1991.

[4]U.S. Department of Labor, Mine Safety and Health Administration. Mine Injuries and Worktime, Quarterly. Jan.-Dec. 1991.

[5]Energy Information Administration. Coal Production 1991. Oct. 1992.

[6]Missouri Area Labor Trends. Apr. 1992.

[7]Work cited in footnote 4.

[8]Energy Information Administration. Coal Production 1990, Sept. 1991, and Coal Production 1991, Oct. 1992.

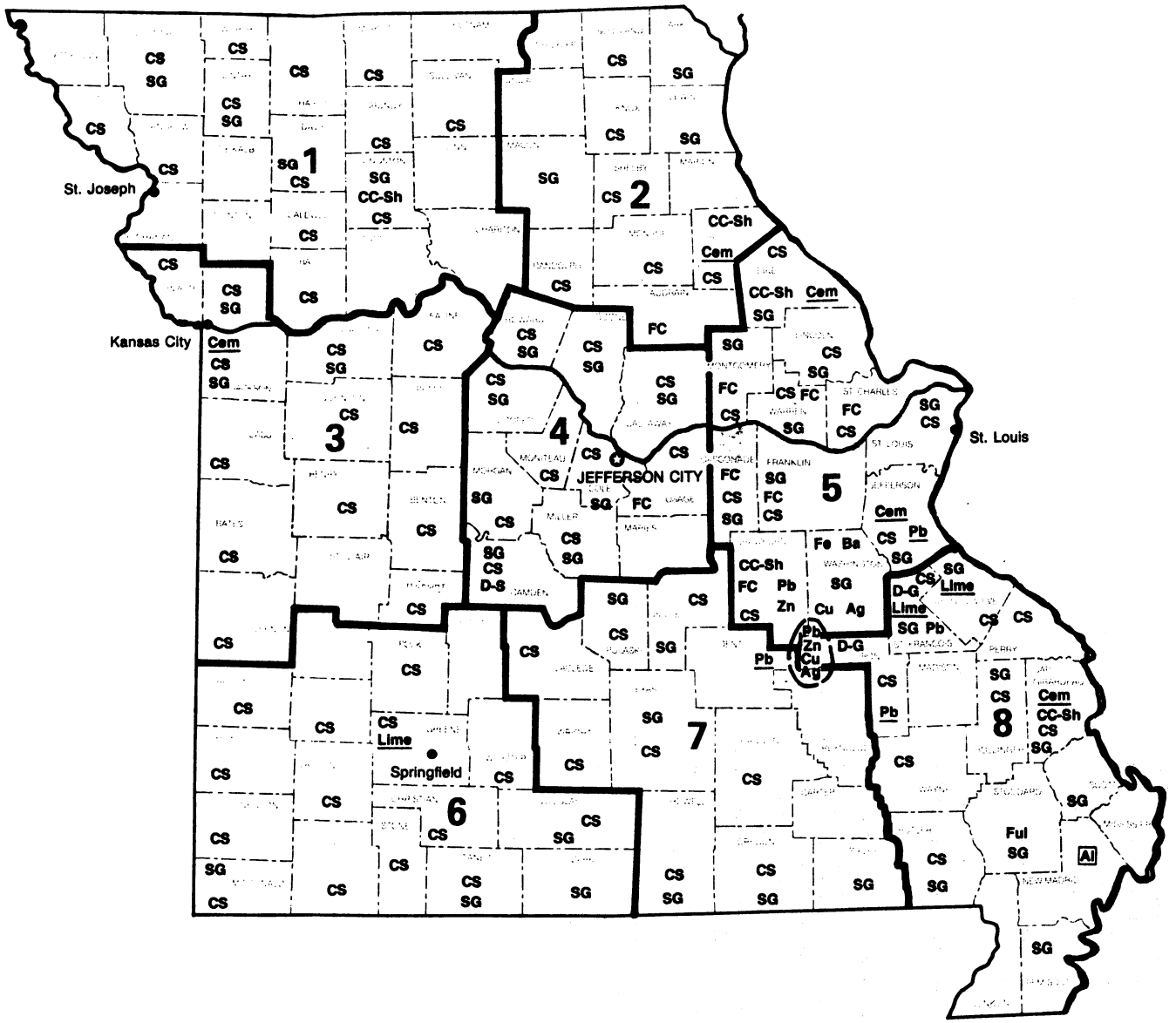
[9]———. Natural Gas Annual 1991, and Petroleum Supply Annual 1991.

[10]Work cited in footnote 3.

[11]U.S. Department of Commerce, Bureau of Census. Permit Authorized Construction in Permit Issuing Places.

[12]Minerals Management Service. Mineral Revenues 1991.

MISSOURI



LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Al	Aluminum plant
Ba	Barite
CC-Sh	Common Clay & Shale
Cem	Cement plant
CS	Crushed Stone
Cu	Copper
D-G	Dimension Granite
D-S	Dimension Sandstone
FC	Fire Clay
Fe	Iron
Ful	Fuller's earth
Lime	Lime plant
Pb	Lead
Pb	Lead smelter
SG	Sand and Gravel
Zn	Zinc
	Concentration of mineral operations

Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Noranda Aluminum Inc., a subsidiary of Noranda Mines Ltd.	Box 70 New Madrid, MO 63869	Plant (smelter)	New Madrid.
Barite:			
Baroid Drilling Fluids Inc., NL Baroid Industries	Box 218 Potosi, MO 63664	Mine and plant	Washington.
Cement:			
Continental Cement Co.[1]	Box 71 Hannibal, MO 63401	Quarry, clay pit, plant	Marion and Ralls.
Holdnam Inc., Dundee Cement Division, a subsidiary of Holderbank Financiere Glaris, Ltd.[2]	Box 67 Clarksville, MO 63336	Quarries and plants	Pike.
Lafarge Corp.[3]	Box 1017 Independence, MO 64051	Plant	Jackson.
Lone Star Industries Inc.[3]	Box 520, 25245 Spring St. Cape Girardeau, MO 63701	Quarry and plant	Cape Girardeau.
River Cement Co., a subsidiary of IFI International of Italy (Instituto Finanziario Industriale S.p.A.)[4]	Box 14545 St. Louis, MO 63178	Quarry and plant	Jefferson.
Clays:			
Buildex Inc.	Route 1, Box 224 Dearborn, MO 64439	Pit and plant	Platte.
Golden Cat Corp.	Box 1086 Cape Girardeau, MO 63701	Pits and plants	Scott and Stoddard.
A. P. Green Industries Inc.	Green Blvd. Mexico, MO 65265	do.	Audrain, Gasconade, Osage.
Iron ore:			
Pea Ridge Iron Ore Co., a subsidiary of Fluor Corp.[5]	Route 4 Sullivan, MO 63080	Underground mine and plant	Washington.
Iron oxide pigments (finished):			
Columbian Chemicals Co.	Box 16309 Lemay, MO 63125	Plant	St. Louis.
Lead:			
ASARCO Incorporated:[6]	Route 1, Box 202C Bunker, MO 63629		
Glover smelter	Box 7 Glover, MO 63646	Smelter	Iron.
Sweetwater Unit	Rural Branch Sweetwater, MO 63680	Underground mine and plant	Reynolds.
West Fork Unit	Route 1, Box 202C Bunker, MO 63629	do.	Do.
Cominco American Inc.-Dresser Industries:[6] Magmont Mine	Magmont Mine Rd. Bixby, MO 65439	do.	Iron.
The Doe Run Co.:[6]	11885 Lackland Rd. Suite 400 St. Louis, MO 63146		
Brushy Creek	Box 158 Viburnum, MO 63629	do.	Iron.
Buick	Route KK Boss, MO 65440	Underground mine, plant, smelter	Dent.
Casteel (Viburnum #35)	Highway 32 Bix, MO 65439	Underground mine	Inron.
Fletcher	Box 257 Bunker, MO 63629	Underground mine and plant	Reynolds.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Lead—Continued:			
The Doe Run Co.—Continued:			
Herculaneum smelter	Main St. Herculaneum, MO 63048	Smelter	Jefferson.
Viburnum No. 28	Box 500, St. Joe Blvd. Viburnum, MO 65566	Underground mine and plant	Iron.
Viburnum No. 29	Box 500, St. Joe Blvd. Viburnum, MO 65566	do.	Iron.
Lime:			
Ash Grove Cement Co.[3]	Route 3, Box 323 Springfield, MO 65804	Quarries and plant	Greene.
Mississippi Lime Co.	Drawer 31 St. Genevieve, MO 63670	Plant	Ste. Genevieve.
Resco Products Inc.	Box 440 Bonne Terre, MO 63628	Quarry and plant	St. Francois.
Perlite (expanded):			
Brouk Co.	1367 South Kingshighway Blvd. St. Louis, MO 63110	Plant	St. Louis.
Georgia-Pacific Corp.	Box N Cuba, MO 65453	do.	Crawford.
Sand and gravel:			
Construction:			
Holliday Sand & Gravel Co., a subsidiary of List & Clark Construction Co.	Box 12486 Kansas City, MO 64116	Dredges and plants	Clay.
Limited Leasing Co., a subsidiary of St. Charles Sand Co.	Route 1, Box 158 Hazelwood, MO 63042	Dredges and plants	St. Louis.
Winter Bros. Material Co.	13098 Gravois Rd. St. Louis, MO 63127	Dredge and plant	Do.
Industrial:			
All Purpose Sand Co., a subsidiary of St. Charles Sand Co.[7]	Route 1, Box 158 Hazelwood, MO 63042	Pit and plant	Do.
UNIMIN Corp.[8]	1779 Horine Rd. Festus, MO 63028	do.	Do.
U.S. Silica Co.	Box 96 Pacific, MO 63069	Dredge and plant	St. Louis.
Slag (iron and steel):			
Heckett Division of Harsco Corp.	Box 266309 Kansas City, MO 64126	Plant	Jackson.
Stone:			
Crushed:			
Granite:			
ISP Minerals Inc.[9]	Box 186 Annapolis, MD 20104	Quarry and plant	Iron.
Quality Aggregate Co.-Missouri Pacific Railroad	Box 307 Piedmont, MO 63957	do.	Wayne.
Limestone-dolomite:			
Bussen Quarries[8]	5000 Bussen Rd. St. Louis, MO 63129	Quarries and plants	Jefferson and St. Louis.
Hunt Midwest Mining Inc.	RR 13, 410 Randolph Rd. Randolph, MO 64161	Quarries	Clay and Platte.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone—Continued:			
Limestone-dolomite—Continued:			
Martin Marietta Aggregates	504 S. Hwy. 71, Box 269 Savannah, MO 64485	Quarries and plants	Andrew, Cass, Daviess, Gentry, Grundy, Harrison, Holt, Jackson, Mercer, Nodaway, Phelps, Worth.
Riverview Quarries Inc., J.H. Berra Construction Co.	Box 904 Florissant, MO 63032	Quarries	Jefferson, St. Fancois, St. Louis.
Tower Rock Stone Co.	Box 111 Ste. Genevieve, MO 63670	Quarries and plant	Ste. Genevieve.
Fred Weber Inc.	Box 2501 Maryland Hts, MO 63043	Quarries and plants	Jefferson, St. Charles, St. Louis.
Traprock:			
Missouri Portable Stone Inc.	Box 449 Warrenton, MO 63383	Quarry	Franklin and Warren.
Dimension:			
Granite:			
Graniteville Stone Products Co.	301 South Main Ironton, MO 63650	do.	Iron.
Missouri Red Granite Quarries Inc.	HCR 63, Box 3371 Ironton, MO 63650	Quarry and plant	Iron.
Sandstone:			
Beavers Natural Stone Co.	Box 322 Camdenton, MO 65020	do.	Camden.
Tripoli:			
American Tripoli Inc., a subsidiary of NYCO Mineral and Canadian Pacific Railroad[8]	Box 489 Seneca, MO 64865	Mill	Newton.
Vermiculite (exfoliated):			
Brouk Co.	1367 South Kingshighway Blvd. St. Louis, MO 63110	Plant	St. Louis.

[1]Also clay.
[2]Also clay and crushed limestone.
[3]Also crushed limestone.
[4]Also crushed limestone and crushed sandstone.
[5]Also crude iron oxide pigments.
[6]Also copper, silver, and zinc.
[7]Also construction sand and gravel.
[8]Also crushed sandstone.
[9]Also traprock.

THE MINERAL INDUSTRY OF MONTANA

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Montana Bureau of Mines and Geology for collecting information on all nonfuel minerals.

By R. J. Minarik[1] and R. B. McCulloch[2]

Montana's 1991 nonfuel mineral production value was $590 million, an increase of 3% from that of 1990. Gains in the production value of portland cement, copper, and gold more than offset the decrease in values of molybdenum, platinum-group metals, silver, crushed stone, and zinc.

Metallic minerals—copper, gold, iron ore, lead, molybdenum, platinum-group metals, silver, and zinc—accounted for more than 82% of Montana's total nonfuel mineral production value. The State ranked 17th nationally in value compared with 19th in 1990. Montana was the Nation's sole producer of platinum-group metals and ranked first in talc production; second for bentonite mined; third in vermiculite; fourth in the output of barite, copper, gold, molybdenum, and silver; fifth in lead, phosphate rock, and zinc production; and sixth in the output of natural gemstones.

TRENDS AND DEVELOPMENTS

Overall metal mining activity remained relatively strong, with only molybdenum and silver reporting a drop in quantity produced. On the other hand, prices for many of the metallic minerals produced in Montana were depressed. As a result, only gold and copper had increases in production values, which were enough to raise the value of metal production in 1991 by 5% over that of 1990. In 1991, gold was the leading metal produced in terms of value, followed by copper, platinum-group metals, and silver.

A variety of industrial minerals continued to be produced in the State. Total production value of industrial minerals dropped 5% from that of 1990. In 1991, portland cement was the leading industrial mineral produced in terms of value, followed by talc, construction sand and gravel, clays, and lime. One

TABLE 1
NONFUEL MINERAL PRODUCTION IN MONTANA[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	[2]95,743	[2]$1,835	[2]29,741	[2]$193	362,635	$11,332
Gemstones		NA	2,500	NA	3,692	NA	2,796
Gold[3]	kilograms	12,434	152,941	13,012	161,861	18,511	216,211
Palladium metal[4]	do.	4,850	22,454	5,930	21,735	6,050	16,923
Platinum metal[5]	do.	1,430	23,310	1,810	r27,176	1,730	20,635
Sand and gravel (construction)	thousand short tons	e5,800	e13,900	5,114	14,319	e4,800	e13,700
Silver[3]	metric tons	194	34,367	220	34,114	222	28,893
Stone (crushed)	thousand short tons	2,846	9,718	e4,000	e15,300	2,107	5,725
Talc and pyrophyllite	metric tons	453,978	12,718	430,125	18,883	W	W
Combined value of barite, cement, clays [bentonite (1990), fire (1989)], copper, graphite [natural (1989)], gypsum [crude (1989)], iron ore (usable), lead, lime, molybdenum, peat, phosphate rock, sand and gravel (industrial), stone (dimension), vermiculite, zinc, and values indicated by symbol W		XX	292,394	XX	r275,944	XX	274,082
Total		XX	566,137	XX	573,024	XX	590,297

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.
[3]Recoverable content of ores, etc.
[4]Palladium metal separated from platinum-group metals in 1990. Data revised for 1989.
[5]Platinum metal separated from platinum-group metals in 1990. Data revised for 1989.

highlight was the completed expansion of a quicklime facility, including the addition of a new kiln.

EMPLOYMENT

According to the Research and Analysis Bureau of the Montana Department of Labor and Industry, overall mining employment, including petroleum and coal industry workers, dropped to 5,800, a decrease of 500 workers from that reported in 1990. Metal mining employment decreased to 2,300 workers, compared with 2,600 employees in 1990. Average weekly earnings for Montana's mineral industry nonsupervisory personnel increased to $594 from the $591 figure recorded in 1990.

REGULATORY ISSUES

Work continued on cleaning up the Warm Springs Ponds section of the Silver Bow Creek/Butte area of the Clark Fork Superfund site. Contamination of the ponds was the result of decades of mining, milling, and smelting waste being dumped into Silver Bow Creek in Deer Lodge County. The Anaconda Co. built a series of three tailings dams to prevent waste from entering the Clark Fork drainage. During periods of high water, the creek was allowed to flow around the ponds down the Mill-Willow bypass; this practice is no longer allowed. Work included the removal of tailings and associated soils from the bypass, reinforcement of the existing ponds, and the construction of a new water-treatment facility.

EXPLORATION ACTIVITIES

There was a downturn in mineral exploration activity in 1991, according to the Montana Bureau of Mines and Geology (MBMG), with much of it confined to later stage projects. The primary target continued to be gold and other precious metals; however, interest started to build in massive sulfide deposits of copper, lead, and zinc. The Montana Department of State Lands reported a total of 207 active exploration permits in 1991, up from 202 in 1990. Of that total, 14 were new and the remainder renewals. The U.S. Bureau of Land Management reported the filing of 5,745 new mining claims in the State, compared with 6,692 in 1990 and 13,084 in 1989. The total number of active claims was estimated at 53,791. There were 194 plans of operation filed with the U.S. Forest Service, compared with 339 in 1990. Deer Lodge National Forest had the most at 73, followed, in order, by Kootenai, Helena, Gallatin, and Beaverhead.

In the northwest region, ASARCO Incorporated (Asarco) was preparing a draft Environmental Impact Statement (EIS) for its Rock Creek copper-silver project in the Cabinet Mountains, Sanders County. South of Libby, U.S.M.X. drilled and trenched its Libby Gold project. The former Orvana Resources property is sited between Flower and Granite Creeks. Also in Lincoln County, George Shaw drove exploration drifts on the Raven property in the Snowshoe drainage, Newmont Exploration Ltd. drilled its Tip Top project in the Branigan drainage, and Hardrock Mining Co. explored a gold vein system on Houghton Creek. Others with drilling programs included Kennecott Exploration on its Snake Creek project south of Troy; Asarco on properties in Rock Creek, Trout Creek, and Miners Gulch of the Vermillion River; Dorothy Davis on the Star Meadow project in the Meadow Creek mining district; and south of Plains, Cominco American Resources Ltd. on its Fork project. In the Garnet Mountains, Newmont drilled on its Copper Cliff property, and Pegasus Gold Inc. drilled and trenched along a trend between Garnet and Coloma. South of the Garnets, American Gold Resources and FMC Corp. explored in Upper Willow Creek and Miners Gulch. FMC also drilled and developed roads on its properties in Brewster Creek and Stoney Creek. South of Maxville, Cameco drilled and trenched on the Londondarry property, a former Westgold project. Northwest of Anaconda, Pegasus drilled its Hidden Lake property, and Independence Mining Co. drilled and built road on its Robinson and Northern Cross properties. North of Elliston, FMC drilled in the Meadow Creek drainage, and south of town, Phelps Dodge completed a portion of its drilling program on the Karger project, then began reclamation. East of Deer Lodge, Hecla Mining Co. drilled and trenched in the Emery district.

In the Helena region, the joint venture of Canyon Resources Corp. and Phelps Dodge continued exploration and development of the Seven-Up Pete and McDonald prospects near Lincoln. The venture continued to gather baseline data necessary for permitting the open-pitable gold deposits. The properties were purchased from Western Energy Co. Nearby, Phelps Dodge explored in the Keep Cool and Ethel Gulch areas. Near Rogers Pass, Leonard Orr drilled in the Alice Creek drainage and Asarco on its Heddleston project. Newmont explored the Swan project in the Elkhorn district south of Helena. In search of massive sulfides near White Sulfur Springs, Cominco American explored its Sheep Creek project, and the partnership of Kennecott Exploration and BHP Utah International conducted a drilling program on the Moose Mountain project on Adams Creek. Near Townsend, Pegasus, in a joint venture with FMC, had a massive drilling and road building program underway on its Miller Mountain project. Other drilling in the area included Independence Mining in Bar Gulch, east of Helena; Placer Dome U.S. Inc. in Keating and Charity Gulches west of Radersburg; Noranda Exploration Inc. in upper Cement Gulch near Townsend, and Amax Gold on the Blue Dick property west of Utica.

In the Butte region, North Lily Mining Co. drilled and trenched its Southern Cross property west of Anaconda, Deer Lodge County. Swansea Gold Mines contracted to have a large-scale bulk mining test at its Arcadia Placer mine near Wisdom, Beaverhead County. Others working in the area included Cyprus Metals Co. near the Old Faithful property, and Phelps Dodge near China Town, both in Beaverhead County; FMC

in the Rochester Basin near Twin Bridges; Reynolds and Compass Metals Co. on the Smith claims east of Twin Bridges; and Battle Mountain Gold at the Pacific Mine west of Virginia City.

In the south-central region, the joint venture of Noranda and Crown Butte Resources Ltd. continued exploration and reserve development at its New World deposit near Cooke City, Park County. Permitting of the property, which includes two open-pitable deposits and an underground reserve of copper, gold, and silver, was begun. The joint venture of Pegasus and Fischer-Watt Gold continued exploration of their Emigrant Gulch property, south of Livingston, Park County. An agreement was reached in which Pegasus could earn an interest in the property and be the operator. Also in the Emigrant Creek drainage, Harrison Western and Montana Mining and Reclamation evaluated placer gravels. East of Jardine, American Copper and Nickel Co. and the Jardine Joint Venture continued a long-term exploration program, including drilling, on property held by the joint venture. South of Big Timber, Pathfinder Gold and Pegasus completed geophysical work in the Independence Mining District.

In the north-central region, exploration was largely done by two operating companies, Canyon Resources near its C.R. Kendall Mine, Fergus County, and by Pegasus near its Zortman and Landusky properties in the Little Rockies, Phillips County.

LEGISLATION AND GOVERNMENT PROGRAMS

The Montana College of Mineral Science & Technology, Butte, received an allotment of $148,000 from the U.S. Bureau of Mines in 1991. The school has received a total of $3.12 million since inception of the Mineral Institute Program in 1978.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Aluminum.—The quantity of aluminum produced in Montana remained virtually unchanged from that of 1990, but the value dropped by almost 20% owing to the continued downturn in prices. Columbia Falls Aluminum Co., the State's sole aluminum producer, reportedly operated its Flathead County reduction plant near the annual rated capacity of 168,000 metric tons.[3]

Antimony.—United States Antimony Corp. produced antimony oxide and sodium antimonate for use in the glass industry at its refinery on Prospect Creek, about 18 miles southwest of Thompson Falls, Sanders County. Antimony metal and sulfide concentrates were purchased on contract from China.

Copper.—Copper production increased almost 18% in quantity and nearly 5% in value from that of 1990. Production was reported by three companies in two counties.

The Continental Pit in Butte, Silver Bow County, was the State's leading copper producer. The joint venture of Montana Resources Inc. (MRI) and Asarco, with MRI the operator, also produced gold, molybdenum, and silver. The operation has started pushing back the north wall, and since the pit has bottomed out on the south end, backfilling of that portion has begun. The bulk of the copper concentrates was shipped to Asarco's facilities in Arizona and Texas. In Lincoln County, Asarco operated its Troy Unit, the second largest copper producer in the State. A room-and-pillar mining method was used to extract ore from the 8,500-metric-ton-per-year copper-silver mine. In an effort to increase productivity, the company reduced staff through attrition and changed from 8-hour to 12-hour shifts. Asarco continued exploration in the Ross Creek drainage area in an effort to increase reserves. A small amount of byproduct copper production was reported by New Butte Mining Co. from its Butte Hill property.

Gold.—Gold production in Montana increased in both quantity and value from that of 1990. Production came from nine lode mines in five counties.

The Zortman-Landusky Mine, owned by Pegasus, was the State's largest gold producer; silver was produced as a byproduct. The Zortman and Landusky deposits are approximately 3 miles apart on either side of Antoine Butte in the Little Rocky Mountains, just south of the southern border of the Fort Belknap Indian Reservation, Phillips County. The mine is a conventional open pit, heap-leach operation, except that the ore does not require additional milling after blasting and can be processed as run-of-mine material. After ceasing the use of a contract mining company, all mining activities on the property now are handled by Pegasus employees. During the year, mining was done principally on the Landusky side, as Pegasus was doing preliminary engineering work and permitting on its Zortman expansion project. Production continued on the Zortman through leaching. The project includes construction of a crushing circuit, a new leach pad, and a conveyer system that will allow the company to process harder non-oxide ore on the flats.

Placer Dome operated the Golden Sunlight Mine, Montana's second ranked gold producer. Sited near Whitehall, Jefferson County, the open pit mine also produced byproduct silver. Processing included agitated vat leach with carbon-in-pulp recovery. Golden Sunlight had a decline in production owing to the mining of a lower grade transitional zone and the complex metallurgy of the ore. The company started construction of its new tailings facility.

Pegasus operated the Beal Mountain Mine in German Gulch near Anaconda, Silver Bow County. The open pit, heap-leach operation also produced silver as a byproduct. Construction of a new leach pad area was completed, and the company doubled the capacity of its treatment plant. A new permanent

crushing system was installed, replacing the portable crushing plant that was insufficient in treating the increasing amounts of harder ore found at depth.

Pegasus produced gold at its Montana Tunnels polymetallic mine 25 miles south of Helena, Jefferson County. The large-tonnage, low-grade deposit produced significant quantities of base metals employing a conventional milling circuit. Pegasus discontinued the use of contract miners at Montana Tunnels, and now all of the mining activities are done in-house. Installation of a new gravity circuit increased the overall recovery of gold. The lead concentrate, with the bulk of the precious metals, was trucked to Asarco's smelter at East Helena; the zinc concentrate was sent by rail to the Cominco smelter at Trail, British Columbia.

Although mining at Basin Creek was suspended in 1990 because of lower than anticipated ore grades and low prices, Pegasus continued leaching operations into 1991, when the property was put on a care-and-maintenance basis. Sited about 18 miles southwest of Helena, Pegasus bought the property from Pangea Resources Ltd. in 1989, built a new leach pad, and enlarged the operation.

Gold and silver were produced by Canyon Resources from its C.R. Kendall Mine in Fergus County. The company began construction of a "life of mine" leach pad and added a new storm drainage pond. Reclamation work was done on waste slopes, roads, and some of the pits. Exploration for additional ore bodies was done both near the mine and in the nearby Judith Mountains.

The Mineral Hill underground mine, a joint venture of TVX Gold Inc. and Homestake Mining Co., produced gold near Jardine, Park County. In an effort to maintain the zero discharge design of the surface milling and recovery facilities, the mine deposited dry tailings, the only one in the State to do so. Processing included vat leaching, followed by Merrill-Crowe zinc precipitation. A tailings liner expansion was completed, and a new disk filter system was installed. Exploration of the surrounding area continued.

Near Maiden, in the Judith Mountains, Fergus County, Blue Range Mining Co. produced a small amount of high-grade ore from the McGinnis property, which is adjacent to the closed Spotted Horse Mine. After a leak was detected at its tailings disposal site in 1990, Blue Range voluntarily stopped production from its nearby Geis and Gilt Edge Mines. The company, which processed the ore at the former U.S. Gypsum plant at Heath, was trying to sell the properties.

Additional gold production was reported by New Butte Mining from its zinc-silver Butte Hill Mine in Butte, Silver Bow County.

According to MBMG, placer gold production occurred at several localities. Some of the larger known placer operations were on Cedar Creek in the Superior area, Mineral County; in the Ninemile drainage, Missoula County; on Hughs Creek, Ravalli County; in Vermont and Avalanche Gulches, Meagher County; on Grasshopper Creek, Beaverhead County; and on Sauerkraut Creek and Lincoln Creek, Lewis and Clark County.

Iron Ore.—Iron ore was produced by Hallet Minerals Co. at its Black Butte Mine near White Sulfur Springs, Meagher County. The product was used instate in the manufacture of cement.

Lead.—Lead production increased more than 7% in quantity, but dropped 22% in value from that of 1990. Lead was recovered as a byproduct from three base and precious-metal mines in three counties. The Montana Tunnels Mine, Pegasus Gold's polymetallic operation near Helena, accounted for the bulk of the production.

Molybdenum.—The quantity of molybdenum produced decreased by almost 7% and value fell more than 27% from that of 1990. Molybdenum was recovered as a byproduct of copper production at Montana Resources' Continental Pit in Butte. The Silver Bow County mine was the State's sole molybdenum producer. Concentrates were shipped to foreign facilities for processing.

Platinum-Group Metals.—Platinum-group metal production remained essentially unchanged in quantity, but value decreased more than 23% from that of 1990. The Stillwater Mining Co. operated the Nation's only platinum-group metals mine in the Stillwater Complex, near Nye, Sweet Grass County. The mill concentrate was processed at the company's smelter, sited about 40 miles away in Columbus, Stillwater County. The palladium-platinum matte, which also contained copper, gold, nickel, and rhodium, was shipped to Belgium for additional processing. The company was preparing an EIS that would allow it to essentially double production and was seeking permits to build a new mine, its East Boulder project, south of Big Timber, Sweet Grass County, which would provide additional concentrates for the Columbus facility. Stillwater Mining is a joint venture of Manville Corp. and Chevron Resources Co., with Chevron the managing partner.

Silver.—Although the quantity of silver produced remained essentially unchanged, value dropped more than 15% from that of 1990. Output was reported from nine mines in five counties.

Asarco's Troy Unit was the State's largest silver producer and the fourth ranked silver-producing mine in the Nation. The 8,500-metric-ton-per-day underground copper-silver mine is in Lincoln County near Libby. The Montana Tunnels Mine was the State's 2d largest silver-producing mine and was ranked 13th in the Nation. Pegasus's Zortman-Landusky gold mine in the Little Rockies, Phillips County, ranked 3d in the State and 16th in the Nation for silver production. Ranked 4th in the State, Montana Resources' Continental copper mine in Butte was the Nation's 20th largest silver-producing mine.

Work was halted at the Montanore project, Noranda's massive silver-copper prospect in the Cabinet Mountains near Libby, Lincoln County. Citing

Montana's water nondegradation rules, the Department of State Lands ordered an immediate reduction of nitrate levels in nearby Libby Creek, and the company discontinued all blasting activities. Noranda contended that the nitrate levels in Libby Creek were below the levels allowed in drinking water and was seeking a State-sanctioned exemption. At the time of the work stoppage, a 4,900-meter development decline was nearing completion and an environmental impact statement was being reviewed. The property is owned by the joint venture of Noranda, 55%, and Montana Reserves Co., 45%. Montana Reserves reportedly was having cash-flow problems and was attempting to sell its share.

Zinc.—Although the quantity of zinc produced remained essentially unchanged from that of 1990, production value decreased by almost 29%.

Pegasus's Montana Tunnels polymetallic mine near Helena, Jefferson County, accounted for the bulk of the State's zinc production. The zinc concentrates were sent to Cominco's smelter at Trail, British Columbia, and also to Dowa Mining Corp. in Japan; the lead concentrates, which contain most of the precious metals, were processed at the Asarco smelter in East Helena.

Citing low prices, New Butte Mining closed its underground zinc-silver Butte Hill Mine in Butte, Silver Bow County. The ore had been trucked to the Contact Mill in Philipsburg for processing.

Industrial Minerals

Barite.—Rocky Mountain Minerals Co., formerly Dillon Exploration Inc. and Mountain Minerals Co., mined barite at its underground mine in the Elk Creek-Coloma Mining District, east of Missoula in the Garnet Range, Missoula County. Mined concentrate and previously stockpiled material were shipped for further processing to the company's mill at Lethbridge, Alberta, Canada.

Cement.—The production of cement estimated for Montana in 1991 increased 27% in quantity and almost 26% in value from that reported in 1990. Portland cement was produced by Holnam Inc. at Trident, Gallatin County, and by Ash Grove Cement West Inc. at Montana City, Jefferson County; both companies also sold small amounts of masonry cement.

The bulk of the cement sold was general use, moderate heat Types I and II gray portland cement. Lesser amounts of oil well, Type III high early strength, and Type V high sulfate resistant were also sold. Users of portland cement produced in the State included building material dealers, concrete product manufacturers, government agencies, highway contractors, and ready-mixed concrete companies. Raw materials consumed in cement manufacture were locally mined clay, iron ore, limestone, sandstone, silica, and Wyoming gypsum. Both of the one-kiln wet-process plants used natural gas and coal for fuel and purchased electricity for energy.

Chlorite.—High-purity chlorite was mined by Cyprus Industrial Minerals Co. at its Golden Antler open pit mine near Silver Star, Madison County. The company expanded its reserve base through exploration in Cottonwood Canyon. The chlorite was sold for many of the same industrial applications in which talc was used.

Clays.—Clay production increased significantly in both quantity and value from that of 1990. The bulk of the State's clay production was bentonite. Two companies in Carter County produced swelling-type bentonite; a small amount of nonswelling bentonite also was produced in Carbon County. Uses of bentonite included animal feed supplement, drilling mud, foundry sand, and waterproof sealant. Four companies reported common clay production in Gallatin and Jefferson Counties. Common clay was used in the manufacture of cement, concrete block, and pottery.

Gemstones.—The value of gemstone production decreased more than 25% from that of 1990. Several sapphire mines continued both commercial and hobbyist production, with some production targeted for international sales.

Near Skalkaho Pass, west of Philipsburg in Granite County, the Gem Mountain Sapphire Mine operated on the West Fork of Rock Creek. The mine produced bulk concentrate, as well as cut stones, for over-the-counter sales. Recreational activities included prescreened buckets of dirt ready for sorting by customers. Adjacent to Gem Mountain, a test run of a new floating wash plant was done at the Skalkaho Grazing Association Sapphire Mine.

East of Helena in Lewis and Clark County, sapphires were produced at French Bar and Spokane Bar. Nearby, Lovestone Mining continued the contract production of concentrates. Northeast of Helena, Eldorado Bar had two operations; one was strictly recreational and was the only mine in the State to allow fee digging, while the other included commercially processed gravel and the production of sapphire concentrates. At the famous Yogo Dike in Judith Basin County, Roncor Inc. and Vortex Mining Co. operated sapphire mines. Roncor processed sapphire-bearing material from the Yogo Dike and ran old tailings from the American Mine through its washing plant. Vortex continued to explore at depth a split off the main dike system of a sapphire-bearing breccia south of the American Mine.

Lime.—Lime production dropped by 2% in quantity, but rose 2% in value from that of 1990. Continental Lime Inc., a subsidiary of Graymount Inc., completed expansion of its Indian Creek quicklime facility near Townsend, Broadwater County; this expansion was expected to double capacity. Also, the Great Western Sugar Co. operated a plant in Billings, Yellowstone County, and Holly Sugar Corp. produced quicklime at its plant in Richland County.

TABLE 2
MONTANA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse and fine aggregates: Other construction materials[2]	1,585	3,626	$2.29
Unspecified:[3]			
Actual	488	1,920	3.94
Estimated	32	178	5.56
Total[4]	2,107	5,725	2.72

[1]Includes granite, limestone, miscellaneous stone, quartzite, sandstone, traprock, and volcanic cinder and scoria.
[2]Includes concrete aggregate, coarse; bituminous aggregate, coarse; stone sand; bituminous mix or seal; screening; undesignated; graded road base or subbase; unpaved road surfacing; crusher run or fill or waste; and cement manufacture.
[3]Includes production reported without a breakdown by use and estimates for nonrespondents.
[4]Data may not add to totals shown because of independent rounding.

Peat.—The value of Montana peat production in 1991 nearly doubled from that of 1990. Bulk peat was produced by Martin's Peat Inc. at Swan Lake, Lake County, and by Farmer's Plant Aid Corp. near Hamilton, Beaverhead County.

Phosphate Rock.—The production of phosphate rock increased slightly in both quantity and value from that of 1990. Cominco produced phosphate rock at its Warm Springs Creek operation in Powell County, the last underground phosphate mine in the Nation. The phosphate was shipped by rail to Cominco's fertilizer plant at Warfield, British Columbia, Canada. There, the phosphate was mixed with sulfuric acid from the company's zinc smelter at Trail and was used to make phosphoric acid and other phosphate-base products.

Rhône-Poulenc Chemical Co.'s Silver Bow elemental phosphorus plant, west of Butte, operated at capacity. The plant processed phosphate rock from the company's Rasmussen Ridge Mine in southeastern Idaho.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1990 and estimates for 1989 and 1991. Estimated sand and gravel production for 1991 dropped 6% in quantity and more than 4% in value from that reported in 1990. Major producing counties included Cascade, Flathead, Gallatin, and Yellowstone. Major uses included asphaltic concrete aggregates and other bituminous mixtures; concrete aggregates, including concrete sand; and road base and coverings, including stabilization.

Industrial.—Production of industrial sand and gravel increased by about one-third in both quantity and value from that of 1990. Output was reported by Rhône-Poulenc Chemical from the Maiden Rock Quarry, Beaverhead County. The product was used for flux at the company's Silver Bow elemental phosphorus plant.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Crushed.—The quantity of crushed stone production in 1991 decreased by more than 47% from that estimated in 1990 and 26% from that surveyed in 1989. Value of 1991 crushed stone production dropped by almost two-thirds from that estimated in 1990 and 41% from that surveyed in 1989. Production was reported by 10 companies and governmental agencies in 9 counties. Gallatin, Jefferson, and Yellowstone Counties accounted for 85% of the State's total production. Four companies accounted for 89% of the quantity produced and 86% of the value. The bulk of the crushed stone produced was limestone, which accounted for almost one-half of the total in 1991 production. Limestone in the manufacture of cement was the largest use of crushed stone in Montana in 1991.

Dimension.—The Livingston Marble & Granite Works mined travertine building stone from a quarry north of Gardiner, Park County. The company marketed the product as ashlar, cut stone, and rubble from its plant at Livingston.

Sulfur.—Montana Sulphur & Chemical Co. and the Farmers Union Central Exchange recovered sulfur as a byproduct from petroleum refining near Laurel, Yellowstone County. Montana Sulphur & Chemical continued construction of a new ammonium thiosulfate unit, a small hydrogen plant, and other changes at its chemical and fertilizer complex in Lockwood, outside Billings.

Talc.—Talc production decreased both in quantity and value from that of 1990. Three companies produced talc from four mines in Madison County.

Cyprus Industrial Minerals produced talc at its Beaverhead and Yellowstone Mines. At the Yellowstone Mine, the company continued development of a new ore body and continued backfilling the south main pit and stockpiled top soil for future reclamation. Production at the Beaverhead underground mine, east of Dillon, included cosmetic talc. The company changed the mining method from cut and fill to an underhand method, utilizing cement borrow material, and reportedly realized a cost savings. At the nearby Treasure Chest Mine, Pfizer Inc. completed construction of a new, fully automated talc beneficiation plant that

TABLE 3
MONTANA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	10	2,680	$9,135	$3.41	5	1,045	$2,875	$2.75
Granite	—	—	—	—	2	531	864	1.63
Traprock	2	W	W	3.71	1	W	W	5.00
Sandstone and quartzite	3	97	375	3.87	3	195	667	3.42
Volcanic cinder and scoria	—	—	—	—	1	W	W	2.13
Miscellaneous stone	5	W	W	2.98	1	W	W	4.00
Total[1]	XX	2,846	9,510	3.34	XX	2,107	5,725	2.72

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

utilizes wet grinding and flotation technology. Sharing a common high wall with Cyprus's Yellowstone open pit south of Ennis, Montana Talc Co. operated its Johnny Gulch Mine. Production from the mine was processed at the company's Sappington plant near Three Forks, where improvements also were made in product storage as well as dry ore storage.

Vermiculite.—Although processed vermiculite from stockpiles continued to be shipped, W.R. Grace & Co. began reclamation of the mine and plant facilities at its Rainy Creek Mine near Libby, Lincoln County. The mine was closed in 1990 owing to a decline in demand for vermiculite, which contains asbestiform minerals.

East of Dillon, Mineral Products Inc. completed a new road to the Monolite Mine and started mill construction. Production was still quite limited. Stansbury Mining Corp. completed preparation, but had not released a draft EIS for its new vermiculite mine near Hamilton, Ravalli County.

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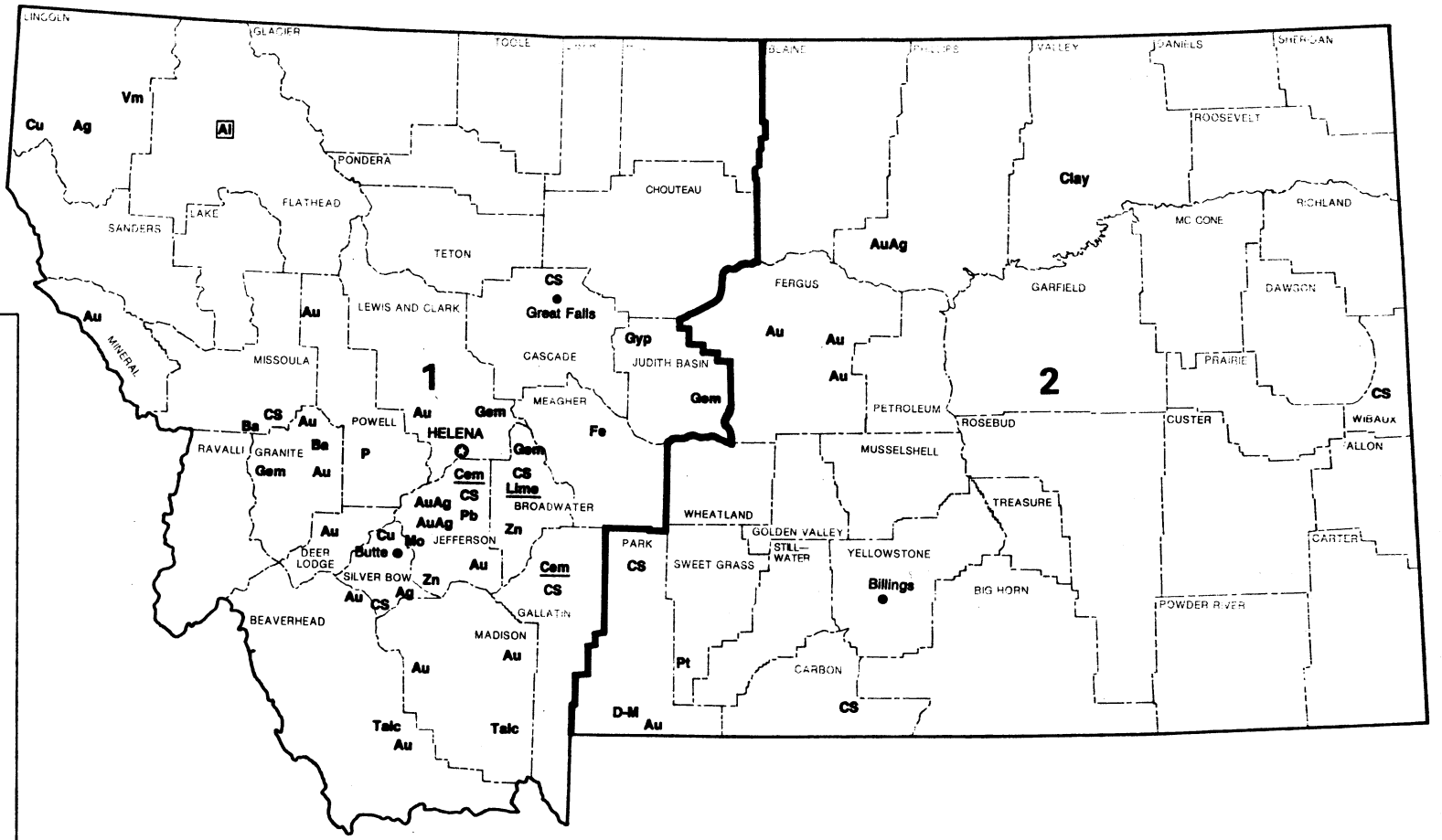
[1]State Mineral Officer, U.S. Bureau of Mines, Spokane, WA. He has 17 years of mineral-related experience in industry and government and has covered the mineral activities in Montana since 1989. Assistance in preparation of the chapter was given by W. A. Lyons, editorial assistant.

[2]Staff mining engineer, Montana Bureau of Mines and Geology, Butte, MT.

[3]American Metal Market. V. 99, No. 248, Dec. 27, 1991.

MONTANA



LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Al	Aluminum plant
Au	Gold
Ba	Barite
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper
D-M	Dimension Marble
Fe	Iron
Gem	Gemstones
Gyp	Gypsum
Lime	Lime plant
Mo	Molybdenum
P	Phosphate rock
Pb	Lead
Pt	Platinum group metals
Talc	Talc minerals
Vm	Vermiculite
Zn	Zinc

Principal Mineral-Producing Localities

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Columbia Falls Aluminum Co.	Columbia Falls, MT 59912	Reduction plant	Flathead.
Cement:			
Ash Grove Cement West Inc.	6720 SW Macadam Ave. Suite 300 Portland, OR 97219	Plant and quarry	Jefferson.
Holnam Ideal Inc.	Box 8789 Denver, CO 80201	do.	Gallatin.
Copper:			
ASARCO Incorporated	Box 868 Troy, MT 59935	Underground mine and plant	Lincoln.
Gold:			
Canyon Resources Corp.	Box 799 Hilger, MT 59451	do.	Pergus.
Homestake Mining Co. and TVX Gold Inc.	Box 92 Gardiner, MT 59030	Underground mine and plant	Park.
Pegasus Gold Inc.	North 9 Post Suite 400 Spokane, WA 99201	Surface mines and leach plants	Jefferson, Phillips, Silver Bow.
Placer Dome Inc.	Box 678 Whitehall, MT 59759	Surface mine and plant	Jefferson.
Lead:			
Pegasus Gold Inc.	North 9 Post Suite 400 Spokane, WA 99201	do.	Do.
Lime:			
Continental Lime Co., a subsidiary of Graymont Inc.	Box 550 Townsend, MT 59644	Surface mine	Broadwater.
Great Western Sugar Co.	3020 State Ave. Box 30878 Billings, MT 59107	Plant	Yellowstone.
Holly Sugar Corp.	Box 1052 Colorado Springs, CO 80901	do.	Richland.
Molybdenum:			
Montana Resources Inc.	600 Shields Ave. Butte, MT 59701	Surface mine and plant	Silver Bow.
Phosphate rock:			
Cominco American Inc.	Box 638 Garrison, MT 59731	Underground mine and plant	Powell.
Platinum-group metals:			
Stillwater Mining Co.	Star Route 2 Box 365 Nye, MT 59061	do.	Stillwater.
Silver:			
ASARCO Incorporated	Box 868 Troy, MT 59935	do.	Lincoln.
Montana Resources Inc.	600 Shields Ave. Butte, MT 59701	Surface mine and plant	Silver Bow.
Pegasus Gold Inc.	North 9 Post Suite 400 Spokane, WA 99201	do.	Jefferson.

TABLE 4—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone:			
Crushed:			
Ash Grove Cement West Inc.	6720 SW Macadam Ave. Suite 300 Portland, OR 97219	Quarry	Jefferson.
Empire Sand & Gravel	Box 1215 Billings, MT 59103	do.	Yellowstone.
Holnam Ideal Inc.	Box 8789 Denver, CO 80201	Quarries	Gallatin.
Weaverstone Co.	1506 Thiel Rd. Laurel, MT 59044	do.	Carbon and Yellowstone.
Dimension:			
Livingston Marble and Granite Works	711 E. Park Livingston, MT 59047	Quarry and plant	Park.
Sulfur (recovered):			
Montana Sulphur & Chemical Co.	Box 31118 Billings, MT 59107	Plant	Yellowstone.
Talc:			
Cyprus Industrial Minerals Co.	Box 3299 7000 South Yosemite Englewood, CO 80155	Plant, surface, and underground mines	Gallatin and Madison.
Montana Talc Co.	28769 Sappington Rd. Three Forks, MT 59752	Plant and surface mine	Do.
Pfizer Inc.	Box 1147 Dillon, MT 59725	do.	Beaverhead and Madison.
Zinc:			
Pegasus Gold Inc.	North 9 Post Suite 400 Spokane, WA 99201	do.	Jefferson.

THE MINERAL INDUSTRY OF NEBRASKA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Conservation and Survey Division of the University of Nebraska (Nebraska Geological Survey) for collecting information on all nonfuel minerals.

By Eileen K. Peterson[1] and Raymond R. Burchett[2]

The value of nonfuel mineral production in Nebraska decreased slightly from 1990's level. The $89.4 million of production represented the second year in a row that values have fallen since the record-high level of 1989. Of the six minerals produced in Nebraska, only crushed stone increased in output and value over that of 1990. Nebraska ranked 44th nationally in the production of nonfuel minerals, accounting for less than 1% of the national total. Most nonfuel minerals produced in Nebraska were basic construction materials, and production reflected construction trends in the State. Industrial sand was used in the production of glass and had some applications outside of construction. Lime and talc were processed at plants in Nebraska, both from imported raw materials. Uranium and oil and gas were also produced in 1991. No metals were reported mined in Nebraska in 1991.

TRENDS AND DEVELOPMENTS

The decreases in nonfuel mineral output and value primarily can be ascribed to lower production of clays and sand and gravel. Lower production levels of these construction materials reflects a decrease in construction activities. The number of new private and public residential units authorized for construction during the year fell about 9% from 1990 figures to 6,235 units. The value of nonresidential construction awards for offices, stores, industrial plants, and alterations or additions to existing buildings, etc., fell to $288 million from $357 million in 1990. Major construction projects included work on I-80, I-480, I-680, and reconstruction of runways at Offutt Air Base south of Omaha.

The 8th U.S. Circuit Court of Appeals ruled that the U.S. Environmental Protection Agency was justified in approving injection mining of uranium by Ferret Exploration Co. near Crawford, Dawes County.[3]

EMPLOYMENT

In 1991, about 2,000 persons were employed in mining industries and construction activities employed another 27,600 people. The average unemployment rate for Nebraska was 2.7%, up slightly from the 1990 figure of 2.2%.[4]

Average annual pay in mining was about $24,000, while the average wage in Nebraska was $18,400.

REGULATORY ISSUES

Work continued toward establishing a five-State, low-level radioactive waste facility in northeastern Nebraska. The Nebraska Department of Environmental Control began reviewing an application filed by US Ecology to build and operate the facility west of Butte in Boyd County. Nebraska was chosen as the host State for the facility by the Central Interstate Low-

TABLE 1
NONFUEL MINERAL PRODUCTION IN NEBRASKA[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	224,624	$880	227,292	$1,685	198,319	$909
Gemstones		NA	2	NA	7	NA	1
Sand and gravel (construction)	thousand short tons	e15,200	e41,800	11,453	30,056	e10,100	e27,300
Stone (crushed)	do.	3,978	20,050	e4,000	e21,200	4,861	23,328
Combined value of cement, lime, and sand and gravel (industrial)		XX	41,085	XX	37,381	XX	37,854
Total		XX	103,817	XX	90,329	XX	89,392

eEstimated. NA Not available. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers)

Level Radioactive Waste Compact. Members of the five-State compact are Arkansas, Kansas, Louisiana, Nebraska, and Oklahoma. Opposition to establishment of the waste facility in Nebraska continued.

A State-funded joint research project was initiated to study potential uses of the 336,000 metric tons (370,000 short tons) of fly ash produced in Nebraska each year as a byproduct of burning coal to make electricity. The $165,000 research project will include the State, the University of Nebraska-Lincoln, two public power districts, and a private company.

The city of Fremont is seeking approval from the Nebraska Department of Environmental Control and the U.S. Army Corps of Engineers to use fly ash blocks as bank stabilization along the Platte River. The city powerplant generates about 10,911 metric tons (12,000 short tons) per year of fly ash that is now being shipped to a landfill.

LEGISLATION AND GOVERNMENT PROGRAMS

The 1991 Nebraska Legislature passed and the Governor signed LB837 giving the State more control over the proposed five-State, low-level radioactive waste facility to be built in Boyd County. The bill provided for all five States to accept proportional liability for waste stored at the facility. The bill also provided that Nebraska would have two additional members on the compact commission with one member voting, and that Nebraska would set fees for storage of waste. All five States in the compact will have to pass bills accepting the terms of Nebraska LB837.

The Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, has published a series of updated test-hole logbooks on exploration drilling in the State. Additional publications were completed on the mineral industry of Nebraska and coal, ocher, oil and gas, and uranium deposits in the State.

FUELS

The Nebraska Oil and Gas Conservation Commission reported that 1,716 wells produced about 5.8 million barrels of oil and 657 million cubic feet of casinghead gas. Of the 128 wells drilled in 1991, 49 were for exploration, 71 for development, and 8 were service wells. Well completions were up almost 7% from 1990 levels. Counties showing the most exploration and development wells were Cheyenne, Hays, Hitchcock, and Kimball. Two natural gas processing plants are in Nebraska, one in Kimball County and the other in Cheyenne County. The plants produced natural gasoline, cycle products, liquid petroleum gases, and ethane.

In May, Ferret Exploration Co. began in situ leaching of uranium under a 1,200-hectare tract (3,000 acres) southeast of Crawford in Dawes County. About 12.2 million kilograms (27 million pounds) of uranium oxide reserves is reported in the Ferret properties. Ferret holds leases on another 85,000 hectares (210,000 acres) in the panhandle of Nebraska. Ferret began production at a rate of 181,400 kilograms (400,000 pounds) per year. Ore grades range from 0.05% to 0.5% uranium oxide along the 9.7-kilometer-long (6-mile-long) ore trend. Bicarbonate of soda, carbon dioxide, and oxygen are being introduced into the ore body to dissolve and free the uranium. An on-site processing plant dewaters the yellowcake (uranium) before it is sent out of State for final processing. Ferret has a 3-year, 68,000-kilogram-per-year (150,000-pound-per-year) contract for uranium with a domestic utility.[5]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Nonfuel mineral production in Nebraska consisted entirely of industrial minerals. In 1991, the Nebraska Geological Survey, Conservation and Survey Division, noted there were 737 mining operations active in the State, 26 limestone quarries, 676 sand and gravel pits, 8 clay or shale pits, 25 sandstone pits, 1 quartzite quarry, and 1 uranium mine.[6] These 737 operations represented an increase of 11 over those of 1990. Total land disturbance during 1991 was estimated to be 156 hectares (385 acres); 75 hectares (186 acres) was restored.

Cement.—Cement was again the leading nonfuel mineral produced in Nebraska, in terms of total value of output. The Ash Grove Cement Co., with a single plant near Louisville in Cass County, remained Nebraska's only producer of portland and masonry cement. Production of portland cement increased slightly and masonry decreased slightly. Limestone, shale, and gypsum were the chief raw materials used in cement manufacture.

Clays.—Output of clay dropped almost 13% from that of 1990. Most of the production came from Jefferson and Cass Counties. Clay was used in the manufacture of common and face bricks and cement. Three brick companies operated in the State, Endicott Clay Products Co. near Endicott in Jefferson County, Yankee Hill Brick Manufacturing Co. near Lincoln in Lancaster County, and Omaha Brick Works near Ralston in Douglas County.

Lime.—Lime was produced by Western Sugar Co. primarily for use in refining sugar from sugar beets. Limekilns at Scottsbluff and Mitchell in Scotts Bluff County and at Bayard in Morrill County produced lime from limestone imported from Wyoming.

Sand and Gravel.—Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1990 and estimates for 1989 and 1991.

Construction sand and gravel was the second most important nonfuel mineral commodity produced in Nebraska in

TABLE 2
NEBRASKA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch): Riprap and jetty stone[2]	114	668	$5.86
Coarse and fine aggregates: Unpaved road surfacing[3]	530	3,014	5.69
Other construction materials[4]	1,388	7,293	5.26
Agricultural: Agricultural limestone[5]	253	1,675	6.62
Chemical and metallurgical: Cement manufacture	W	W	1.92
Special: Asphalt fillers or extenders	W	W	10.00
Other miscellaneous uses[6]	886	1,760	1.99
Unspecified:[7]			
Actual	1,658	8,798	5.31
Estimated	31	121	3.87
Total[8]	4,861	23,328	4.80

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[1]Includes limestone.
[2]Includes macadam.
[3]Includes graded road base or subbase and crusher run or fill or waste.
[4]Includes concrete aggregate, coarse, bituminous aggregate, coarse, stone sand, bituminous mix or seal, screening, undesignated, and roofing granules.
[5]Includes poultry grit and mineral food, and other agricultural uses.
[6]Includes withheld amounts for chemical and metallurgical and special.
[7]Includes production reported without a breakdown by use and estimates for nonrespondents.
[8]Data may not add to totals shown because of independent rounding.

terms of value and the largest in terms of distribution of activity and number of companies and people involved.

Sand and gravel was mined in all but 8 of Nebraska's 93 counties.[7] Estimated output for 1991 declined slightly from 1990 levels. The largest producers operated in the east-central area of the State near Omaha and Lincoln. More than one-third of the State's total output comes from Cass, Douglas, Sarpy, and Saunders Counties in the Omaha area.

Industrial.—The amount of industrial sand produced in the State has remained nearly constant for 3 years with a very small level of output.

Stone (Crushed).—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1990 and actual data for 1989 and 1991.

In terms of quantity, crushed stone was the third most significant nonfuel mineral produced in Nebraska. Production of crushed stone in 1991 was significantly higher than that in 1989, the last year of actual data. Production increased more than 20% from 1989 and almost 18% over the estimated 1990 figure. The average unit value was $4.80 per short ton, compared with $5.04 in 1989. Limestone was the principal type of stone produced.

Limestone was produced from 13 quarries in eastern Nebraska, 5 near Weeping Water in Cass County. Cass County was the leader in limestone production followed by Washington County. Principal producers of crushed limestone are Fort Calhoun Stone Co., Kerford Limestone Co., and Martin Marietta Aggregates with operations in Cass, Pawnee, and Washington Counties. In October, Kerford Limestone began work on a new limestone mine near Weeping Water when reserves at the company's other limestone mine were nearly depleted. The new underground mine has 50 years of limestone reserves.[8] Nebraska's limestone is used primarily for aggregate in concrete, cement manufacture, road base, riprap, agricultural lime, wallstone, and mineral fillers.

Limestone processing in Nebraska included three firms that produce agricultural lime exclusively near Garland in Seward County, near Nelson in Nuckolls County, and near Ponca in Dixon County. Most of the crushed limestone plants in southeastern Nebraska also produced some agricultural lime. Three firms produced finely ground limestone (calcium carbonate) for feed supplements and fillers for cement, paint, and rubber. Producers were Kerford Limestone and Iowa Limestone Co. west of Weeping Water in Cass County and Texasgulf Inc. southeast of Weeping Water. One plant located on a reclaimed quarry site west of Weeping Water in Cass County produced limestone pellets for agricultural, lawn, and garden use. Thirteen Nebraska firms, seven near Omaha, cut stone imported from other States.

Other Industrial Minerals.—Fertilizer plants in Nebraska produced anhydrous ammonia, urea, and ammonium nitrate. Major producers were Arcadian Corp. at La Platte in Sarpy County, Farmland Industries Inc. at Fremont in Dodge County and near Beatrice in Gage County, and Cominco-American, also operating near Beatrice in Gage County.

One plant, owned by Cyprus Mines Corp., United Sierra Div., near Grand Island in Hall County, produced ground talc from raw material obtained outside the State. The talc was used in paper, ceramics, rubber, paint, insecticides, and textiles.

Perlite was manufactured by the Zonolite Div. of W. R. Grace & Co. near Omaha in Douglas County. Crude perlite was imported from other States and expanded at the Omaha plant. The expanded perlite was sold as filler material, as aggregate for plaster and concrete, and as a horticultural product.

The only producer of vermiculite in Nebraska was Construction Products Div. of W. R. Grace & Co. The plant, near Omaha, processes crude vermiculite from Montana. The expanded vermiculite was used principally for insulation, concrete

TABLE 3
NEBRASKA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	15	3,978	$20,050	$5.04	13	4,861	$23,328	$4.80

aggregate, and fire-proofing.

Many small firms around the State cut and polish gems and ornamental stone such as agate, chalcedony, chert, jasper, petrified wood, and quartz.

Metals

Although no metals were mined in Nebraska, ASARCO Incorporated continued to operate a lead-zinc and precious-metals refinery at Omaha in Douglas County. The refinery has been in existence since 1870 and processes bullion brought in from other States. Most of the lead produced goes into the manufacture of storage batteries.

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[1]Mining engineer, U.S. Bureau of Mines, Denver, CO. She has 16 years of mineral-related work with the Government. Assistance in the preparation of the chapter was given by Pat La Tour, editorial assistant.

[2]Research geologist, Conservation and Survey Division of the University of Nebraska-Lincoln (Nebraska Geological Survey), Lincoln, NE.

[3]Lincoln Journal-Star. Uranium Mine Approval Justified, Judges Rule. Sept. 18, 1991.

[4]Nebraska Labor Market Information Annual Summary Report, 1991.

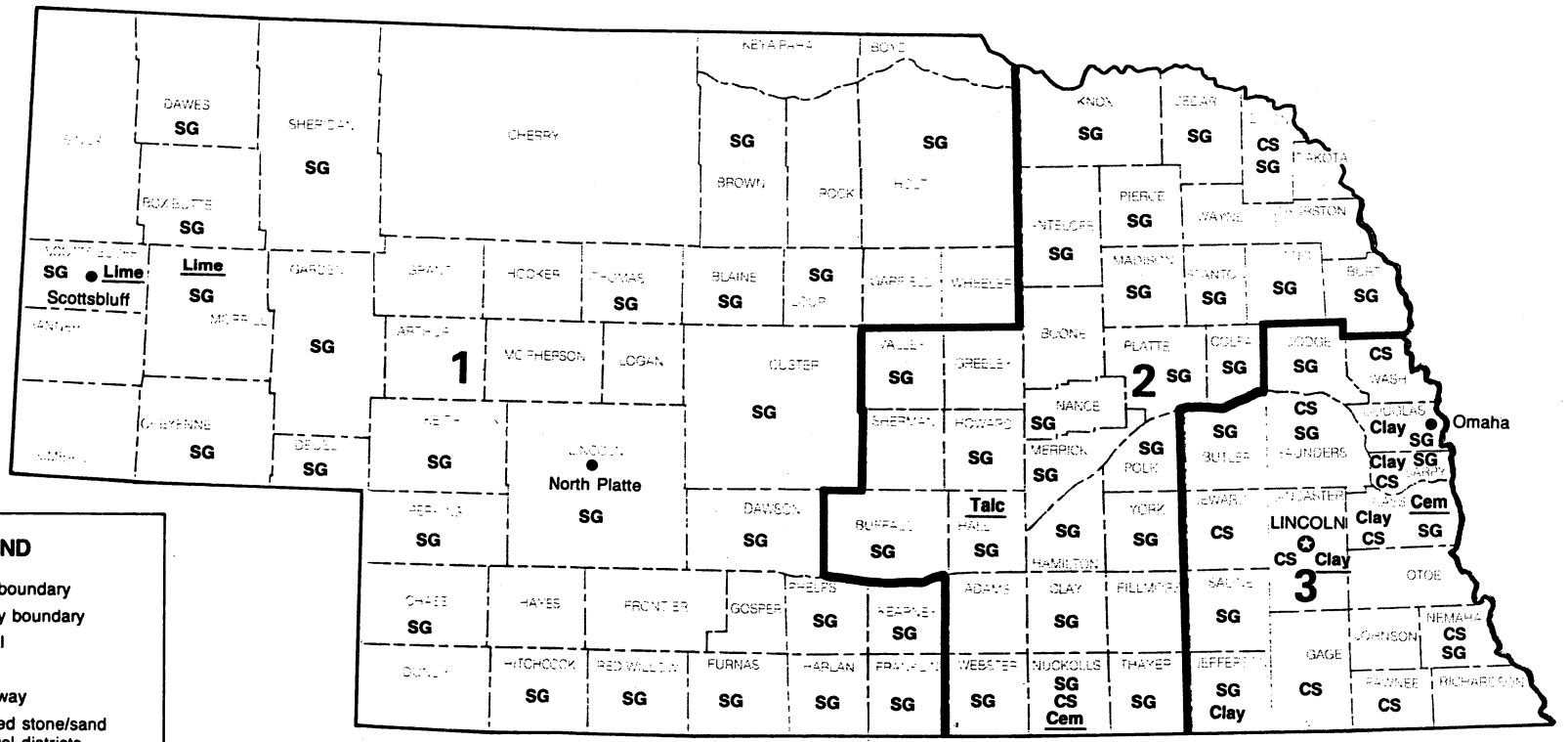
[5]Rocky Mountain Pay Dirt. Ferret Brings Nebraska In Situ Uranium Operation On Line. July 1991, p. 17A.

[6]Burchett, R. R., and D. A. Eversoll. Nebraska Mineral Operations Review, 1991. Nebraska Geological Survey, Apr. 1992, 15 pp.

[7]Work cited in footnote 6.

[8]Lincoln Journal-Star. Opening of Mine a Rarity in Cornhusker State. July 5, 1991.

NEBRASKA



LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Cem	Cement plant
Clay	Clay
Clay	Clay products
CS	Crushed Stone
Lime	Lime plant
SG	Sand and Gravel
Talc	Talc plant

Principal Mineral-Producing Localities

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Ash Grove Cement Co.[1]	Box 25900 Overland Park, KS 66225	Quarry, clay pit, plant	Cass.
Clays:			
Endicott Clay Products Co.	Box 17 Fairbury, NE 68352	Pit and plant	Jefferson.
Omaha Brick Works	Box 27073 Ralston, NE 68127	do.	Douglas.
Yankee Hill Brick Manufacturing Co.	Route 1 Lincoln, NE 68502	do.	Lancaster.
Lime:			
Western Sugar Co.	Anaconda Towers Suite 1400 555 17th St. Denver, CO 80202	Plants	Morrill and Scotts Bluff.
Sand and gravel (construction):			
Central Sand & Gravel Co. Inc.	Box 626 Columbus, NE 68601	Pits and plants	Butler, Madison, Nance, Platte.
Hartford Sand & Gravel Co.	Box Z Valley, NE 68064	Dredges and pits	Dodge and Douglas.
Lyman-Richey Sand & Gravel Corp.	4315 Cuming St. Omaha, NE 68131	Pits and plants	Cass, Douglas, Platte, Saunders.
Western Sand & Gravel Co.[2]	Box 28 Ashland, NE 68003	Dredges and pits	Cass, Dodge, Saunders.
Stone (crushed):			
Limestone-dolomite:			
Fort Calhoun Stone Co.	1255 South St. Blair, NE 68008	Quarries and plants	Washington.
Kerford Limestone Co.	Box 449 Weeping Water, NE 68463	Quarry and plant	Cass.
Martin-Marietta Aggregates, Central Div.	Box 30013 Raleigh, NC 27622	Quarries and plants	Cass, Nemaha, Nuckolls, Pawnee, Saunders.

[1]Also clays in Cass County.
[2]Also industrial sand in Saunders County.

THE MINERAL INDUSTRY OF NEVADA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Nevada Bureau of Mines and Geology for collecting information on all nonfuel minerals.

By Fred V. Carrillo,[1] Jonathan G. Price,[2] Stephen B. Castor,[3] and Richard B. Jones[4]

Nevada's 1991 nonfuel mineral production was valued at $2,392,901, approximately 8.7% lower than that of 1990. Nevada ranked third nationally in the value of its nonfuel mineral production, accounting for 8% of the U.S. total.

Nevada was the largest producer of barite, gold, mercury, and silver among the States. It was the sole producer of mined magnesite and brucite. Gold mining accounted for 86.5% of the total nonfuel mineral value produced in the State during 1991 and 61% of the Nation's total gold production. Silver, almost all as a byproduct from gold production, accounted for an additional 5% of the State's production value. Principal nonfuel minerals produced in Nevada, in order of value, were gold, silver, construction sand and gravel, diatomite, lithium carbonate, lime, cement, barite, gypsum, and clay.

The data presented in table 1 are based on 1991 production figures that were reported by industry to the U.S. Bureau of Mines. The Nevada Bureau of Mines and Geology (NBMG) collected and reported similar information, partly obtained from the Nevada Department of Minerals, in a 51-page NBMG special publication (MI-1991), "The Nevada Mineral Industry, 1991." In addition to production statistics, this publication contains sections on metals, precious metals, industrial minerals, oil and gas, geothermal energy, and a directory of active mining operations.

TABLE 1
NONFUEL MINERAL PRODUCTION IN NEVADA[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Barite	thousand metric tons	209	$3,473	337	$5,884	374	$11,933
Clays[2]	metric tons	57,264	5,457	34,625	4,098	15,553	3,204
Gemstones		NA	1,402	NA	407	NA	958
Gold[3]	kilograms	153,995	1,894,172	r179,078	r2,216,233	177,312	2,071,009
Lead[3]	metric tons	—	—	830	842	W	W
Mercury	do.	W	W	W	W	57	2C2
Perlite	short tons	5,000	136	W	W	W	W
Sand and gravel:							
Construction	thousand short tons	e20,000	e70,000	18,377	59,008	e20,300	e69,000
Industrial	do.	718	W	607	W	546	W
Silver[3]	metric tons	625	110,442	r646	r100,146	578	75,050
Stone (crushed)	thousand short tons	1,560	4,638	e1,600	e5,000	1,199	6,527
Zinc[3]	metric tons	—	—	7,889	12,973	W	W
Combined value of brucite, cement (portland), clays [fuller's earth (1990-91), kaolin], copper, diatomite, fluorspar (1989-90), gypsum (crude), lime, lithium minerals, magnesite, molybdenum, salt, and values indicated by symbol W		XX	220,441	XX	r216,820	XX	155,018
Total		XX	2,310,161	XX	r2,621,411	XX	2,392,901

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value include with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.
[3]Recoverable content from ores, etc.

TRENDS AND DEVELOPMENTS

After 11 straight years of continued increases, gold production in the State declined slightly during 1991 from about 180,000 kilograms in 1990 to 177,312 kilograms or 5,700,705 troy ounces in 1991. Nevada continued to be the leading gold-producing State in the Nation yielding more than 60% of all gold produced in the United States and approximately 9% of all gold produced in the world. Relatively low gold prices, uncertainties regarding the access to Federal lands, and increasingly more restrictive State and Federal regulations caused a substantial decrease in exploration activity since the peak in 1988.

Two of the three base metal operations in the State, the Ward Mountain lead-zinc-copper-silver operation in White Pine County and the Cyprus-Tonopah (Hall) molybdenum-copper Mine near Tonopah in Nye County shut down during the year.

Industrial minerals experienced an 8% decline in total value of production, attributed to a slowdown in construction activities in both California and Nevada, that resulted in lower production of aggregate and gypsum.

EMPLOYMENT

According to the Nevada Employment Security Department, 13,005 workers were employed in the Nevada mining industry in December 1991, a 6.5% decrease from that of the previous year and a 7% drop from the peak employment of 15,000 workers reported in July 1990. Metal mining employment averaged 12,144 workers during the year. Precious-metals operations employed the largest number of workers, followed by the sand and gravel industry. Other mining employment averaged 1,200 workers during 1991 for a total yearly average of 13,345 workers in the mining industry.

REGULATORY ISSUES

Several bills were passed by the 1991 Nevada Legislature that affected mining regulations. These included Assembly bill 78, which revised several mining regulations and required each mining operator to file a yearly report with the Nevada Department of Minerals on the status of their mining, exploration, and reclamation operations; Assembly bill 351, which provided penalties for violation of State hazardous waste provisions; Assembly bill 533, which imposed annual assessments from $50 to $10,000 on the development of a body of water injurious to wildlife; and Assembly bill 592, which revised requirements for mining reclamation payments, fees, and verification of surety.

In addition, the Senate enacted S.B. 41, which authorized the State's Division of Environmental Protection to develop new rules governing hazardous chemicals. The law required firms that deal with hazardous chemicals to register with the State, provide an inventory of their chemicals, list safety procedures, and complete a safety and risk evaluation.

EXPLORATION ACTIVITIES

Precious-metals exploration activities in the State continued to decline as many gold producers shifted their exploration programs to foreign countries, partly in response to increased regulations as well as lower prices and more favorable conditions offshore. However, exploration drilling continued throughout Nevada, with most activity centered around producing gold properties. A survey conducted by the Nevada Department of Minerals showed that 27 exploration offices in Reno had reduced their geology staffs by 23% from March 1990 to March 1991.

Two significant gold exploration discoveries were announced during the year. Placer Dome Inc. announced the discovery of a sizable gold ore body at the Pipeline deposit in Lander County in 1991. The discovery, near the Cortez and Gold Acres deposits, was said to have been made beneath 500 feet of alluvium.

In November, Atlas Corp. encountered a new gold ore body, which was designated the Gold Canyon deposit, northwest of its Gold Ridge Mine in Eureka County.

Exploration near eight producing mines added new reserves, mostly from deep deposits. Among those were the New Deep/Gracie deposit in the Jerritt Canyon district of Elko County; the Dee Mine properties on the Carlin trend, the Getchell Mine, deep deposits below the Sleeper Mine, at Talapoosa in Lyon County; the Aurora in Mineral County; and at the Rosebud deposit in Pershing County.

LEGISLATION AND GOVERNMENT PROGRAMS

The U.S. Bureau of Land Management announced the availability of seven open file reports on areas in Nevada being considered for possible recommendation as suitable for wilderness. The reports were prepared by the U.S. Geological Survey and the U.S. Bureau of Mines. Areas that were studied included: Marble Canyon-White Pine County; Lime Canyon, Clark County; Black Rock Desert, Humboldt County; Queer Mountain, Esmeralda County; Grapevine Mountain, Esmeralda County; La Madre Mountains, lark County; and El Dorado and Ireteba Peaks, Clark County.

During fiscal year (1991), the MacKay School of Mines, University of Nevada, Reno, received allotment grants of $148,000 under the Mining and Minerals Research Institute (MMRRI) program. Programs included its Generic Mineral Technology Center; Mineral Industry Waste Treatment; and recovery, pyrometallurgy, and comminution studies.

A major effort at the U.S. Bureau of Mines, Reno Research Center, during 1991 was to develop advanced technology for the processing of ores, scrap, and waste into useful products. Investigations resulted in developing a promising new method for recovering platinum-group metals (PGM) from spent catalytic

convertors. Work also continued on a potential low-temperature way to recover PGM from Stillwater, MT ores by bio-oxidation. Research was also conducted on microwave heating of ore minerals, in-place leaching chemistry, rapid rate reduction and smelting technology, in situ leaching, and the recovery of flake graphite from kish (a steelmaking waste).

Research on environmental technology at the Reno Research Center focused on fundamental studies to delineate the origin, source, and significant factors leading to acid formation and metal and non metal contamination. Among the methods studied were control strategies to minimize acid formation and metal and non metal contamination by inhibiting the reactions and migration of contaminated waters, and treatment technology to neutralize acid waters while recovering or removing toxic metals and non metals. Research was also begun on effective closure methods for metallurgical processing operations.

Another area of research at the center was the Bureau's Advanced Mining Systems program, which addressed revolutionary new mining methods that could recover minerals more efficiently and curtail the harmful impact of mining on the environment. Among these were studies to determine if micro-organisms can be used to extract metals from ores under conditions of in situ leaching and whether bacteria can be used to decompose sulfide minerals in situ. Investigations were also begun on the stability of frozen tailings as backfill material and their durability for long-term deposition in underground mines.

The Bureau continued research on the use of micro-organisms in hydrometallurgical applications, including bacterial heap leaching of domestic manganese ores and oxidation of a PGM sulfide concentrate by bacterial preleaching followed by subsequent chemical leaching to recover a high-grade PGM product.

FUELS

Nevada's 1991 oil production decreased about 15% from that of 1990. Total net production of 3,425,960 barrels (1 barrel equals 42 gallons) was reported from 10 fields, according to the Nevada Department of Minerals. Three wells in the Grant Canyon Field of Nye County accounted for 62% of Nevada's total 1991 oil production. Four new producing wells were reported during the year, all from fields in Railroad Valley in Nye County.

The Kate Spring Field in the Railroad Valley area produced 53,304 thousand cubic feet of gas in 1991, which was used to operate production and related equipment at the lease sites of Apache Corp., David M. Evans, Inc., and Western General, Inc.

Forty-five geothermal well permits were issued by the Nevada Department of Minerals during 1991, and 14 geothermal wells with a total footage of 41,200 feet were reported to have been drilled. Total Nevada geothermal electrical energy net production in the State in 1991 was estimated by the Nevada Department of Minerals to be 895,021 megawatt hours with a sales value of about $76,500,000. Production capacity from the 10 existing geothermal power/plants in Nevada was 146.6 mega-watts.

REVIEW BY NONFUEL MINERAL COMMODITIES

For some commodities, 1991 production data obtained by the U.S. Bureau of Mines and NBMG is differed. Production data obtained from a single company may differ between the agencies, and some companies reported production to one agency, but not to the other. The NBMG production figures are mainly obtained from local offices of the reporting companies, whereas the U.S. Bureau of Mines data come mainly from the national headquarters. In addition, there are differences in the types of materials reported by the two agencies. For instance, NBMG collected data on magnesia production from an operation in Nevada, whereas the U.S. Bureau of Mines obtained data on magnesite and brucite production from the same operation. Other commodities for which the two agencies received significantly different data include barite, clays, crushed stone, and lime. The two agencies are currently working to resolve differences in production statistics.

Metals

Copper.—After a dramatic rise in 1990 copper production, Nevada's 1991 copper output dropped 54%. Copper was principally produced in the State from oxide dumps at Airmetco International Inc.'s Copper Tek Mine in Lyon County. Production was increased with the help of a new 65,000-pound-per-day solvent extraction-electrowinning plant, at the Yerington Mine, that was completed in the fall. Airmetco International Inc. and Holcorp Mines Ltd. acquired the MacArthur property, 4 miles north of Weed Heights in Lyon County, to expand their copper mining operation west of the Yerington Mine. The Nevada Department of Minerals reported Airmetco produced 4.25 million pounds of copper from the Yerington property. Most of the production was from an old stockpile, mined by the former owner, which was said to contain more than 30 million tons of oxide material grading 0.25% copper.

Magma Nevada Mining Co., a subsidiary of Magma Copper Co., purchased a 12,000-acre position in the Robinson Mining District, west of Ely. Magma announced plans to begin mining copper ore at its property in 1994, and feasibility studies were begun to supply concentrates for the company's smelter in Arizona. The October purchase was said to ensure a long-term supply of low-cost copper concentrates for the companies smelter in Arizona.

Alta Gold shut down its Ward Mine/Taylor mill copper, silver, lead, and zinc operations in March at both White Pine County facilities.

Gold.—Nevada continued to maintain its position as the Nation's principal gold-producing state. Fifteen of the Nation's leading 25 gold mines in 1991 were in Nevada. The value of Nevada's annual

gold production dropped about 6% from that of 1990 to $2,071,009,000, although production was less than 1% below the 1990 total, as gold prices continued their decline from the 1987 high. Nevada mines produced 177,312 kilograms (5.70 million troy ounces) of gold during 1991. Production was reported to the U.S. Bureau of Mines from 57 lode and 2 placer mines in 9 counties. Eureka County was the largest gold-producing county, followed, in descending order, by Humboldt, Nye, Elko, Lander, and Mineral Counties, all of which produced more than 200,000 ounces of gold.

Newmont Gold Co. (NGC), with operations centered around Carlin in northeastern Eureka County, was the State's dominant gold-producing company. NGC reported gold production of 49,144 kilograms (1.58 million troy ounces) during 1991 from its five mill and heap-leach operations along the Carlin Trend. According to the Nevada Department of Minerals, the majority was from the Gold Quarry Mine, which reported 1,034,500 ounces (32,177 kilograms) of gold production in 1991, making it the first North American Mine to produce 1 million ounces in a single year. To achieve the 1991 production, 80 million tons of material was mined, 9.1 million tons was treated in two mills, and another 15.6 million tons was treated by heap leaching. NGC announced increased reserves at the end of the year of 20.1 million ounces from 18.9 million ounces at the end of 1990.

The Barrick Goldstrike Mine, owned and operated by American Barrick Resources Corp. produced 546,146 troy ounces of gold (16,987 kilograms) and 22,000 ounces of silver (684.3 kilograms) during 1991, according to the Nevada Department of Minerals. Barrick's Mill No. 2 officially started up on April 13 as part of the planned expansion to process the higher grade sulfide ores. Two autoclaves were also added to the system, which was operating at a rate of 9,000 tons per day by August.

Independence Mining Co. announced plans in April to expand its milling facilities and increase the size of its tailing pond at the Jerritt Canyon Mine in Elko County. During the year ore was mined from two open pits within the Jerritt Canyon property—Upper North Generator Hill and West Generator Hill. The ore was processed at two fluid bed roasters on the property that handle approximately 3,700 tons per day of highly refractory ore and 4,000 tons per day processed in the mill's existing chlorination treatment system.

New mine openings slowed from the rapid expansion since 1982, but new operations were announced at three Nevada mines. Santa Fe Pacific poured its first gold at the Lone Tree Mine near Valmy in Humboldt County on August 13th. USMX began mining operations at its Winrock property in White Pine County in early July, when mining was completed at its Casino Mine after 1 year of operation. According to news reports, final ore production at Casino totaled 594,000 tons with a total gold content of about 32,000 troy ounces (995 kilograms), most of which was expected to be recovered by heap leaching. USMX also began mining and stockpiling ore at its Yankee Mine and process facilities 5 miles south of the Alligator Ridge Mine in White Pine County. Mining and stockpiling of ore was begun at the rate of 50,000 tons of ore per month. A portable, three-stage crushing plant was moved on-site from the Alligator Ridge Mine. Amax Gold Inc. completed construction of a larger grinding mill with throughput running about 2,250 tons of ore per day at its Sleeper Mine in Humboldt County. St. George Metals processed ore and developed four different adit levels within the underground Dean gold mine near Battle Mountain. Pilot production was started in stopes between levels four and three and between levels six and five.

Independence Mining Co. delineated considerable reserves at its New Deep/Gracie deposit near the Jerritt Canyon Mine in Elko County. First Mississippi Gold encountered additional reserves at its Getchell Mine in Humboldt County, reportedly increasing its proven and probable minable mill reserves by 15% and average ore grade by 20%. Crown Resources drilled on the Cord Ranch property located on the southern end of the Carlin Trend in Eureka County. Rayrock Yellowknife Resources completed infill definition drilling work to add further ore reserves to the Dee Mine in Elko County and the Pinson Mine in Humboldt County.

Besides exploration activities in these areas, Oliver Hills Mining Co. drilled in the Billy the Kid area in Storey County, and Consolidated Nevada Goldfields explored near Willow Springs in Nye County. Battle Mountain Exploration Co. and Santa Fe Pacific Mining Co. explored Horizon Gold Corp.'s Buffalo Valley property in Lander County.

Cornucopia Resources Ltd. and Galactic Resources Ltd. began a $1.7 million drilling program at their Ivanhoe Joint Venture on the Carlin Trend. Consolidated Nevada Goldfields started a developmental drilling program in Nye County near its Aurora Mine near Hawthorne.

Mining operations at Cominco Resources Buckhorn Mine in Eureka County ceased in May, but gold recoveries from the heap-leach operation were to be continued into 1992. Mining operations also ceased at Atlas Corp.'s Goldstone-South deposit in Eureka County in July. Gold King Consolidated suspended mining at the Adelaide-Crown Mine in Humboldt County in the 2d quarter of 1991. Near yearend, Asamera Minerals suspended all production operations at its Storey County Gooseberry Mine. Homestake Mining Co. completed mining operations at the Wood Gulch Mine in Elko County and began reclamation work at the 40-acre mine/site, including neutralization of the leach pad and reclamation of the leach pad and plant facilities. Inland Gold & Silver Corp. ceased operations at the Toiyabe Mine in Lander County in May 1991 and began reclamation and detoxification of the site.

Mercury.—Nevada was the principal mercury producer in the United States with production derived as a byproduct recovered from gold operations in Elko, Eureka, Humboldt, Mineral, Nye, and Washoe Counties. Total production was

1,654 flasks or 57.02 metric tons of mercury, valued at more than $200,000. FMC Corp's Paradise Peak Mine in Nye County was the principal producer.

Silver.—Most of the 11% decline in Nevada's 1991 silver production from that of 1990 was attributed to decreased production at the Candelaria Mine in Mineral County. Candelaria ceased mining in 1990, but continued to produce silver in 1991 from its heap-leaching operations. Despite the decline, Nevada remained the leading silver-producing State in the Nation, reporting 578 metric tons of silver valued at $75,050,000. The Couer Rochester Mine, with a silver-to-gold production ratio of approximately 95:1 and the Candelaria Mine, with a silver-to-gold production ratio of approximately 590:1 were the only producers to qualify as silver mines.

About 60% of the silver produced in Nevada in 1991 was a byproduct from gold mining. Byproduct silver production increased considerably during the year at Echo Bay Mines Ltd.'s McCoy/Cove Mine to a reported 1.4 million troy ounces (about 44 metric tons) as a result of mining the more silver-rich ore from the Cove deposit.

Other Metals.—Mill production at the Cyprus-Tonopah molybdenum-copper Mine in Lyon County ceased in 1991. Lead and zinc production in the State was solely from Alta Gold Co's Ward Mine, which shut down operations at its White Pine County site in March.

Industrial Minerals

Barite.—Nevada was the leading producer of barite among the States with more than 75% of the total, followed by Georgia and Missouri. It was used principally in drilling fluids with minor use in chemicals and as fillers in paper, plastics, and glass. Nevada's barite production in 1991 was reported to be 374,000 metric tons, which was slightly above the 1990 production. Production valued at $11,933,000 was more than double the value reported in 1990.

Four firms reported 1991 production in Nevada, with M-I Drilling Fluids Co. again ranked the number one producer from its Battle Mountain operations in Lander County. Milpark Drilling Fluids Inc.'s Argenta Mine in Lander County, Standard Slag Inc.'s P&S Mine in Nye County, and Circle A Construction Inc.'s Dry Creek operation in Elko County were additional producers.

Baroid Drilling Fluids Inc. mined barite from the Rossi Mine near Dunphy, but did not report production to the U.S. Bureau of Mines.

Cement.—Portland cement from the Centex Corp.'s Nevada cement plant near Fernley was Nevada's only reported cement production in 1991. An intensive upgrading program, which was expected to increase capacity, was begun at its plant in 1991.

Clays.—Nevada's total clay production increased 7.5% from that of 1991 and consisted of bentonite, fuller's earth, and kaolin varieties. Kaolin was the most valuable of the three types of clay produced, followed by fuller's earth and bentonite. Total bentonite production of 15,553 metric tons was valued at more than $3.2 million. Leading bentonite producers included Floridin Co.'s IMV Div., and Vanderbilt Minerals Corp. Floridin also produced fullers earth. Centex Corp. was the principal kaolin producer.

Diatomite.—Nevada's 1991 diatomite production ranked second to California among the States, despite a 5% drop. Eagle-Picher Industries Inc. was the State's largest producer, mining diatomite at three locations in northern Nevada. Eagle-Picher's Colado plant in Pershing County and Clark plant in Lyon County produced diatomite for filtration, insulation, and filler uses. C.R. Minerals in the Fernley area and Grefco Inc. at Basalt also produced absorbent and filler-grade material in Churchill and Esmeralda Counties.

Gypsum.—Weakness in the construction industry in Nevada and California in 1991 resulted in a 12.7% decrease in Nevada's crude gypsum production and a 17% decrease in calcined gypsum production. Pacific Coast Building Products Inc. and PABCO Gypsum near Las Vegas in Clark County were the largest crude gypsum producers in Nevada followed by USG Corp. at Empire in Washoe County and James Hardie Gypsum and Georgia Pacific Corp. near Las Vegas. Nevada ranked fifth among the States producing calcined gypsum. James Hardie Gypsum in Clark County was the State's largest calcined gypsum producer, followed by U.S. Gypsum in Washoe County and PABCO and Georgia Pacific in Clark County.

Homestead Minerals, a subsidiary of the Art Wilson Co., mined gypsum and anhydrite near Carson City that was sold to cement manufacturers and agricultural users. Nevada Gypsum and Southwestern Minerals mined small amounts of Gypsum in Clark County. Development of the White Beauty gypsum mine on Mount Charleston in Clark County was halted by Delta Minerals Corp. and the company ceased to exist.

Lime.—In 1991, lime production in Nevada increased by about 12% over that of 1990. Chemstar Inc. produced dolomitic lime in Henderson from dolomite mined at Sloan, south of Las Vegas, and high-calcium lime at Apex just northeast of Las Vegas. Chemstar continued to evaluate a high-calcium lime project near Winnemucca. Continental Lime, Inc. produced high-calcium lime at its Pilot Peak operation near Wendover in Elko County, supplying gold recovery operations in northern Nevada.

Sand and Gravel.—Construction.—Construction sand and gravel is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990. Nevada sand and gravel

TABLE 2
NEVADA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse and fine aggregates: Unpaved road surfacing[2]	135	410	$3.04
Other construction materials[3]	299	1,924	6.44
Other miscellaneous uses[4]	621	3,554	5.73
Unspecified:[5]			
Actual	2	8	3.48
Estimated	141	630	4.47
Total[6]	1,199	6,527	5.45

[1]Includes dolomite, granite, limestone, miscellaneous stone, traprock, volcanic cinder, and scoria.
[2]Includes terrazzo and exposed aggregate, and other coarse and fine aggregates.
[3]Includes concrete aggregate, coarse, stone sand, and bituminous mix or seal.
[4]Includes poultry grit and mineral food, other agricultural uses and cement manufacture.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.
[6]Data may add to total shown because of independent rounding.

TABLE 3
NEVADA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2	
	Quantity	Value	Quantity	Value
Construction aggregates:				
Coarse aggregates, graded[1]	—	—	W	W
Fine aggregates (-3/8 inch)[2]	—	—	W	W
Coarse and fine aggregates[3]	(4)	(4)	W	W
Other construction materials	—	—	326	2,033
Agricultural[5]	(4)	(4)	—	—
Chemical and metallurgical[6]	(4)	(4)	—	—
Other miscellaneous uses	729	3,856	—	—
Unspecified:[7]				
Actual	2	8	—	—
Estimated	—	—	141	630
Total	731	3,864	467	2,663

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes concrete aggregate (coarse)
[2]Includes stone sand (concrete).
[3]Includes unpaved road surfacing, terrazzo and exposed aggregate, and other coarse and fine aggregates.
[4]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[5]Includes poultry grit and mineral food, and other agricultural uses.
[6]Includes cement manufacture.
[7]Includes production reported without a breakdown by end use and estimates for nonrespondents.

statistics are compiled by geographical districts as depicted in the State map. Tables 2 and 3 present end-use statistics for Nevada's two districts.

Nevada's construction sand and gravel output was estimated to have increased about 10% to 20,000,000 short tons in 1991, from 1990's reported production of 18,377,000 short tons despite the State's recent construction declines. The NBMG reported a 1991 construction aggregate production of 23 million short tons, of which about 10% was crushed stone.

Large producers in the Las Vegas area in 1991 were Bonanza Materials, Inc. (Beazer USA), Nevada Ready Mix Co., Las Vegas Paving Corp., Southern Nevada Paving, Frehner Construction Co., and Wells Cargo, Inc. Although residential construction slowed considerably in 1991, a highway project in Henderson and work on Las Vegas International Airport runways sustained production at near 1990 levels.

Granite Construction Co. was the largest producer in the Reno-Sparks-Carson City area in 1991. Robert L. Helms Construction Co., Paiute Pit Aggregates Inc., Rocky Ridge, Inc., and Sha-Neva Inc. were also major producers. Eagle Valley Construction Co., a major producer in 1990, went out of business in 1991.

Industrial.—Simplot Industries was the principal supplier of industrial sand in Nevada from its Overton pit near Las Vegas. Production of approximately 560,000 tons of silica sand (reported by NBMG) was about 3% less than the 1990 production and more than 20% below record production reported in 1989.

Stone (Crushed).—Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1990 and 1992, and actual data for 1991. Crushed stone in Nevada was derived principally from limestone, dolomite, lightweight granite rock, traprock and volcanic cinders, or scoria. Quantities of crushed stone reported in 1991 were slightly lower than those reported in 1989, with a total of 1,199,000 short tons from all categories. But, value was calculated to be $6,527,000 or 30% higher than that of 1989. Most of the crushed stone was used in construction aggregates, agricultural, chemical, and metallurgical aplications. More specific uses included unpaved road surfacing, terrazzo aggregate, poultry grit, mineral food, and cement manufacture.

TABLE 4
NEVADA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	2	W	W	$2.85	2	W	W	$5.76
Dolomite	5	W	W	3.93	3	W	W	4.65
Marble	1	(1)	$1	22.00	—	—	—	—
Granite	1	32	48	1.50	1	33	$53	1.61
Traprock	2	W	W	1.00	2	W	W	3.28
Volcanic cinder and scoria	1	96	640	6.67	1	21	535	25.48
Miscellaneous stone	6	407	1,136	2.79	3	W	W	4.92
Total	XX	1,560	4,638	2.97	XX	1,199	6,527	5.44

W Withheld to avoid disclosing company proprietary data, included in "Total." XX Not applicable.
[1]Less than 1/2 unit.

Other Industrial Minerals.—Basic Inc.'s mine in Nye County was the sole producer of brucite in the United States. Premier Services Ltd., a European refractories manufacturer, acquired the Basic Inc. magnesite mine and magnesia plant at Gabbs during the year. Cyprus Foote Mineral Co. was the only producer of lithium carbonate from brines in the United States which are refined at its adjacent Silver Peak plant in Esmeralda County. Plaster Aggregates, a subsidiary of USG Corp. produced a small amount of expanded perlite from its Empire plant in Washoe County. The Wilkin Mining and Trucking Co. shipped crude and expanded perlite from Lincoln County.

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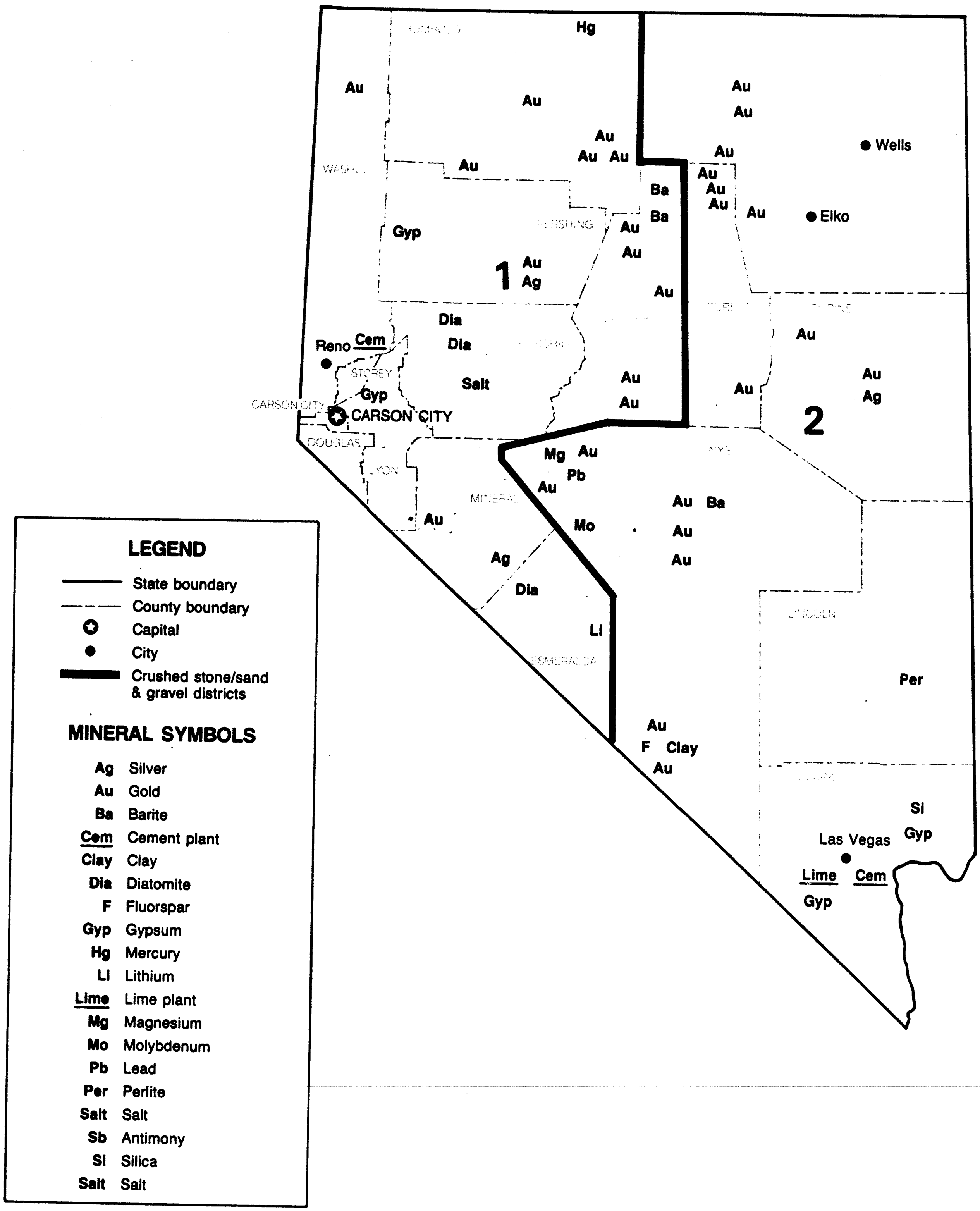
[1]State Mineral Officer, U.S. Bureau of Mines, Reno, NV. He has 26 years of mineral-related government experience and has covered the mineral activities in Nevada for 10 years. Assistance in the preparation of the chapter was given by Marguerite Roberto, program assistant.

[2]State geologist, Nevada Bureau of Mines and Geology, Reno, NV.

[3]Geologist, Nevada Bureau of Mines and Geology, Reno, NV.

[4]Geologist, Nevada Bureau of Mines and Geology, Reno, NV.

NEVADA



Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Barite:			
Milpark Drilling Fluids Inc.	Box 22111 Houston, TX 77242	Surface mine and mill	Lander.
M-I Drilling Fluids Inc.	Box 42842 Houston, TX 77242	do.	Do.
Baroid Drilling Fluids Inc.	3000 Sam Houston Pkwy. Houston, TX 77251	Surface mine	Elko.
Cement:			
Centex Corp., Nevada Cement Co.	Box 895 Fernley, NV 89408	Plant	Lyon.
Clays:			
IMV Division of Floridin Co.	Route Box 549 Amargosa Valley, NV 89020	Surface mine and mill	Nye.
Copper:			
Airmetco Inc.	100 Burch Dr. Yerington, NV 89447	do.	Lyon.
Alta Gold Co.	Box 324 East Ely, NV 89315	do.	White Pine.
Cyprus Minerals Co.	Box 3299 9100 E. Mineral Circle Engelwood, CO 80155	do.	Esmeralda.
Diatomite:			
Eagle-Picher Industries Inc., Minerals Div.	Box 10480 Reno, NV 89510	Surface mine and plants	Lyon and Pershing.
Grefco Inc., Dicolite Div.	Box 288 Mina, NV 89422	Surface mine and plant	Esmeralda.
Moltan Co.	Box 860 Fernley, NV 89408	do.	Churchill.
Gold:[1]			
Newmont Gold Co., a subsidiary of Newmont Mining Corp.	Box 979 Carlin, NV 89822	Surface mine, mill, refinery	Eureka.
Round Mountain Gold Corp.	Box 480 Round Mountain, NV 89045	do.	Nye.
American Barrick Resources Corp.	Box 29 Elko, NV 89801	do.	Eureka.
Independence	Mountain City Star Route Elko, NV 89801	do.	Elko.
Battle Mountain Gold Co.	Box 1627 Battle Mountain, NV 89820	Surface mine and mill	Lander.
AMAX Gold Inc.	Box 1820 Winnemucca, NV 89445	do.	Humboldt.
Gypsum:			
James Hardie Gypsum, Inc.	Box 2900 Las Vegas, NV 89124	Surface mine and plant	Clark.
Pacific Coast Building Products Inc.	Box 45 Newark, CA 94560	do.	Do.
USG Corp	101 South Wacker Dr. Chicago, IL 60606	do.	Washoe.
Georgia Pacific Corp.	Box 30006 North Las Vegas, NV 89030	do.	Clark.
Lime:			
Chemstar Inc.	901 Mariner's Island Blvd. Suite 425 San Mateo, CA 94404	Surface mine and plant	Do.

See footnote at end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Lime—Continued:			
Continental Lime, Inc.	Box 2520 Wendover, NV 89883	Surface mine and plant	Elko.
Lithium compounds:			
Cyprus Foote Mineral Co.	301 Lindenwood Dr. Suite 301 Malvern, PA 19335-1740	Dry lake brines and plant	Esmeralda.
Magnesite:			
Premier Services Inc.	Box 177 Gabbs, NV 89409	Surface mine and mill	Nye.
Mercury:			
FMC Corp.	Box 1237 Hawthorne, NV 89415	Surface mine and plant	Do.
Placer Dome U.S. Inc., joint venture	Box 497 McDermitt, NV 89421	do.	Humboldt.
Perlite (expanded):			
USG Corp.	Empire, NV 89405	Plant	Washoe.
Wilkin Mining and Trucking Co.	Box 472 Panaca, NV 89042	Underground mine and plant	Lincoln.
Salt:			
Huck Salt Co.	895 Harrigan Rd. Fallon, NV 89406	Solar evaporation	Churchill.
Sand and gravel:			
Construction:[1]			
Nevada Ready Mix Co.	Box 530 Las Vegas, NV 89125	Pit	Clark.
Las Vegas Paving Corp.	1770 South Industrial Rd. Las Vegas, NV 89102	Pit	Do.
Robert L. Helms Construction Co.	Drawer 608 Sparks, NV 89432-0608	Pit	Lander and Washoe.
WMK Transit Mix, Inc.	Box 14697 Las Vegas, NV 89114	Pits and mills	Clark.
Wells Cargo Inc.	Box 159 Wadsworth, NV 89442	Pit and mill	Washoe.
Granite Construction Co.	Box 2087 Sparks, NV 89432	Pits and mills	Do.
Bonanza Materials (Beazer USA)	565 Lalif Rd. Henderson, NV 89015	do.	Clark.
Frehner Construction Co.	124 W. Brooks Ave. North Las Vegas, NV 89030	do.	Do.
Southern Nevada Paving	3555 Polaris Ave. Las Vegas, NV 89102	Surface mine and plant	Do.
Sha-Neva	Drawer 669 Truckee, CA 95739	do.	Washoe.
Sand (industrial):			
Simplot Industries	Box 308 Overton, NV 89040	do.	Clark.
Stone (crushed):			
Rocky Ridge Inc.	Box 2669 Tuckee, CA 95737	do.	Do.
All-Lite Aggregate	Box 10865 Reno, NV 89510	do.	Storey.

See footnote at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone (crushed)—Continued:			
Rilite Aggregate Co.	Box 11767 Reno, NV 89511	Surface mine and plant	Washoe.
Basalite	2600 Boeing Way Carson City, NV 89706	do.	Lyon.
Southern Nevada Lightweight	4675 Wynn Rd. Las Vegas, NV 89103	do.	Clark.
Centex Corp., Nevada Cement Co.	Box 985 Fernley, NV, 89408	Quarry	Lyon.
Chemstar Inc.	901 Mariner's Island Blvd. Suite 425 San Mateo, CA 94404	Quarries	Do.
Silver:			
Coeur-Rochester Inc.	Box 1057 Lovelock, NV 89419	do.	Pershing.
FMC Corp.	Box 1237 Hawthorne, NV 89415	do.	Nye.
NERCO Minerals Co.	Box 1246 Hawthorne, NV 89415	do.	Mineral.

[1]Listed in descending order of production.

THE MINERAL INDUSTRY OF NEW HAMPSHIRE

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the New Hampshire Department of Environmental Services for collecting information on all nonfuel minerals.

By Donald K. Harrison[1]

The value of New Hampshire's nonfuel mineral production in 1991 was $30.4 million, a decrease of $4.8 million from that of 1990. Crushed stone, construction sand and gravel, and dimension stone accounted for most of the State's mineral production; common clay and a small amount of gemstones collected by hobbyists and gem dealers accounted for the remainder. Crude gypsum was imported into the State and calcined at two plants in Rockingham County.

TRENDS AND DEVELOPMENTS

Sand and gravel and stone have traditionally accounted for most of the State's mineral value. In 1991, the value of these two minerals accounted for more than 99% of the State's total value. Because most of New Hampshire's mineral output is consumed by the construction industry, mineral output is usually influenced by demand from this industry. The overall value of building contracts in New Hampshire, as well as in most of the other surrounding New England States, has been steadily declining since 1988. In 1991, the value of total construction contracts in New Hampshire was down 14% from that of 1990, 112% lower than that of 1988.

Although the value of nonbuilding construction contracts was up almost 75% from 1990 levels, this was offset by declines in other categories. In 1991, the value of residential construction contracts was down 57% from that of the previous year. The value of nonresidential construction also declined by 6% in the same period. Although output of crushed stone was up from the 1990 estimated output, decreases in tonnages for both construction sand and gravel and dimension stone were reported. As a result, the overall mineral value in 1991 was down 14% from that of the previous year.

EMPLOYMENT

In 1991, the average number of workers[2] employed in the mineral extractive industries in New Hampshire was 386, a total of 79 less than that of 1991. This included 271 at sand and gravel operations, 102 at crushed and dimension stone operations, and 13 workers who were employed at mineral-related mills and preparation plants in the State.[3]

REGULATORY ISSUES

Voters in the town of Londonderry rejected a $5 million bond proposal to pay for capping the Auburn Road landfill, a Federal Superfund waste site. The landfill, which closed in 1980, was a former town dump, septic lagoon, and landfill. At the time of the closure, the State found hazardous materials in both the soil and ground water at the 200-acre site. The site was placed on the Federal Superfund list in 1986 and cleanup was estimated to cost $23 million. The U.S. Environmental Protection Agency (EPA) determined in 1990 that the town was responsible for $5 million of the cleanup costs. The EPA also determined that

TABLE 1
NONFUEL MINERAL PRODUCTION IN NEW HAMPSHIRE[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gemstones		NA	$51	NA	$38	NA	$31
Sand and gravel (construction)	thousand short tons	e6,000	e20,400	7,901	26,599	e4,700	e16,200
Stone:							
Crushed	do.	771	4,020	e600	e2,500	1,542	9,148
Dimension	short tons	55,305	8,769	e45,073	e6,029	34,803	5,013
Total[2]		XX	33,240	XX	35,166	XX	30,392

eEstimated. NA Not available. XX Not applicable.
[1]Production, measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Partial total, excludes values that must be concealed to avoid disclosing company proprietary data.

TABLE 2
NEW HAMPSHIRE: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Riprap and jetty stone	34	208	$6.12
Filter stone	40	281	7.03
Coarse aggregate, graded:			
Concrete aggregate, coarse	29	164	5.66
Bituminous aggregate, coarse	400	2,392	5.98
Fine aggregate (-3/8 inch):			
Stone sand, concrete	92	531	5.77
Stone sand, bituminous mix or seal	227	1,077	4.74
Screening, undesignated	15	586	3.87
Coarse and fine aggregates: Crusher run or fill or waste[2]	193	1,038	5.38
Unspecified:[3]			
Actual	181	1,039	5.74
Estimated	241	2,359	9.79
Total	1,452	[4]9,148	6.30

[1]Includes granite, limestone, miscellaneous stone, and traprock.
[2]Includes graded roadbase or subbase.
[3]Includes production reported without a breakdown by use and estimates for nonrespondents.
[4]Data do not add to total shown because of independent rounding.

eight private parties were responsible for the cleanup. One of the eight parties was the Derry Sand & Gravel Co., which operated a sand and gravel pit at the site.

LEGISLATION AND GOVERNMENT PROGRAMS

House bill 742, "Expansion of Sand and Gravel Regulations," was signed into law (Chapter 310) during the 1991 legislative session. The legislation was the result of lengthy negotiations between environmental groups and sand and gravel operators and developers to close loopholes in the existing 1989 law (Chapter 363) regulating gravel pits. Chapter 310 provides stricter operating standards for open pits and gives communities more flexibility to zone them out of residential neighborhoods. The law also tightens restrictions on digging in gravel pits that had been abandoned for 2 years and sets minimum standards for the slope of such pits near bodies of water.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Clays.—Kane Gonic Brick Corp., the State's only clay producer, mined common clay at a pit in Gonic, Strafford County. The clay was used to manufacture face brick and was marketed primarily in the Boston, MA, area.

Gypsum.—Two companies calcined imported gypsum in New Hampshire. In 1991, total gypsum calcined in the State was down 7% from that of 1990, primarily because of the continuing building slump in the Northeast. Most of the gypsum was made into wallboard and sold to the construction industry.

National Gypsum Co. operated a wallboard manufacturing plant at Portsmouth, Rockingham County. Crude gypsum for the plant was imported from the company's subsidiary in Canada through the Port of Portsmouth.

Domtar Inc., a Canadian-based company, operated a $30 million gypsum wallboard manufacturing plant along the Piscataqua River in Newington, Rockingham County. Crude gypsum for the plant, which began operating in 1990, was shipped from a company-owned quarry in Newfoundland, Canada.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

In 1991, construction sand and gravel was the leading mineral commodity produced and accounted for 53% of the State's mineral production value. Estimated output was 4.7 million short tons valued at $16.2 million. The estimated output in 1991 was 41% lower than that of 1990 and was the lowest since 1983 when 4 million short tons was produced. The decline was largely attributable to the continuing depressed construction industry in the State, the main consumer of aggregates.

Construction sand and gravel was produced by 42 companies from 55 operations at 71 pits in 11 counties. Leading counties, in order of output, were Merrimack, Carroll, Hillsborough, and Strafford. Major uses were for concrete aggregate, asphaltic concrete, and road base.

In December, the Raymond Planning Board unanimously agreed to suspend the permits for two gravel pits owned by Thibeault Corp. Problems seen by the board included possible wetlands damage, excavating below proper depths, and clearing land in excess of what the permit allows. The board also directed the town engineer to meet with State officials and Thibeault Corp. in an effort to identify any problems at the controversial sand and gravel operation and to report back with findings and proposed remedies. In addition, Thibeault was ordered to reapply for new permits in compliance with local, State, and Federal regulations. The board gave Thibeault 6 to 8 months

TABLE 3
NEW HAMPSHIRE: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	2	W	W	$6.57	1	W	W	$5.72
Granite	2	W	W	5.40	6	1,056	$5,796	5.49
Traprock	1	W	W	6.05	2	W	W	10.76
Miscellaneous stone	3	272	$1,063	3.91	1	W	W	5.75
Total[1]	XX	771	4,020	5.21	XX	1,452	9,148	6.30

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

to address any environmental problems.[4]

Stone.—Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Crushed.—Crushed stone was the State's second leading mineral commodity after construction sand and gravel. Crushed stone output in 1991 was 1.5 million short tons valued at $9.1 million. Average unit value rose from $4.16 per short ton in 1990 to $5.93 in 1991.

Crushed granite, traprock, and limestone were produced by 9 companies operating 10 quarries in 5 counties. Leading counties, in order of output, were Hillsborough, Rockingham, Merrimack, Cheshire, and Grafton. Main uses were for road base, bituminous aggregate, road surfacing, macadam, and concrete aggregate.

A Massachusetts-based company was seeking approval from the Eliot Planning Board to begin operating a 125-acre quarry on a 300-acre parcel near the Eliot-South Berwick line. The Barletta Co. was seeking a conditional use permit from the town for a proposed $1.8 million quarry and rock crushing plant. The quarry and plant site proposal was also under review by the State Department of Environmental Protection.

Dimension.—New Hampshire ranked 12th of 34 States that produced dimension stone in 1991. Dimension granite was mined by three companies at three quarries, two in Hillsborough County and one in Merrimack County. Primary uses were for rough blocks, curbing, and monumental stone.

Barretto Granite Corp. and its affiliated company, Kitledge Granite Corp., laid off 56 workers, almost one-half of its work force, after the company's bank failed in December 1990. The layoffs at the Hillsborough County, 80-acre dimension stone quarry were the result of action by the Federal Deposit Insurance Corp., in declaring Barretto's funding bank, New England All Bank of Gardener, MA, insolvent. At yearend, attempts to get new financing were unsuccessful, but the company did manage to avoid seeking bankruptcy protection under chapter 11. In the last couple of months of 1991, Barretto also spent $150,000 on new quarry equipment and company officials were anticipating to spend an additional $500,000 on equipment purchases if it made new financing arrangements. Most of the dimension granite produced at the quarry was sold for curbing.

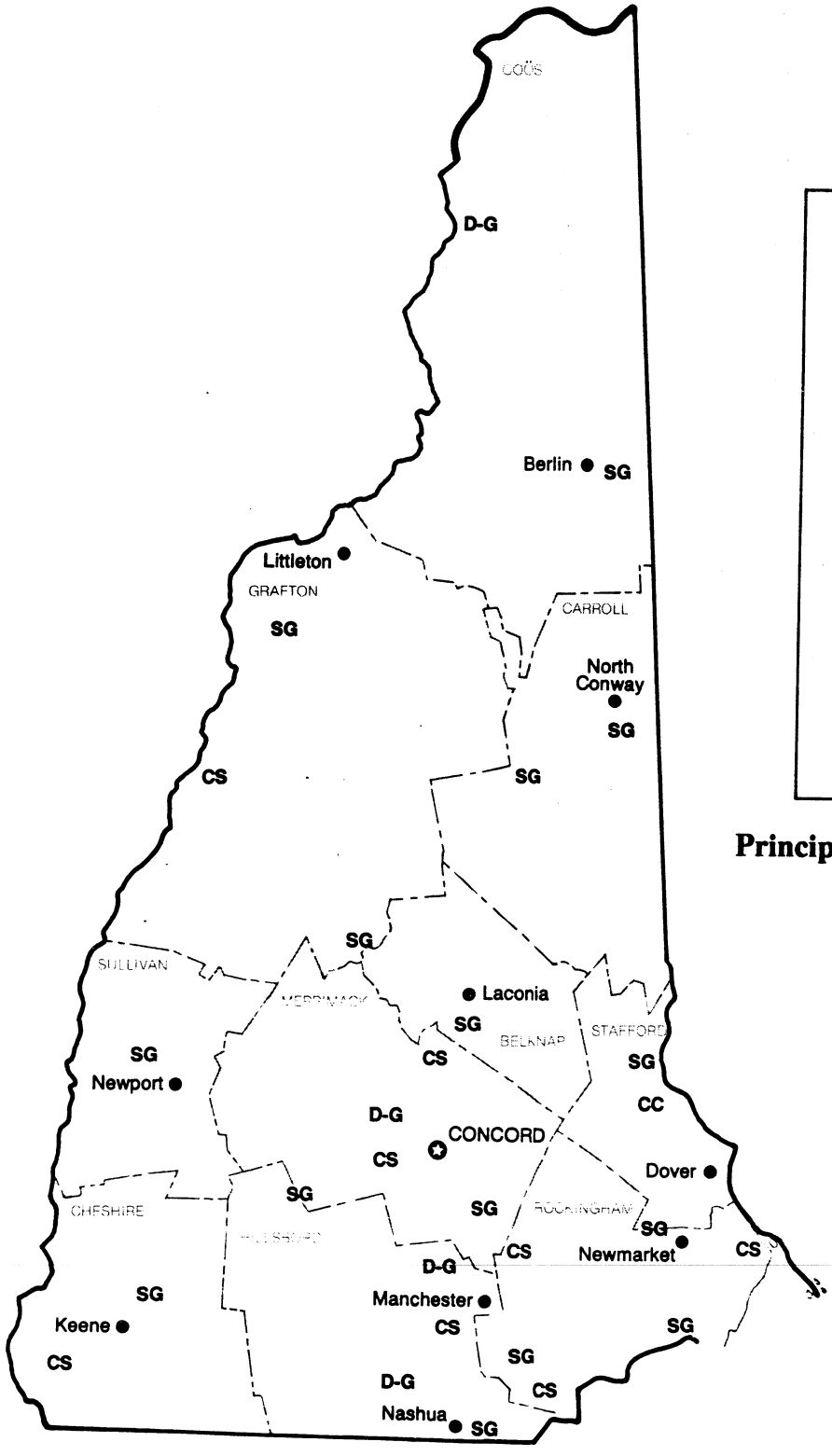
[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related experience and has covered the mineral activities in New Hampshire for 7 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]"Average number of workers" is a summary of the average number of workers at individual mining establishments during periods (not necessarily continuous) of active operations.

[3]U.S. Department of Labor, Mine Safety and Health Administration. Mine Injuries and Worktime Quarterly, Jan.-Dec. 1991, 33 pp.

[4]Union Ledger (Manchester, NH). Raymond Planners Pull Gravel Pits. Dec. 7, 1991, p. 7.

NEW HAMPSHIRE



LEGEND

State boundary
County boundary
Capital
City

MINERAL SYMBOLS

CC Common Clay
CS Crushed Stone
D-G Dimension Granite
SG Sand and Gravel

Principal Mineral-Producing Localities

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
Kane-Gonic Brick Corp.	Box 7400 Gonic, NH 03867	Pit	Strafford.
Gypsum (calcined):			
Domtar Gypsum Inc.	1222 Old Dover Rd. Newington, NH 03801	Plant	Rockingham.
National Gypsum Co.	4100 First International Bldg. Dallas, TX 75270	do.	Do.
Sand and gravel (1990):			
Brox Paving Materials[1]	1471 Methuen St. Dracut, NH 01826	Pits	Hillsborough, Merrimack, Strafford.
Coastal Material Corp.	Box 415, Dunbarton Rd. Manchester, NH 03105	do.	Hillsborough and Strafford.
Concord Sand & Gravel Inc.	Route 106, Box 1133 Concord, NH 03301	Pit	Merrimack.
Manchester Sand & Gravel	Box 415 Hooksett, NH 03106	Pits	Carroll and Merrimack.
Plourde Sand & Gravel Co. Inc.[1]	21 Union St. Suncook, NH 03275	Pit	Merrimack.
Rosenfeld Concrete Corp.	Box E Milford, MA 01757	Pit	Carroll.
A. Whitcomb Inc.[1]	Lancaster Rd. Gorham, NH 03581	Pits	Belknap, Cheshire, Coos, Grafton.
Stone:			
Crushed:			
Continental Paving Inc.	1 Continental Dr. Londonderry, NH 03053	Quarry	Rockingham.
John Iafolla Co. Inc.	Peverly Hill Rd., Box 840 Portsmouth, NH 03801	do.	Do.
Lebanon Crushed Stone Co.	Plainfield Rd. West Lebanon, NH 03784	do.	Grafton.
Pike Industries	U.S. Rte 3 RFD 2, Box 9 Tilton, NH 03276	Quarries	Merrimack.
F. W. Whitcomb Construction Corp.	Box 100 Walpole, NH 03608	do.	Cheshire.
Dimension:			
Fletcher Granite Co.	Groton Rd. W. Chelmsford, MA 01863	do.	Hillsborough.
Kitledge Granite Corp.	Armory Rd. Milford, NH 03055	do.	Do.
J. Swenson Granite Co.	North State St. Concord, NH 03301	do.	Merrimack.

[1]Also crushed stone.

THE MINERAL INDUSTRY OF NEW JERSEY

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Geological Survey, Division of Water Resources, New Jersey Department of Environmental Protection, for collecting information on all nonfuel minerals.

By Donald K. Harrison[1]

The value of nonfuel mineral production in 1991 was $205 million, a $24.5 million decrease from that of 1990. The decrease in 1991 was largely attributable to lower sales of crushed stone and construction sand and gravel, the State's two leading mineral commodities. Other mineral commodities produced included common and fire clays, industrial sand, peat, titanium, and zircon concentrates. Nationally, the State ranked 37th in the production of nonfuel minerals. New Jersey was the only State that produced greensand, was one of only two States that produced zircon and rutile, and one of only three States where ilmenite was recovered. The State ranked third in peat sales, and fourth in industrial sand and exfoliated vermiculite output.

TRENDS AND DEVELOPMENTS

Overall, construction remained depressed in New Jersey in 1991, but began showing some signs of recovery. In 1991, residential, nonresidential, and nonbuilding construction, which relies heavily on mineral aggregates, remained well below the peak building years of 1987 and 1988. However, during the last quarter of 1991, improvements were seen in homebuilding and public works construction. These improvements should have a beneficial effect on other sectors of the economy. Although demand for construction mineral aggregates remained soft in 1991, the slight recovery should be somewhat helpful for this industry.

EMPLOYMENT

In 1991, the average number of workers[2] employed in the minerals extractive industries in New Jersey was 1,724. Most of these workers (885) were employed at sand and gravel operations. Mineral-related mills and preparation plants in the State employed 394 workers.[3]

LEGISLATION AND GOVERNMENT PROGRAMS

In response to recent mine subsidence problems, a bill (Assembly bill 3052, "Mine Subsidence Insurance") was introduced into the 1991 legislature. The bill would require insurance companies to cover mine collapses as part of basic

TABLE 1
NONFUEL MINERAL PRODUCTION IN NEW JERSEY[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Clays[2]	metric tons	18,492	$400	W	W	W	W
Gemstones		NA	3	NA	$3	NA	$3
Peat	thousand short tons	W	638	W	527	W	541
Sand and gravel:							
Construction	do.	e15,200	e68,400	13,862	64,245	e10,300	e47,900
Industrial	do.	1,797	26,138	1,762	26,190	1,634	23,738
Stone (crushed)	do.	20,799	140,998	e21,200	e131,700	3 16,680	3 119,287
Zircon concentrates	metric tons	W	8,988	W	W	W	W
Combined value of clays [common, fire (1990-91)], marl (greensand), stone [crushed sandstone and other (1991)], titanium concentrates [ilmenite and rutile (1991)], and values indicated by symbol W		XX	3,318	XX	6,805	XX	13,519
Total		XX	248,883	XX	229,470	XX	204,988

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; value included with "Combined value" figure.
[3]Excludes certain stones; value included with "Combined value" figure.

property insurance. It would authorize the issuance of mine subsidence insurance by the New Jersey Underwriting Association in those parts of the State where abandoned mines are located in the amount of $50,000 for each occurrence. The bill died in the 1991 legislative session but was reintroduced in February 1992 as Assembly bill 985. There are more than 400 known iron and copper mines in the State, some dating to the Revolutionary War period. Over the past 20 years, about 30 mine shaft collapses have been reported in New Jersey. Most of these collapses involved abandoned iron mines and most occurred in Morris County.

A number of bills concerning environmental issues were introduced in 1991 or carried over from the 1990 legislature. Topics addressed included solid waste disposal, radon gas testing, recycling, and hazardous materials disposal. Several bills regarding solid waste (A 300, A 1808, A 1817, and S 2260) were signed into law during the year. Other bills that became law included establishing radioactive waste fees (S 3054), hazardous substance discharge liabilities (S 2440), and disposal of used batteries (S 2700).

The New Jersey Geological Survey (NJGS), part of the Department of Environmental Protection (DEP), continued to be the primary State agency responsible for investigating the State's mineral and ground water resources.

Research in 1991 by the NJGS included conducting microgravity surveys to search for locations of 19 possible abandoned shafts of the Schuyler copper mine, Bergen County. In late 1989, the Victoria shaft of the Schuyler Mine suddenly collapsed. At yearend 1991, four shafts had been located and remediation was in progress. The NJGS was also participating in an assessment of the heavy-mineral distribution of the submerged portion of the New Jersey Coastal Plain. Offshore vibracore samples were processed by the U.S. Geological Survey and were being evaluated for their heavy-mineral contents.

Several publications related to mining were published by the NJGS in 1991. An inventory of active and abandoned sand and gravel mining operations in New Jersey (GSR 25) was published. Open File Report 91-1 concerns the detection of abandoned mines using high-resolution geophysical methods in Randolph Township, Morris County. At least 20 abandoned iron mines have been identified in that township.

The U.S. Army Corps of Engineers completed a $4.4 million beach nourishment project at Cape May. The project, which extended from Cape May Inlet to Lower Township, was authorized in the Water Resources Development Act of 1986 and called for construction of two groin extensions, placement of beachfill, and continued beach nourishment every 2 years if required. The Corps placed almost 800,000 cubic yards of sand at the project site. The sand was dredged from an offshore source.[4]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Clays.—Two companies reported clay production in 1991. Glen-Gery Brick mined common clay and shale at an operation in Somerset County, and The Morie Co. Inc. produced fire clay at Clayville, Cumberland County. Production of common clay, used primarily for manufacturing common brick, decreased in 1991. Fire clay output, used primarily in foundries, increased over 1990 levels.

Greensand.—New Jersey was the only State that produced greensand. The Inversand Co., a subsidiary of Hungerford and Terry Inc., Clayton, Gloucester County, was the only producer. Greensand, also known as the mineral glauconite, is a hydrous iron potassium silicate containing various amounts of aluminum, magnesium, sodium, and trace elements. It was processed and sold mainly as a filtration medium to remove soluble iron and manganese from well water. A secondary use was as an organic conditioner for soils.

Peat.—New Jersey ranked third of 19 States that reported peat sales. Three companies mined peat in 1991, two in Sussex County and one in Warren County. Most of the peat was sold for general soil improvement and as an ingredient in potting soil.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

In 1991, construction sand and gravel was the second leading commodity produced, and accounted for almost one-quarter of the State's mineral production value. Estimated output was 10.3 million short tons valued at $47.9 million. The estimated output in 1991 was the lowest since 1984 when 9.5 million short tons was produced. Output of construction sand and gravel has been steadily declining since the peak output year of 1988 when 18.3 million tons was produced. The decline was largely attributable to the continuing depressed construction industry in the State, the main consumer of aggregates.

Construction sand and gravel was produced by 52 companies at 75 pits in 15 of the State's 21 counties. Leading counties, in order of output, were Ocean, Cumberland, Morris, Cape May, and Sussex. Major uses were for concrete aggregates, asphaltic concrete aggregates, fill, and roadbase and coverings.

After 17 years of operations, countless run-ins with the Pittsgrove Township Committee Planning Board, and several lawsuits, a gravel pit operation in Pittsgrove, Gloucester County, was ordered out of business. In September, the Superior Court ordered the mine's owner to terminate all operations at the 114-acre mine. It was determined by the court that the mine was operating

TABLE 2
NEW JERSEY: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	75	813	$10.83
Riprap and jetty stone	121	997	8.23
Filter stone	226	1,491	6.60
Coarse aggregate, graded:			
Concrete aggregate, coarse	1,322	9,660	7.31
Bituminous aggregate, coarse	4,945	37,517	7.59
Bituminous surface-treatment aggregate	859	6,988	8.14
Railroad ballast	606	3,743	6.18
Fine aggregate (-3/8 inch):			
Stone sand, concrete	148	1,109	7.47
Stone sand, bituminous mix or seal	320	2,245	7.01
Screening, undesignated	303	2,119	6.99
Coarse and fine aggregates:			
Graded road base or subbase	997	6,367	6.39
Unpaved road surfacing	803	6,051	7.54
Terrazzo and exposed aggregate	63	1,090	17.43
Crusher run or fill or waste	54	305	5.63
Other construction materials[2]	658	4,330	6.58
Agricultural:			
Agricultural limestone	60	900	15.00
Poultry grit and mineral food	1	30	30.00
Chemical and metallurgical:			
Lime manufacture	95	428	4.50
Flux stone	3	40	16.00
Special:			
Mine dusting or acid water treatment	3	45	15.00
Asphalt fillers or extenders	38	581	15.14
Other fillers or extenders	5	95	19.00
Unspecified:[3]			
Actual	4,884	31,603	6.47
Estimated	91	743	8.16
Total	16,680	[4]119,287	7.15

[1]Includes granite, limestone, and traprock; excludes a minor amount of miscellaneous stone and sandstone withheld to avoid disclosing company proprietary data.
[2]Include roofing granules.
[3]Includes production reported without a breakdown by use and estimates for nonrespondents.
[4]Data do not add to total shown because of independent rounding.

without the proper license since 1983.

Industrial.—Nationally, New Jersey ranked fourth of 37 States that produced industrial sand in 1991. Output declined by 7% from that of 1990. Seven companies operated 22 stationary plants in 6 counties. Leading counties, in order of output, were Cumberland, Ocean, Atlantic, Camden, Cape May, and Gloucester. Principal uses for the industrial sand were for glass products, molding and core, and sandblasting.

In December, Genstar Stone Products Co. filed a lawsuit against Fairfield Township, Cumberland County, to overturn an August 28 Zoning Board decision that denied the company's request for a variance to mine industrial sand on 308 acres it owns in northeast Fairfield. The Fairfield Zoning Board cited an August 1990 township ordinance banning any new resource-extracting operations as the chief reason for its denial of Genstar's variance request. The Maryland-based sand and stone firm had sued Fairfield in Federal court in 1990 to void the mining ban, but the court put the lawsuit on hold, saying Genstar had not exhausted its administrative remedies, such as trying to obtain a variance.[5]

Stone (Crushed).—Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Crushed stone, the State's leading mineral commodity, accounted for 58% of the State's total mineral value. In 1991, production was 16.7 million short tons valued at $119 million. Output in 1991 was the lowest since 1986 when 15.3 million short tons was produced. All of the crushed stone was produced in district 1 in the northern part of the State, as depicted on the principal mineral-producing localities map. In 1991, 22 quarries produced traprock, granite, and limestone. A small amount of sandstone was also produced. Leading counties, in order of output, were Somerset, Morris, Passaic, Mercer, Sussex, and Hunterdon. Main uses of crushed stone were for concrete aggregate, road base and coverings, and bituminous aggregate.

Millington Quarry, a crushed stone operation in Bernards Township, was awarded the Gold Medallion Award for Excellence in Community Relations by the National Stone Association (NSA). Inaugurated by NSA in 1989, the Community Relations Program recognizes aggregate producers whose community involvement and support activities have contributed to the improvement of their public image as a good neighbor and a responsible corporate citizen. There were a total of eight quarries in the United States and Canada that received Gold Medallion awards.[6] During the year,

TABLE 3
NEW JERSEY: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991[1]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	6	1,968	$15,416	$7.83	2	460	$4,416	$9.60
Granite	5	6,487	47,093	7.26	9	7,454	54,955	7.37
Traprock	14	12,345	78,490	6.36	11	8,766	59,916	6.84
Total[2]	XX	20,799	140,998	6.78	XX	16,680	119,287	7.15

XX Not applicable.
[1]Excludes miscellaneous stone and sandstone; withheld to avoid disclosing company proprietary data.
[2]Data may not add to totals shown because of independent rounding.

Millington Quarry Inc.'s Oxford Quarry in Warren County was 1 of 25 aggregate mining operations nationwide to receive the NSA's Showplace Award in its About Face Program.[7] The purpose of the ongoing program is to recognize and reward crushed stone operators who have made constructive and positive efforts to enhance the appearance of their property and to call attention to these efforts through publicity within the aggregates industry and the local communities.

Other Industrial Minerals

In addition to the mineral commodities mined and listed in table 1, the production and value of some processed or manufactured mineral commodities were also surveyed by the U.S. Bureau of Mines.

American Minerals Inc. crushed and ground imported barite at a plant in Camden. The barite was sold primarily for use as fillers and extenders and in paint manufacturing.

Gypsum imported from Nova Scotia, Canada, was calcined by the National Gypsum Co., Burlington County, and by Domtar Gypsum, Camden County. Both output and value declined in 1991.

Crude iodine was shipped into New Jersey by four companies to manufacture various iodine-containing compounds. The compounds were used as laboratory reagents and in sanitation products, pharmaceuticals, and specialty organic and inorganic compounds.

Crude perlite from out-of-State sources was expanded by The Schundler Co., Edison, and sold primarily for horticultural purposes and cavity-fill insulation.

Steel slag was produced by two companies, one in Burlington County and the other in Middlesex County.

Elemental sulfur was recovered as a nondiscretionary byproduct at two refineries in the State. Mobil Oil Corp. recovered sulfur at a refinery in Gloucester County and Exxon Co. USA at its Bayway refinery in Union County.

Nord Ilmenite Corp., a wholly owned subsidiary of Nord Resources Corp., recovered titanium (ilmenite and rutile) and zircon concentrates from tailings at Glidden Co.'s former mineral sands operations near Lakewood.

Crude vermiculite was exfoliated by The Schundler Co. in Edison and by W. R. Grace & Co., Construction Products Div., Trenton. Principal uses were for insulation, lightweight building aggregates, and horticultural agents.

Metals

Although there was no metal mining in New Jersey in 1991, a number of companies processed or manufactured metal commodities.

AMAX Specialty Coppers Corp. produced oxygen-free copper and copper alloys at a plant in Carteret. The products were used in the electronics, plating, and construction industries.

Shieldalloy Metallurgical Corp., a subsidiary of Metallurg Inc., produced ferroalloys at a plant in Newfield, Gloucester County.

Iron oxide pigments were produced by two companies in Camden and Middlesex Counties.

New Jersey Steel Corp. produced steel at an electric furnace minimill in Sayreville, Middlesex County. Almost all of the production was rebar. Raritan River Steel Co., a leading producer of wire rod, operated an electric arc furnace and continuous caster in Perth Amboy, Middlesex County.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related experience and has covered the mineral activities in New Jersey for 9 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]"Average number of workers" is a summary of the average number of persons working at individual mining establishments during periods (not necessarily continuous) of active operations.

[3]U.S. Department of Labor, Mine Safety and Health Administration. Mine Injuries and Worktime Quarterly, Jan.-Dec. 1991, 33 pp.

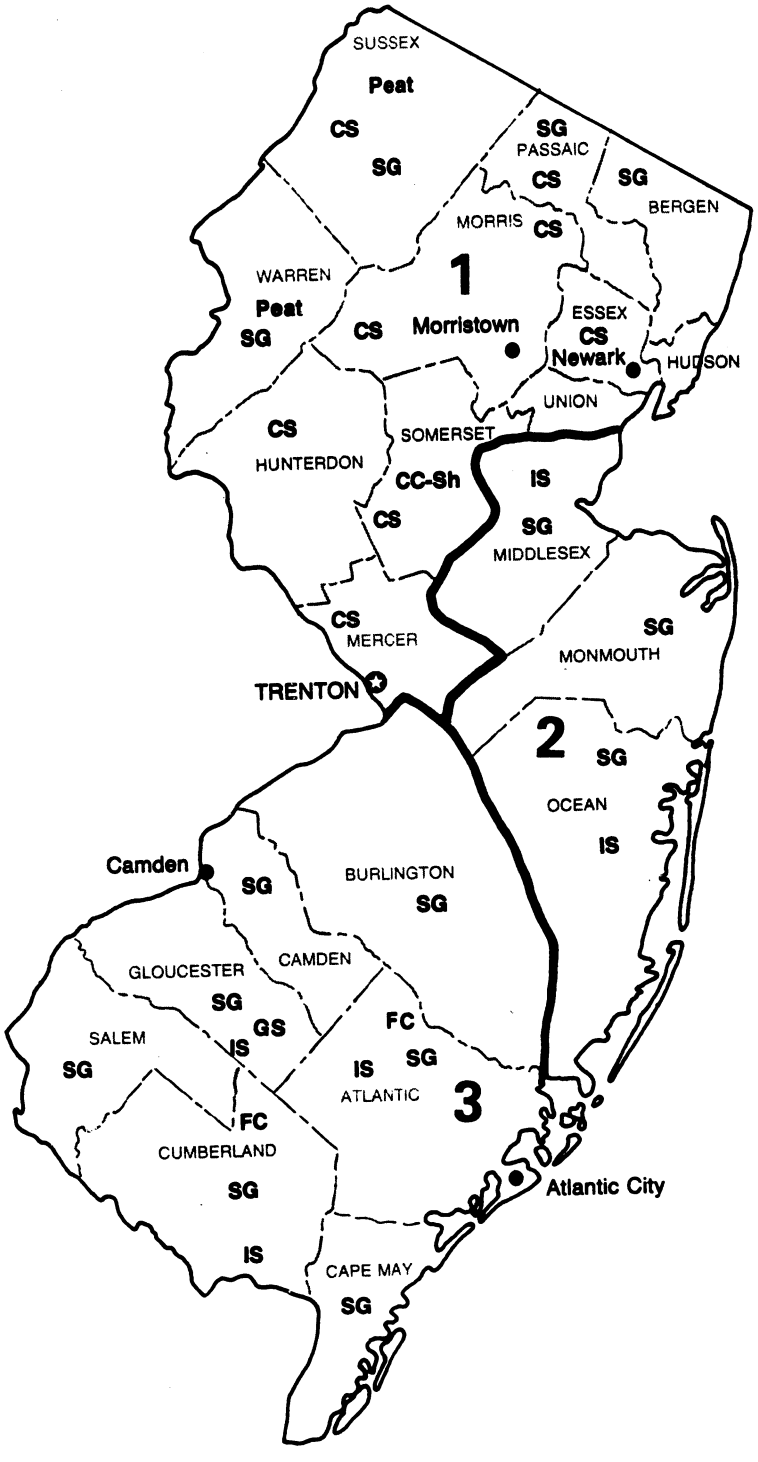
[4]Constructioneer. Beach in Cape May. Oct. 21, 1991, p. 36.

[5]The Press (Atlantic City, NJ). Firm Sues Fairfield Over Permit. Dec. 12, 1991, p. C1.

[6]Randolph (NJ) Reporter. Millington Quarry Inc. Receives Top Community Relations Award. Apr. 4, 1991, p. 6.

[7]National Stone Association. NSA Digest, Dec. 6, 1991.

NEW JERSEY



LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

CC-Sh	Common Clay & Shale
CS	Crushed Stone
FC	Fire Clay
GS	Greensand
IS	Industrial Sand
Peat	Peat
SG	Sand and Gravel

Principal Mineral-Producing Localities

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
The Morie Co. Inc.[1]	1201 North High St. Millville, NJ 08322	Pit	Cumberland.
Glen-Gery Brick	75 Hamilton Rd. South Somerville, NJ 08876	Pit and plant	Somerset.
Greensand:			
Inversand Co., a subsidiary of Hungerford & Terry Inc.	Box 650 Clayton, NJ 08312	Pit	Gloucester.
Gypsum (calcined):			
Domtar Gypsum Inc.	1101 South Front St. Camden, NJ 08103	Plant	Camden.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	do.	Burlington.
Iron oxide pigments (finished):			
American Minerals Inc.[2]	Box 677 Camden, NJ 08101	do.	Camden.
Columbian Chemicals Co.	303 Hoffmeister Ave. St. Louis, MO 63125	do.	Middlesex.
Peat:			
Glacial Soils Lab	346 Grand Ave. Englewood, NJ 07631	Bog	Sussex.
Hyponex Corp.	14111 Scotslawn Rd. Marysville, OH 43041	Bog	Do.
Kelsey Humus Co.	Kelsey Park Great Meadows, NJ 07838	Bog	Warren.
Perlite (expanded):			
The Schundler Co.[3]	Box 251 Metuchen, NJ 08840	Plant	Middlesex.
Sand and gravel:			
Construction:			
Clayton Sand Co.	Box 928 Lakewood, NJ 08701	Pit	Ocean.
Continental Somerset Sand & Gravel Co.	P.O. Box 1475 Blackwood, NJ 08012	Pit and plant	Camden.
Dallenback Sand Co. Inc.	Box 333 Dayton, NJ 08810	Dredge	Middlesex.
Mays Landing Sand & Gravel Co.	Box 539 Vineland, NJ 08360	Pit	Cumberland.
The Morie Co. Inc.	1201 North High St. Millville, NJ 08332	Dredge	Atlantic, Cape May, Cumberland.
Saxon Falls Sand & Gravel	Box 576 Stanhope, NJ 07874	Pit	Morris.
Tuckahoe Sand & Gravel	Box 248 Tuckahoe, NJ 08250	Pit	Cape May.
Industrial:			
Unimin Corp., Dividing Creek Plant	258 Elm St. New Canaan, CT 06840	Pit	Cumberland.
U.S. Silica Co.	Box 458 Newport, NJ 08345	Pit	Do.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued:			
Industrial—Continued:			
Ricci Bros. Sand Co. Inc.	Box 429, Dragston Rd. Port Norris, NJ 08349	Pit	Cumberland.
Whitehead Bros. Co.	Box 259, River Rd. Leesburg, NJ 08327	Pits	Do.
Stone:			
Granite (crushed and broken):			
Mount Hope Rock Products Inc.	625 Mount Hope Rd. Wharton, NJ 07885	Quarry	Morris.
Passaic Crushed Stone Co. Inc.	Foot of Broad St. Prompton Lakes, NJ 07442	do.	Passaic.
Riverdale Quarry Co.	125 Hamburg Turnpike Riverdale, NJ 07457	do.	Morris.
Tri-County Asphalt Corp.	R.D. 3, Box 561 Lake Hopatcong, NJ 07849	do.	Sussex.
Traprock (crushed and broken):			
Fanwood Crushed Stone Co.	141 Central Ave. Westfield, NJ 07090	do.	Union.
Millington Quarry Inc.	Box 407 Millington, NJ 07946	do.	Somerset.
Minnesota Mining & Manufacturing Co.	3M Center 224-6 SW St. Paul, MN 55101	do.	Do.
Stavola Construction Materials Inc.	810 Thompson Ave. Bound Brook, NJ 08805	do.	Do.
Trap Rock Industries Inc.	Box 419 Kingston, NJ 08528	Quarries	Hunterdon, Mercer, Somerset.
Sulfur (recovered):			
Exxon Co. U.S.A.	Box 23 Linden, NJ 07036	Refinery	Union.
Mobil Oil Corp.	Box 428 Paulsboro, NJ 08066	do.	Gloucester.
Vermiculite (exfoliated):			
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	Plant	Mercer.
Zircon:			
Nord Ilmenite Corp.[4]	Box 118 Jackson, NJ 08527	do.	Ocean.

[1]Also industrial sand.
[2]Also milled zircon.
[3]Also exfoliated vermiculite.
[4]Also ilmenite and rutile.

THE MINERAL INDUSTRY OF NEW MEXICO

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the New Mexico Bureau of Mines and Mineral Resources for collecting information on all nonfuel minerals.

By Jean A. Dupree[1] and Robert W. Eveleth[2]

The Land of Enchantment ranked 10th in the Nation in 1991 nonfuel mineral production. Value of State output was $985.5 million, a drop of 11% from the 1990 total. Nonferrous metal production accounted for approximately 66% of the mineral value, or nearly $654 million. Unit prices of all metals produced in the State declined substantially. Among the industrial minerals, potash, fire clay, and crushed stone posted small value gains. The principal contributors to New Mexico's total mineral value continued to be copper and potash, although sand and gravel, molybdenum, crushed stone, and perlite also were mined in important quantities.

Revenues derived from the extractive industries were extremely important to the State; only gross sales receipts (sales taxes) drew a higher amount. About $400 million in taxes, royalties, and other revenues was paid to the State of New Mexico by the extractive industries in 1991.

TRENDS AND DEVELOPMENTS

The Waste Isolation Pilot Plant (WIPP), 26 miles southeast of Carlsbad, continued to be a focus of controversy. The Department of Energy (DOE) wanted to test the storage facility by shipping plutonium-contaminated waste from Idaho to a WIPP 2,150-foot-underground storage site in excavated salt caverns. In January 1991, the Department of the Interior administratively transferred WIPP land to DOE, a move nullified about 2 months later by a U.S. District Court judge's decision and by the House Interior and Insular Affairs Committee. On October 3, 1991, DOE again assumed control over the 10,240-acre site from the Interior Department after breakdown of congressional negotiations on a land transfer plan. In response, the State filed suit in U.S. District Court to prevent

TABLE 1
NONFUEL MINERAL PRODUCTION IN NEW MEXICO[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	31,012	$94	[2]27,994	[2]$74	[2]27,794	[2]$74
Copper[3]	do.	259,640	749,540	262,815	713,622	252,859	609,454
Gemstones		NA	279	NA	225	NA	100
Gold[3]	kilograms	1,076	13,231	888	11,041	W	W
Lead[3]	metric tons	W	W	W	W	193	142
Perlite	short tons	487,000	13,080	501,000	r13,181	W	W
Potash	thousand metric tons	1,365	242,619	1,451	245,571	1,469	250,900
Pumice	metric tons	77,000	795	W	W	W	W
Sand and gravel (construction)	thousand short tons	e11,800	e45,400	10,362	39,708	e9,200	e35,900
Silver[3]	metric tons	W	W	48	7,431	W	W
Stone (crushed)	thousand short tons	2,784	11,672	e2,400	e12,800	2,801	13,089
Combined value of cement, clays [fire (1990-91)], gypsum (crude), helium (Grade-A), iron ore [includes byproduct material (1989-90), usable], mica (scrap), molybdenum, salt, stone (dimension), zinc, and values indicated by symbol W		XX	45,593	XX	r59,828	XX	75,851
Total		XX	1,122,303	XX	r1,103,481	XX	985,510

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; value included with "Combined value" figure.
[3]Recoverable content of ores, etc.

waste shipments into New Mexico and contended that DOE's decision to open WIPP without congressional approval was illegal and unsafe. In early November, the U.S. Senate approved a bill that would allow up to 8,000 drums of waste to be shipped for a 5-year test. Although the bill transferred ownership of the WIPP site to DOE, it would have made the Environmental Protection Agency (EPA) the overseer and regulator of WIPP and provided the State with $600 million in Federal impact aid. Action on the bill was postponed by the House until 1992. During late November, a U.S. District judge enjoined DOE to halt shipments of nuclear waste to WIPP for its test program. Also during November, four environmental groups filed a lawsuit alleging that DOE was 2 years late in filing permit applications for WIPP under the provisions of the 1976 Resource Conservation and Recovery Act.

About 750 pounds of Tyrone Mine copper was donated by Phelps Dodge Corp. for a memorial honoring the Buffalo Soldiers who served on the New Mexico frontier between 1866 and the turn of the century. Cathode copper, fromthesolvent-extraction-electrowinning (SX-EW) plant, was to be used in casting a bronze statue at Fort Bayard near Silver City. The statue, modeled after Corporal Clinton Greaves, Company C, 9th U.S. Cavalry, was to be cast by the Desert Crucible Foundry in Tucson and finished by Gregory Whipple, a Silver City sculptor.

Tenneco Minerals donated 81,000 acres of mineral rights on the Gray Ranch Preserve in Hidalgo County to the Nature Conservancy. The Gray Ranch contains grassland prairies of the Chihuahuan desert surrounded by forested watersheds of the Animas Mountains and is home to such species as the ferruginous hawk, golden and bald eagles, and the ridge-nosed rattlesnake.

EMPLOYMENT

New Mexico's economy, one of the strongest State economies, outperformed that of the United States in 1991, particularly in terms of personnel income growth and job increases. State unemployment, however, rose to 6.9% in 1991, up from 6.3% the previous year. Total nonagricultural employment stood at 585,400 statewide, improving by 5,000 jobs from the 1990 total. Mining employed 16,700 people in 1991, of which 2,100 were employed in metal mining, 4,200 in nonmetal mining, and 10,400 in oil and gas extraction. Jobs in the mining sector increased 2.5% in 1991, employment in metal mining held steady, the coal and nonmetallic work force grew 2.4%, and employment in the oil and gas industry rose 3%. New Mexico's oil and gas industry was among the economic sectors that showed strength: about 1,000 jobs had been added to the New Mexico oil and gas industry since 1989 thanks to higher energy prices during the Persian Gulf War and Federal tax cuts for newly discovered coal-seam gas near Farmington and Raton.

REGULATORY ISSUES

During 1991, the EPA began the final phases of remediation at the Cimarron Mining and Milling Superfund site near Carrizozo (Lincoln County). Southwest Minerals Corp. extracted precious metals from the property between 1979 and 1982 and discharged cyanide-bearing liquids into an unpermitted and unlined pit. During November, the U.S. Bureau of Reclamation began drilling seven wells to pump contaminated ground water into the town's sewer system. The EPA planned to dilute and detoxify cyanide-contaminated water at the Carrizozo sewage plant. Although the EPA agreed to compensate the town for the costs of treatment, it rejected the town's request for the Agency to pay for an independent evaluation of the town's wastewater treatment system.

Another Superfund site, the Sierra Blanca mill site, was discovered during the remedial investigation of the Cimarron Mill site. The 7.5-acre Sierra Blanca site contained metal-contaminated soils, tank sediments, and discharge-pit sediments. Of primary concern were contaminants, such as arsenic, barium, and lead, that might leach deeper into the soil or into the ground water. The EPA recommended remediation that would cost $79,000 and involve excavation of contaminated materials, mixing them with cement, transporting them to an on-site disposal pit, capping them with an impermeable cover, and covering the pit with clean soils. New Mexico Bureau of Mines specialists called the solution "overkill" and indicated that acid-neutralizing abilities of local soils was so high that downward leaching could be prevented by mixing tainted materials with soil alone.

The New Mexico Environment Department and the EPA continued remedial investigation of the Cleveland Mill Superfund site, 5 miles northeast of Silver City. Previous investigations indicated that Little Walnut Creek was receiving acid drainage containing arsenic, copper, lead, silver, and zinc from about 12,000 cubic yards of tailings on the site. A portable X-ray fluorescence survey conducted to initially characterize the site was completed during the summer.

Cleanup of the abandoned Billings Smelter slag pile in the western part of Socorro was completed at a cost of $1.37 million. The EPA, through a contractor, began cleaning up lead-containing soil on the Superfund site in August 1990. Although the EPA asserted that the soil contained unsafe quantities of lead, scientists at the New Mexico Institute of Mining and Technology and the New Mexico Bureau of Mines and Mineral Resources contended that the lead was chemically fixed in the alkaline soil, was not bioavailable and, therefore, was not hazardous. Elevated mercury levels were found at the nearby Cuba Road Stamp Mill during a preliminary site investigation. The mercury came from an old pan amalgam operation, once known as the New Orleans and La Joya Smelter. At another Socorro-area Superfund site, the 44-acre Cal-West Metals site, the EPA conducted a phase 2 remedial investigation to fully characterize the site and perform risk assessment. The Cal-West Metals site was used intermittently as a battery

recycling site and smelter facility between 1979 and 1981.

Progress was also made toward remediation of the United Nuclear Corp.'s Church Rock Mill. This Superfund site, near the border of the Navajo Indian Reservation, operated between 1977 and 1982. A 1979 break in a tailings pond dam released 93 million gallons of mill tailings fluid into the Rio Puerco. Seepage from the tailings dam contaminated local aquifers and the Upper Gallup River. A mister/pond evaporation system was installed as were a series of alluvial pumping wells. Due to the slow movement of ground water through the aquifers, remedial action is expected to require many years for completion.

Several access routes, picnic shelters, and campgrounds in Pecos Canyon were closed by the U.S. Forest Service and the New Mexico Department of Game and Fish because unprocessed mine waste from the inactive Terrero Mine had been used to surface the gravel roads during the 1970's. Several roads contained elevated levels of cadmium, copper, lead, and zinc. Additionally, about 90,000 fish at the New Mexico Department of Game and Fish Lisboa Springs Hatchery died during the March snowmelt allegedly as the result of poisoning from mine runoff. The Forest Service planned to work closely with the U.S. Bureau of Reclamation through its Toxic Cleanup and Superfund Assistance Program to replace lead-contaminated soils with clean soils by spring 1992. Meanwhile, AMAX Inc. collected ground and surface water runoff samples on the mine site itself for analysis, their results to be shared with the New Mexico Environment Department. AMAX is involved with site cleanup because it is the corporate heir to the American Metals Co. that mined at Terrero during the 1920's and 1930's. Although AMAX no longer owns the problem land, which the State Game Commission bought after mining ceased, a potential company liability existed.

A lawsuit between Chino Mines Co., owned by Phelps Dodge Corp. and Mitsubishi Corp., and the New Mexico Environment Department was settled in August 1991 when Chino paid the State $500,000. The lawsuit was filed because the company operated an SX-EW plant during 1988 and part of 1989 without a State-approved discharge plan. According to Phelps Dodge, the company did not believe it needed a permit because the plant was designed to be self-contained with no discharges to the environment. Discharges after a 1989 pipe breakage triggered the complaint filed by the State Environment Department in 1990. In a separate case, the company also paid the New Mexico Citizens for Clean Air and Water $225,000 for discharges of combined process water and stormwater runoff into Whitewater Creek near Hurley.

During May 1991, a pipeline broke at Molycorp Inc.'s Questa Mine and spilled about 20,000 gallons of slurry into an irrigation ditch and onto irrigated farmland near Questa. The pipeline was constructed to route the slurry from the company's processing mill to a tailings pile. The spill was the company's sixth since 1989. Molycorp paid a $30,000 fine in 1991 for the five previous spills and for a diesel fuel discharge into the Red River in 1987.

Molycorp and a coalition of several environmental groups entered into nonbinding mediation regarding the company's planned Guadalupe Mountain tailings disposal site. In 1990, the Director of the Bureau of Land Management (BLM) rescinded the agency's earlier approval of Molycorp's plan to construct a new tailings pond on Guadalupe Mountain northwest of the company's Questa Mine. The State BLM office was directed to write a supplement to the project's environmental impact statement because the original statement did not adequately assess alternative sites.

EXPLORATION ACTIVITIES

The largest and most controversial 1991 exploration project in New Mexico was Pegasus Gold Inc. and LAC Minerals Ltd.'s joint venture on the Ortiz Mine Grant in southern Santa Fe County. The 57,000-acre property contains two important discoveries: the Lukas Canyon deposit, which contains about 10 million metric tons of 1 gram-per-metric-ton gold, and the Carache Canyon deposit, which contains about 15.4 million metric tons of 2.4 grams-per-metric-ton gold. The Lukas Canyon skarn deposit, although the smaller of the two, is nearer the surface and probably would be the first developed. At the Carache Canyon deposit, mineralization occurs as tabular bodies in a collapsed breccia pipe.

During October, Pegasus released copies of an environmental assessment prepared for Santa Fe County concerning the two deposits. The company was the first to apply for a mining permit under Santa Fe County's new mining regulations, among the strictest in the Nation. According to the company, the proposed open pit mine would disturb 1,100 acres in the Ortiz Mountains over a 10-year mine life. Pegasus faced intense opposition from a nearby ranch owner and a local environmental group (Friends of Santa Fe County). Local hostility has been worsened by ground water contamination in the form of cyanide and nitrates left by a previous mining company, Consolidated Goldfields, after it stopped mining in the area in 1987. Pegasus voluntarily assumed the task of cleaning ground water and spent leach piles on Goldfields' Ortiz Mine site. In August, Pegasus applied for an emergency water permit from the State Engineer's office to dewater the Carache Canyon Decline to allow geologists to enter and sample, a permit that was first denied, then reconsidered. As 1991 closed, battle lines were drawn for a water-rights war as ranch owners of Lone Mountain Ranch applied for 1,500 acre-feet of water rights 1 day before Pegasus filed its own request for 810 acre-feet. State Land Commissioner Jim Baca and Attorney General Tom Udall appealed to the Governor in November to halt the type of gold mining proposed.

FMC Gold entered into a joint-venture agreement to acquire a 51% interest in Vera Cruz Minerals Corp.'s gold prospect near Carrizozo in Lincoln County. FMC planned an initial exploration program, including induced

polarization surveys and core drilling. Vera Cruz had reported encouraging exploration results from first phase drilling in 1989. The second phase of drilling confirmed initial results and disclosed the presence of a sulfide zone at depths of about 90 meters (300 feet). The weighted average assay of 240 meters (785 feet) of drill hole intercepts was reportedly in excess of 10.3 grams of gold per metric ton (0.3 troy ounce per short ton). The sulfide body is open both vertically and horizontally.

Phelps Dodge staked claims in Grant County to evaluate portions of the Burro Mountains mining district. Several companies spent considerable effort in the Steeple Rock district in western New Mexico. Biron Bay Resources continued drilling on the Summit and Billali Norman-King properties and fulfilled its obligation to NovaGold Resources to earn a 60% interest in the area. NovaGold further reduced its interest to 22%, increasing Biron Bay's share to 78%. Biron Bay's drilling discerned a virgin ore zone about 180 meters (600 feet) east of the main vein structure that could increase reserves by 25%. Previously, reserves on the property had been announced as 990,000 metric tons (1 million short tons) of material grading 6.3 grams of gold per metric ton (0.183 troy ounce per short ton) and 398 grams of silver per metric ton (11.6 troy ounces per short ton).

Weaco Resources Ltd. of Vancouver agreed to purchase all outstanding shares of Royal Minerals Inc., a New Mexico company that owns a 5-year lease on the Carlisle Mine in the central Steeple Rock District. Royal was purchased for 200,000 shares of Weaco and $20,000. Weaco planned to explore for both underground and open pit precious-metal and base metal targets. Metallic mineralization on the property occurs in parallel fault breccia zones and is hosted by Tertiary volcanics. Between 1880 and 1890 the Carlisle Mine produced 3.33 metric tons (107,000 troy ounces) of gold and 50.0 metric tons (1.6 million ounces) of silver. Mine workings purportedly contain 90,700 metric tons (100,000 short tons) of broken ore that, prior to World War II, was considered too difficult to treat.

Kokanee Explorations Ltd., of Vancouver, announced the completion of four diamond drill holes at the Lazarus gold project in Santa Fe County. Results confirmed a zone of high-grade gold mineralization between 350- and 550-feet deep on a northeast-trending structure on strike with the nearby San Pedro Mine. Kokanee planned a detailed surface mapping program to better define the zone before beginning definition drilling.

Regarding industrial minerals exploration, Northern Arizona Land and Lardner/Rocky Mountain Stone investigated the Mesa del Oro area of western Valencia County for travertine deposits.

LEGISLATION AND GOVERNMENT PROGRAMS

Members of the 40th Legislature, First Session, witnessed the introduction of nearly 2,000 bills and resolutions, of which 338 bills and 2 joint resolutions passed. As noted by the New Mexico Mining Association,[3] the legislative year may be remembered as much by what did not become law as what did. Several bills filed could have significantly affected the mining industry.

House bill 348, the Department of Environment Act, was enacted and established a new Department of Environment whose director is named by the Governor and serves in the Governor's executive cabinet. The bill separated the existing Environmental Improvement Division from the Health and Environment Division. House bill 564, the New Mexico Mining Act, would have regulated exploration, mining, and reclamation on Federal, State, and private lands to meet, at a minimum, requirements set by the Federal Resource Conservation and Recovery Act of 1976. Supported by the New Mexico Mining Association, the act was opposed by environmental lobbyists and was tabled in its second House committee. The program would have been developed and coordinated by a commission including members from State and local governments and appointees of the Governor. The commission would hear appeals of the Mining and Minerals Division Director's decisions. Included in the bill were provisions for civil and criminal penalties and for a broad spectrum of citizens' suits.

Following the election of many candidates that ran on environmental issues, a rash of bills were filed to create new environmental regulations, although none were signed into law. Citizen suits were given high priority, and one far-reaching bill, Senate bill 72, would have provided for standing to sue for damages, for equitable relief, for attorney's fees and costs, and, most significantly, for court determination of the sufficiency of regulations. The bill, which never left its first committee, would have imposed a court-imposed standard where no standards exist or where regulations were deemed inadequate. House bill 573 provided injunctive relief for citizen suits, attorney fees to the prevailing party, and a 30-day notice to the agency prior to filing suit. The bill was defeated (24-34) on the House floor. House bill 252, which also failed to pass, would have provided for reclamation of sand and gravel mines on public, private, and Native American lands.

Two pieces of whistleblower legislation failed. Senate bill 73 would have prevented discharge of employees who report violations of environmental laws to government officials or to the media. The bill would have limited defenses and put the burden of proof on employers. A similar bill, House bill 810, would have provided stronger disincentives to frivolous suits.

Many bills were filed that would have raised penalties under the State's Clean Water, Clean Air, Solid Waste, and Hazardous Wastes Acts; none passed, however.

The U.S. Congress failed to ratify a bill that would have created a 100,000-acre National Recreation Area in the Jemez Mountains and that would have barred future mining claims in the area. The bill's sponsor, Representative Bill Richardson, reportedly sought a

consensus among timber interests, recreational users, Native Americans, and others who claimed mining would detract from land value. The legislation effectively would have halted an attempt to patent the land at an existing 1,520-acre pumice mine above the Jemez River. The owner, Copar Pumice Co. Inc., had been mining in the area for 2 years, and Copar's owner, Richard Cook, indicated that he would sue the Federal Government for $300 million if he was denied a patent because of the bill.

The U.S. Supreme Court upheld a Federal appeals court decision that rejected the Navajo Tribe's right to tax Pittsburg and Midway Coal Mining Co.'s McKinley North Mine near Gallup. The higher court ruled that the mine is not within the Navajo Indian Reservation, reversing an earlier district court decision upholding the tribe's ability to tax the mine.

Santa Fe County Commissioners passed a new ordinance in January to regulate mineral development. The new law established a nine-member Mining Plans Review Board that will evaluate all applications for exploration and mining operations in Santa Fe County. The bill requires mining companies to prove that there would be no adverse effects from the use of hazardous chemicals in mine operations. One of the toughest in the Nation, the law also demands the preparation of broad environmental impact statements and reclamation plans. According to the Executive Director of the New Mexico Mining Association, the law operates in the favor of big mining companies that can use the new law as a target to prove their environmental responsiveness. Small companies, on the other hand, will find it difficult, if not impossible, to operate in the county.

The Mining and Minerals Division of the New Mexico Department of Energy, Minerals, and Natural Resources published its "Annual Resources Report." The report contained tables and discussions of statistics on the 1991 State extractive industry. Also issued in 1991 was a directory of "Mines, Mills, and Quarries in New Mexico" prepared jointly by the Division and the New Mexico Bureau of Mines and Mineral Resources. In 1991, the Bureau also published several other items of interest to mineral-resource specialists, including "Developments in Uranium During 1990" (Circular 201), "Geology and Mineral Resources of the Manuelito Quadrangle, McKinley County, New Mexico" (Geologic Map 66), and "Petrographic and Well Log Analysis of Four Exploration Wells in Southwestern New Mexico" (Open File 380).

In conjunction with the New Mexico Bureau of Mines and Mineral Resources and the U.S. Geological Survey, the U.S. Bureau of Mines continued its assessment of mineral deposits in BLM's 14.5-million-acre Roswell Resource Area in the southeastern part of the State. The Bureau also began an inventory of Great-Plains-margin-type deposits in New Mexico and southern Colorado. Such deposits, allied to alkaline intrusions, include the Gallinas Mountains porphyry belt, the Ortiz Mountains, the Cornudas Mountains, and the Laughlin Peak area in New Mexico. Work continued by the Bureau on an appraisal and inventory of known mineral resources in the Carson National Forest in northern New Mexico.

The U.S. Bureau of Mines continued to provide funding to the New Mexico Mining and Mineral Resources Research Institute (MMRRI) housed at the New Mexico Institute of Mining and Technology. Total funds allocated by the Bureau to MMRRI in 1991 were $148,000.

FUELS

During March, April, and May, natural gas prices sank to $1.03 per million cubic feet. In comparison, gas sold in 1990 for $1.57 to $1.60 per million cubic feet, at that time the lowest price in real dollars since 1976. According to an official with the New Mexico Oil & Gas Association, the industry was "in a holding pattern;" pessimism in the face of depressed prices was compounded by the debilitating effect of foreign intrusions into the U.S. market (including a Canadian drive into California) and by uncertainties regarding the impact of the pending North American Free Trade Agreement on U.S. markets.

Yet, in spite of these factors, New Mexico's natural gas production climbed 5.2% to exceed 1 trillion cubic feet (1.015 trillion cubic feet), a high watermark last achieved in 1981. New Mexico was the Nation's fourth largest natural gas producer in 1991. Value of natural gas produced was $1.45 billion, down 13% from that of 1990. Coalbed methane production, nonexistent 4 years ago, grew 76% over the 1990 total and amounted to almost one-quarter (23%) of New Mexico's gas production, or 232 billion cubic feet. Additionally, the State was the seventh largest producer of crude oil with 70.4 million barrels, up 3.5% from that of 1990. Lea, Eddy, Rio Arriba, and San Juan Counties contributed 96% of the State's total oil and 97% of its total gas production. Because of lower prices, however, value of crude oil produced dropped to $1.36 billion, a 10% decline.

According to Petroleum Information Corp., New Mexico ranked sixth in total 1991 well completions with a total of 1,092 wells. Oil well completions were up 14%. Gas well completions dropped 1.1% in 1991, and sharp declines were posted during the third and last quarters. San Juan County (321 well completions) and Lea County (286 well completions), however, were the fourth and fifth most actively drilled counties in the United States. Twelve horizontal wells were drilled, twice the 1990 total.[4]

In 1991, New Mexico slipped behind Utah to rank 14th in coal production. A total of 21.5 million short tons of subbituminous and bituminous coal was mined, down 11.4% from that of 1990 when production hit a historical high of 24.3 million short tons. Seven mines, six surface and one underground, were active in Colfax, McKinley, and San Juan Counties.[5]

Pittsburg and Midway Coal Mining Co. established a 15-year contract with Wisconsin Electric Power Co. Beginning in 1992, Pittsburg and Midway will ship 2 million short tons of coal per year from its York Canyon Mine to Wisconsin.

During October, BLM and the Salt River Project signed New Mexico's first Federal coal lease agreement in a dozen years. Formed in 1903, Salt River Project is the second largest public power utility in the United States, serving 540,000 customers in central Arizona. BLM accepted the utility's bid of $2.4 million for a 6,442-acre coal lease in Cibola County. With that acquisition, Salt River Project's land parcel numbered 18,000 acres and its coal reserves more than 120 million short tons. The utility's proposed Fence Lake low-sulfur coal mine on the property could be operating by 1994 to fuel the Coronado generating station near St. Johns, AZ. The Coronado station supplies electricity to Phoenix.

New Mexico led the Nation in domestic uranium resources, amounting to 43% of U.S. resources or nearly 1 billion pounds of U_3O_8. However, only 179,000 pounds of U_3O_8 was produced in 1991, all by Rio Algom Mining Corp. The State ranked sixth in uranium production.[6] The low output, the lowest on record, resulted from the January closure of the Mount Taylor Mine (Cibola County) by Chevron Resources Co. and suspension of all uranium recovery operations in New Mexico by Homestake Mining Co.

New Mexico's only uranium producer, Quivira Mining Co. (a subsidiary of Rio Algom Mining Corp.), leached mine stopes in the Ambrosia Lake District and produced a yellowcake slurry the company shipped to Oklahoma. According to Rio Algom's annual report, the company produced 179,000 pounds of U_3O_8 in 1991. The low price of uranium caused part of the Ambrosia Lake leaching operations to be suspended during 1991. Pending permit modification and approval, plans were made to dry the yellowcake at the mine plant.

Rio Algom Mining Corp. and Uranium Resources Inc. tried and failed to achieve a merger in 1991. Uranium Resources owned property near Churchrock, purchased from United Nuclear Corp. in 1987, and Crownpoint, a property formerly jointly held by Conoco Minerals Co. and Westinghouse Electric Corp. According to Uranium Resource's annual report, the company continued permitting activities on the Crownpoint property and hoped to apply for a mining permit in 1992.

Chevron Resources sold its uranium assets, including its Mount Taylor Mine in Cibola County, to General Atomics Corp. Following the sale, former Chevron properties were managed under the name Rio Grande Resources Co. Production halted at Mount Taylor in January 1990, and the mine was allowed to flood in the summer of 1990. General Atomics indicated that it planned to keep the mine on standby until the uranium market improved. An estimated 120 million pounds of uranium reserves remained at the deposit.

Reclamation of former Anaconda Minerals Co.'s Jackpile-Paguate Mine ran almost 1 year ahead of schedule. Work was conducted by the Laguna Construction Co., a firm created 3 years ago by Laguna Pueblo officials when they signed a $43.6 million contract with Anaconda Minerals to reclaim the 2,600-acre site. Anaconda operated the mine from 1951 until 1982, when the uranium market collapsed. Mine workings included three open pits and nine underground mines.

Gibbons and Reed Co. was selected by the U.S. Department of Energy to clean up an inactive uranium processing site at Ambrosia Lake. As planned, construction would involve excavating, consolidating, and stabilizing a 2.1-million-cubic-yard tailings pile. It was anticipated that remediation would begin in September 1992, take about 36 months to complete, and utilize about 80 people during peak periods.

REVIEW BY NONFUEL MINERAL COMMODITIES[7]

Metals

Copper.—Copper is the third most widely used metal, after iron and aluminum, and one that is employed in electrical and telecommunications products, building construction, industrial machinery, transportation, consumer products, and in strategic military applications. In 1991, New Mexico remained second, behind only Arizona, of 12 copper-producing States. State copper production ebbed about 4%. The State's copper output, 253 million metric tons, contributed 16% of total domestic production. The Metals Week average U.S. producer copper price fell to $1.09 from $1.23 in 1990. Total value of copper produced declined from $714 million in 1990 to $609 million.

The following companies mined copper in New Mexico in 1991: Phelps Dodge Corp., Chino Mines Co. (a subsidiary of Phelps Dodge Corp. and Mitsubishi Corp.), Cyprus Minerals Co., St. Cloud Mining Co. (a subsidiary of the Goldfield Corp.), Goldfield-Hidalgo (a subsidiary of Goldfield and Federal Resources Corp.), and Mount Royal Mining and Exploration Co. Copper was mined in Grant, Hidalgo, and Sierra Counties, although the bulk of New Mexico's production came from Grant County.

Phelps Dodge is the world's second largest producing copper company, behind only Codelco, the state-owned Chilean mining company. Its Tyrone operation produced mill-grade ore throughout the year. Phelps Dodge announced in October, however, that the concentrator would shut down in January 1992, and between 175 and 200 of the 700 employees would suffer layoffs. As the era of milled ore at Tyrone ended, the mine yielded only 56,800 metric tons (62,600 short tons) of concentrate and precipitate in 1991 (according to Phelps Dodge's annual report), a drop of 39% from that of 1990. According to the company's annual report, output of electrowon copper inched up slightly from 51,300 metric tons (56,500 short tons) produced in 1990 to 54,000 metric tons (59,500 short tons) produced in 1991. In spite of the production decline at Tyrone, the mine was second in the State in 1991 copper production and fifth in the Nation.[8] Phelps Dodge planned to continue leaching low-grade oxide and sulfide ore to yield electrowon copper for the next 10 years. Unions and the

company agreed on a new labor contract in July that continued wage rates at the same level as those in the previous agreement.

After a group of unions, including the Amalgamated Steelworkers, Operating Engineers, and Teamsters, filed charges with the National Labor Relations Board, a policy to provide bonuses only to nonunion employees at Tyrone was ruled discriminatory. Phelps Dodge was ordered to make retroactive payments, plus interest, to excluded workers. Tyrone had granted quarterly bonuses to all employees until April 1990 when the bonuses, based on copper prices, were awarded only to nonunion employees.

In 1991, the Chino Mine in Grant County assumed the lead from Tyrone as the State's largest copper producer; the mine was fourth in the United States for 1991.[9] Chino Mines Co. operated the mine, concentrator, and SX-EW plant at Santa Rita and a smelter in Hurley. Phelps Dodge held a two-thirds interest in the company; the remaining one-third interest was held by Heisei Minerals, a subsidiary of Mitsubishi Corp. and Mitsubishi Materials Corp. According to Phelps Dodge Corp.'s annual report, Chino produced a record 142,800 metric tons (157,400 short tons) of copper, including 50,000 metric tons (55,200 short tons) of electrowon copper. The mine employed nearly 1,150 people.

A $9.4 million project to boost Chino production by at least 5% began in June. The project involved the addition of a second stage recycle crushing plant that will crush ore finer than the original recycle plant. With the improvement, the concentrator's daily capacity was expected to increase from 42,000 metric tons (46,500 short tons) to about 44,000 metric tons (49,000 short tons), a gain of 30% over its original 1982 capacity.

According to Phelps Dodge's annual report, the National Labor Relations Board in Washington upheld the election held at Chino in September that decertified the Machinists Union.

Cyprus Minerals Co.'s underground Pinos Altos Mine in Grant County produced about 726 metric tons (1.6 million pounds) of copper, according to Cyprus' 1991 10-K form. The mine, acquired in 1987 from Boliden Minerals, produced copper, gold, silver, and zinc. In July, 60 workers, including 13 employees at the company's mill in Deming, were laid off when the mine was shut down for 6 months. Reasons cited for the shutdown were high operating costs and declining zinc prices which tumbled from 80 cents per pound to 47 cents per pound.

Small amounts of copper were also produced by Mount Royal Mining and Exploration Co. from the Center Mine in the Steeple Rock District in Grant County.

Effective September 1990, Goldfield-Hidalgo, Inc., a wholly owned subsidiary of the Goldfield Corp., entered into a joint-venture agreement to mine, mill, and explore properties owned by Federal Resources Corp. According to the agreement, Federal conveyed the properties to the Lordsburg Mining Co., equally owned by Federal and Goldfield-Hidalgo and managed by Goldfield-Hidalgo. According to Goldfield's annual report, Lordsburg Mining Co. shipped 45,524 metric tons (50,182 short tons) of siliceous smelter flux from its mine in Hidalgo County containing 62 metric tons (136,357 pounds) of copper.

According to Goldfield's annual report, its subsidiary St. Cloud Mining Co. sold 10,175 metric tons (11,216 short tons) of siliceous smelter flux from its mine in Sierra County, material that included 21 metric tons (46,839 pounds) of copper. San Pedro Mining Corp., another subsidiary, completed a copper mine and flotation mill at the San Pedro Mine in Santa Fe County that had a capacity of 272 metric tons (300 short tons) per day.

Mueller Industries Inc. announced a reorganization of bankrupt Sharon Steel Corp. properties. Mueller took over the nonsteel businesses of Sharon Steel. The announcement, coupled with the increase in copper prices since the mine closed in 1982, fueled speculation that the company might reopen the Continental Mine near Fierro in Grant County. Before copper prices fell, the Continental Mine employed about 465 people.

Gold Express Corp. applied to the New Mexico Environment Department for a permit to reconstruct the Copper Flat Mine and concentrator west of Truth or Consequences in Sierra County. Gold Express planned to develop the deposit, purchased in 1990 from Rio Gold Mining Ltd., as an open pit that would have a mine life of 10 years. Copper Flat was last operated briefly in 1982 by Quintana Minerals Corp. According to Gold Express' 1991 Form 10-K, Copper Flat contains 54 million metric tons (60 million short tons) of ore grading 0.43% copper plus byproduct gold, molybdenum, and silver.

Gold.—New Mexico placed last among the Nation's 12 gold-producing States. The quantity of gold the State produced and its value rose in 1991. Most gold was produced by New Mexico's copper mining companies as a byproduct; some also came from smelter processing of metal-bearing siliceous flux. The Chino Mine was, by far, the State's leading producer.

According to its annual report, Goldfield Corp. sold siliceous smelter flux from the St. Cloud Mine that included 7.18 kilograms (231 troy ounces) of gold. During 1991, the Lordsburg Mining Co. sold smelter flux that contained 101 kilograms (3,248 troy ounces) of gold.

Molybdenum.—New Mexico ranked fifth of eight States reporting 1991 molybdenum production. World molybdenum demand is driven largely by steel production, and the recent world recession drove demand downward to create surplus inventories and record low 1991 prices. In this market setting, New Mexico's molybdenum production and value fell by about 11% and 25%, respectively. Questa was New Mexico's only primary molybdenum producer; Chino, in Grant County, continued to produce molybdenum as a byproduct during 1991.

At yearend, Molycorp Inc. announced that mining and processing at Questa in Taos County would be suspended as of

January 1992. The company indicated that all personnel except for a skeleton crew of maintenance and reclamation personnel would be laid off. Molycorp planned to allow water to fill the underground mine, a move signaling a long shutdown. Molycorp, a subsidiary of Unocal Corp., had been mining and milling molybdenum at Questa for 70 years. Unocal officials also announced that Molycorp was for sale.

Silver.—During 1991, the State retained its position as the seventh largest producer of silver of 16 States in the United States. Output and value fell as silver prices crept downward. The average 1991 silver price was $4.04 per troy ounce compared with 1990's average of $4.82. Most New Mexico silver production was a byproduct of primary base metal ore production from Phelps Dodge's Tyrone and Chino Mines. Tyrone was the 18th largest silver-producing mine in the country.

Goldfield Corp.'s subsidiary St. Cloud Mining Co. owned several silver properties in the Chloride District in Sierra County, including the St. Cloud, Midnight, U.S. Treasury, Great Republic, Minnehaha, and Elephant Mines. Operations at the Midnight Mine were temporarily suspended in 1991 because of depressed silver prices. The company announced plans to dewater the St. Cloud Mine to remove pillars. Lower grade silver ore reserves remain at St. Cloud and may be recovered should silver prices return to the $6 or $7 per troy ounce range. During the first half of the year, St. Cloud sold 10,175 metric tons (11,216 short tons) of siliceous flux; according to Goldfield's annual report, the material contained 2.994 metric tons (96,267 troy ounces) of silver.

According to Goldfield Corp.'s 1991 annual report, the Lordsburg Mining Co., owned by Goldfield-Hidalgo and Federal Resources Corp., shipped 45,524 metric tons (50,182 short tons) of siliceous smelter flux that included 1.598 metric tons (51,370 troy ounces) of silver.

Zinc.—New Mexico had the 10th largest zinc production of 12 States reporting in 1991. State production declined 22% as 1991 zinc prices plummeted, and the State's primary zinc producer temporarily shut down.

In reaction to low zinc prices, which dropped to 48 cents per pound during June, Cyprus Minerals Co. announced a 6-month shutdown of the Pinos Altos Mine north of Silver City in July. The company had been recovering zinc, copper, and silver at the mine. About 60 employees were affected by the layoff, including 13 working at the company's mill in Deming. Cyprus began conversion of the property from a zinc to a copper operation, and the mine and mill were expected to function during 1992 on a limited basis. The company also announced it would continue to develop an ore body about 1,000 feet below the surface and about 250 feet below the lowest mine workings.

Effective September 1990, St. Cloud Mining Co. leased Sharon Steel Corp.'s zinc properties in Grant County. Ore was processed at St. Cloud's mill, and concentrates were sold to a zinc smelter in Oklahoma. St. Cloud stopped mining zinc in December 1990, and final milling and deliveries of zinc concentrates were made during the first quarter of 1991. St. Cloud sold 860 metric tons (948 short tons) of concentrate containing 416 metric tons of zinc.

Other Metals.—In the Steeple Rock District in Grant County, Mount Royal Mining and Exploration Co.'s Center Mine produced lead as a byproduct of precious-metal mining during 1991. Lordsburg Mining Corp. also recovered lead in Hidalgo County as did St. Cloud Mining Co. in Sierra County. Lead output and value rose significantly over 1990 totals.

Plans to open a yttrium mine on the Mescalero Apache Indian Reservation were put on hold owing to a drop in the price of raw yttrium and excessive processing costs. The mining site, leased by Molycorp Inc., was on 215 acres in an isolated canyon on Pajarito Mountian. A rare-earth element of the lanthanide series, yttrium is an essential component of television picture tubes where it contributes red hues. Yttrium prices are subject to wild fluctuations in the marketplace.

Industrial Minerals

Cement.—Cement data are estimated for 1991. Continuing a decline begun in 1984, New Mexico's estimated portland cement production dropped about 11% in 1991; its value was down about 10%. Production of masonry cement was down 25% while value fell about 30%.

Gypsum.—According to the New Mexico Division of Mines and Minerals, two gypsum mines operated in New Mexico: Centex American Gypsum Co.'s White Mesa Mine in Sandoval County and the small Couglar Pit in Otero County.[10] State production and value of crude gypsum declined 15%. The State ranked 10th of 20 States reporting crude gypsum production. Of 28 States that calcined gypsum, New Mexico ranked 19th. Compared with 1990 totals, the quantity and value of gypsum calcined in New Mexico also fell 15%.

Centex's new wallboard plant in Bernalillo experienced startup problems throughout most of the year. According to Centex's annual report, the difficulties were magnified by the plant's debut during a construction lull and during a period of financial instability within the wallboard industry. As reported in the company's annual report, the net sales price of wallboard declined more than 14% in 1991, and its cumulative decline over the previous 5 years had been more than 40%.

Mica.—New Mexico tied with North Carolina and Georgia for third place, behind North Carolina and South Dakota, of eight States reporting 1991 mica production. Muscovite and sericite ores were produced at Franklin Limestone Co.'s mine in Taos County and beneficiated at a mill in Velarde in Rio

Arriba County. Both production and value dropped slightly in 1991.

Perlite.—The State continued to lead the country in perlite production with the largest output of six States. New Mexico furnished 79% of domestically produced perlite in 1991. Both output and value fell. As Greek imports continued to negatively impact New Mexico's producers, other countries investigated the economics of exporting their product to the United States.[11] Crude perlite was shipped out of State for expanding because there were no expansion facilities in New Mexico. Grefco Inc., the Nation's largest perlite producer, operated mines in Socorro and Taos Counties, U.S. Gypsum operated a mine in Cibola County, and Celite Corp. mined perlite in Taos County. According to the New Mexico Department of Energy, Minerals, and Natural Resources, the main markets for New Mexico's perlite were its uses in building construction, as filter aids, as a filler, and in agriculture.

Residents near Grefco's Socorro perlite plant petitioned the New Mexico Environment Department to monitor and measure dust generated by plant operations. In an effort to contain dust, the company installed a second baghouse, put their finest-sized materials into a slurry, and planted trees as windbreaks. Although Grefco wetted down the perlite to keep it from blowing, low humidity in the area coupled with periodic high winds at times made the company powerless in its dust suppression efforts. Grefco has mined in the area since 1975 and reportedly has 30 years of remaining reserves.

During 1991, Manville Corp. combined the company's U.S. and European Filtration and Minerals Groups and renamed them the Celite Corp. Later in the year, Manville sold Celite to Allegheny Corp. of New York. Celite Corp. mined perlite in 1991 in Taos County at the No Agua Mine.

Potash.—New Mexico led the four States reporting 1991 potash production and was responsible for 86% of U.S. production. As reported to the U.S. Bureau of Mines, about 1.469 million metric tons of potash was sold during 1991 for a combined value of $250.9 million. According to the New Mexico Department of Energy, Minerals, and Natural Resources, combined product sales amounted to 1.64 million metric tons (1.81 million short tons) of 100% K_2O equivalent, up from 1.49 million metric tons (1.64 million short tons) sold in 1990. Value of potash sales, $250.4 million, up 9% from $229.94 million,[12] represented more than one-quarter of New Mexico's nonfuel mineral production. An important State employment sector, with 2,037 workers, the potash industry constituted 12% of the State's mining work force. According to the State, about 95% of the potash finds its way as a soil amendment in agriculture; the remaining 5% is used in industry for such things as manufacturing television tubes, chinaware, soaps, and synthetic rubber.

Six companies continued mining potash near Carlsbad in Eddy County (in decreasing order of reported production): IMC Fertilizer Group, Inc., Eddy Potash Inc., Horizon Potash Corp., New Mexico Potash, Western Ag-Minerals (a subsidiary of Rayrock Yellowknife Resources Inc.)., and Mississippi Chemical Corp. All six New Mexico potash mines were underground operations. Material was beneficiated by flotation and also by heavy-media separation, dissolution-recrystallization, and washing. Two companies, IMC Fertilizer and Western Ag-Minerals, produced langbeinite, a natural sulfate of potash containing magnesium, and were the only producers of langbeinite in the world.

The State Transportation Authority unanimously approved a request for $35,000 for a feasibility study on a proposed railroad to serve the potash and oil industry of southeast New Mexico. Although New Mexico potash reserves are dwindling and relatively low-grade (compared to Canadian reserves, which have been able to attract most of the U.S. market), a case was made for a need for a railroad line to keep the New Mexico mines competitive.

The NewPotex potash export association, which had consisted of AMAX Potash, New Mexico/Eddy Potash, IMC Fertilizer, and Mississippi Chemical, became effectively deactivated when New Mexico/Eddy Potash withdrew from the organization. Although the organization continued to exist under th Webb-Pomerene Act of 1918, an act introduced to help corporations compete with foreign countries in the export market, the association had ceased to be effective in eliminating competition between the companies for export business.

As part of general modernization of its control and monitoring systems, IMC Fertilizer replaced mechanical level switches with an ultrasonic level measurement system to monitor levels of langbeinite and sylvite ores in underground silos. Replacement allowed continuous monitoring, reduced maintenance costs, and increased safety. According to IMC's annual report, the potash mine set production records of 982,000 metric tons (1.08 million short tons) for 1991.

As 1991 closed, Horizon Gold Corp. signed a letter of intent with Amax Inc. to purchase Amax Potash Corp.; the letter replaced a prior agreement that expired in August. Amax's facilities consisted of a potash mine and refinery near Carlsbad. The mine has been producing since 1952, and an estimated 8 to 10 years of ore reserves remained. Amax employed about 400 people at the facilities.

Western-Ag Minerals Co. announced at the close of the year that it planned to build a new 50,000-ton-per-year langbeinite plant at Carlsbad for production of a coarser fertilizer particle through the use of its new manufacturing process. Plant startup was expected during 1993. The plant would be sited at the existing 450,000-tons-per-year plant in Carlsbad. The new process could produce granular, coarser fertilizer particles by compacting standard-size material. The standard-grade output was falling from favor in the developing

TABLE 2
NEW MEXICO: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	1	3	$3.00
Riprap and jetty stone	41	262	6.39
Filter stone	W	W	1.00
Coarse aggregate, graded:			
Concrete aggregate, coarse	237	577	2.43
Bituminous aggregate, coarse	7	23	3.29
Bituminous surface-treatment aggregate	2	14	7.00
Railroad ballast	600	4,200	7.00
Fine aggregate (-3/8 inch):			
Stone sand, concrete	63	313	4.97
Stone sand, bituminous mix or seal	34	39	1.15
Screening, undesignated	3	14	4.67
Coarse and fine aggregates:			
Graded road base or subbase	391	1,186	3.03
Unpaved road surfacing	176	346	1.97
Terrazzo and exposed aggregate	117	1,773	15.15
Crusher run or fill or waste	75	101	1.35
Other construction materials[2]	76	114	1.50
Roofing granules	7	57	8.14
Chemical and metallurgical:			
Cement manufacture	W	W	3.56
Flux stone	W	W	7.23
Other miscellaneous uses[3]	478	2,011	4.21
Unspecified:[4]			
Actual	54	181	3.35
Estimated	437	1,875	4.29
Total	[5]2,801	13,089	4.67

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes granite, limestone, marble, miscellaneous stone, quartzite, sandstone, traprock, and volcanic cinder.
[2]Includes withheld amounts for coarse aggregate (+1 inch).
[3]Includes withheld amounts for chemical and metallurgical.
[4]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5]Data do not add to total shown because of independent rounding.

world. The company saw a potential inventory reduction of several million dollars as a result of the new process. A pilot plant has been in operation at the Carlsbad refinery since mid-1990. A continuing market was anticipated for the standard product in animal feeds, in the Florida citrus market, and overseas.

Mississippi Chemical Corp. commented in its annual report that plans were under way to begin mining in Carlsbad's fifth ore zone, a band of richer ore that could add to extraction efficiency. New equipment was purchased to ease the transition from the seventh ore zone to the fifth and reduce operating costs. Mississippi Chemical's operation received the Sentinels of Safety Award, the most coveted mine safety award in the Nation. Cosponsored by the Mine Safety and Health Administration and the American Mining Congress, the award is presented to companies for the most employee-hours worked without a lost-time injury. Mississippi Chemical won in the underground nonmetals category for 281,373 employee-hours worked.

Pumice.—Among six pumice-producing States, New Mexico ranked third, behind Oregon and California. Both average value and output dropped significantly in 1991; a decline in construction and the impact of foreign imports probably contributed to the decrease according to the State Department of Energy, Minerals, and Natural Resources. Two companies, General Pumice Corp. in Rio Arriba County and Copar Pumice in Santa Fe County, reported pumice production for 1991. New Mexico pumice was used as decorative building block, as abrasive material, in concrete aggregate, for stonewashing denim, and for landscaping.

Salt.—Salt output and its average value essentially held steady in 1991. New Mexico ranked 11th of 14 States that reported production. Salt was produced in Lea and Eddy Counties and used in oil well drilling, in animal feed, and to de-ice roads. Three companies recovered salt from potash tailings: United Salt Corp. and New Mexico Salt and Minerals Co. in Eddy County and Unichem International Inc. in Lea County. Williams Brine Service recovered salt from brines in Lea County. According to the New Mexico Department of Energy, Minerals, and Natural Resources, the Zuni Indian Tribe also produced salt from Zuni Salt Lake in Catron County, as they have done intermittently for several hundred years.[13]

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1990 and estimates for 1989 and 1991. Based on data received by the U.S. Bureau of Mines, New Mexico's sand and gravel output dropped to 9.2 million short tons. Estimated value, likewise, fell to $35.9 million.

TABLE 3

NEW MEXICO: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2	
	Quantity	Value	Quantity	Value
Construction aggregates:				
Coarse aggregates (+1 1/2 inch)[1]	W	W	W	W
Coarse aggregates, graded[2]	822	4,679	25	134
Fine aggregates (-3/8 inch)[3]	28	130	73	236
Coarse and fine aggregates[4]	447	2,721	312	685
Other construction materials	478	1,800	125	647
Chemical and metallurgical[5]	W	W	W	W
Unspecified:[6]				
Actual	40	134	14	47
Estimated	164	785	273	1,090
Total[7]	1,978	10,249	823	2,839

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap and jetty stone, and filter stone.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), and fine aggregate (screening-undesignated).
[4]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run or fill or waste, and roofing granules.
[5]Includes cement manufacture and flux stone.
[6]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[7]Data may not add to totals shown because of independent rounding.

Stone.—Crushed.—The U.S. Bureau of Mines surveys crushed stone production only during odd-numbered years and estimates data for even-numbered years. This chapter contains estimates for 1990 and actual data for 1989 and 1991.

New Mexico's crushed stone production for 1991 was 2.8 million short tons, up from the 2.4 million tons estimated for 1990. Average product value increased from $12.8 million estimated in 1990 to $13.1. New Mexico's total output was 40th among the 49 States that produced crushed stone. The State's output was sold primarily for use as railroad ballast, for cement manufacture, for graded roadbase, and for concrete aggregate. In decreasing order of output, New Mexico's 33 producers quarried limestone, granite, volcanic cinder, traprock, quartzite, marble, and sandstone.

In June, county commissioners overturned approval for Jobe Inc. to set up the quarry to mine limestone near Mesquite in Dona Ana County. The company filed an appeal of the ruling in State District Court in July.

Another quarry in Dona Ana County north of Las Cruces, owned by Southwest Paving Products Co., Inc., came under fire from local residents who complained that blasting from the quarry was too loud, rattled their homes, and was damaging nearby Fort Selden State Monument. An Albuquerque company, Western Technologies Inc., however, monitored the blasting both at Fort Selden and half way in between the fort and the quarry and found that the blasting did not register on their equipment. After hearing testimony from residents, Dona Ana County commissioners ruled they had no authority to stop an operation that was in compliance with State and local requirements.

Dimension.—New Mexico ranked 14th of 34 States that produced dimension stone. State output remained nearly the same as it was in 1990, although its value decreased by 12%. Three companies quarried dimension stone during the year: Guillen Construction in Dona Ana County, Rocky Mountain Stone Co. in Valencia County, and Apache Springs Co. in Dona Ana County. Guillen Construction produced limestone; the other two companies, marble. Guillen led in output, although Rocky Mountain Stone Co., a marble producer, led in terms of value of material sold. Stone was quarried as cut veneer stone, irregularly shaped decorative stone, and sawed stone blocks.

Other Industrial Minerals.—Other industrial mineral commodities produced in New Mexico included carbon dioxide, clays, gemstones, Grade-A helium, siliceous smelter flux, humate, byproduct sulfur, exfoliated vermiculite, and zeolite.

According to the New Mexico Energy, Minerals, and Natural Resources Department, total New Mexico production of carbon dioxide, used to enhance oil recovery, was 113.2 billion cubic feet valued at $34.7 million. The State was second in the Nation in production of carbon dioxide. The Bueyeros carbon dioxide field (the Bravo Dome) in northeastern New Mexico had the largest proved reserves of carbon dioxide in the country at 16.3 trillion cubic feet.[14]

New Mexico clay production (excluding fire clay) was 27,794 metric tons and was virtually unchanged from the 1990 production total. Three companies—El Paso Brick Co. (Dona Ana County), Kinney Brick Co. (Bernallilo and Santa Fe Counties), and Garcia and Son (San Juan County)—sold common clay for making brick, roofing granules, and quarry tile. Two other companies in southwestern New Mexico, Mathis and Mathis Mining and Exploration Co. (Luna County) and Phelps Dodge Corp. (Hidalgo County), produced fire clay; production increased about 43%. New Mexico was sixth of seven States with fireclay production in 1991.

Gemstones and gem materials produced in the State included agate, azurite, fluorite, onyx, smithsonite, and turquoise. Value of 1991 production fell 56% from that of 1990.

New Mexico ranked last among the four States that produced Grade-A helium

TABLE 4
NEW MEXICO: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	25	1,545	$4,546	$2.94	21	1,287	$4,241	$3.30
Marble	—	—	—	—	1	W	W	44.00
Granite	2	745	4,467	6.00	7	902	5,286	5.86
Traprock	2	W	W	2.22	2	124	267	2.15
Sandstone and quartzite	1	W	W	5.75	2	W	W	6.95
Volcanic cinder and scoria	7	206	1,967	9.55	9	265	2,142	8.08
Miscellaneous stone	2	W	W	5.00	2	W	W	3.95
Total[1]	XX	2,784	11,672	4.19	XX	2,801	13,089	4.67

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

during 1991. One producer, Navajo Refined Helium Co., produced Grade-A helium near Shiprock in San Juan County. State production dropped, and its value plunged about 61%.

Lordsburg Mining Co., jointly owned by the Goldfield Corp. and Federal Resources Corp., sold 3,668 metric tons (4,043 short tons) of metal-barren silica flux in 1991. Goldfield Corp.'s St. Cloud Mining Co. sold 4,148 metric tons (4,573 short tons) of barren siliceous smelter flux recovered from a mine dump near Silver City. The property was leased from Sharon Steel Corp. St. Cloud also sold 19,014 metric tons (20,959 short tons) of mill tailings directly to copper smelters as flash furnace flux according to Goldfield Corp.'s annual report.

Humate (humic-acid-rich carbonaceous shales, claystones, or weathered coal) has become an important nonfuel mineral commodity in the State, according to the State Department of Energy, Minerals, and Natural Resources. New Mexico contains enormous reserves of humate, more than 11 billion short tons in the San Juan Basin, principally in northeastern New Mexico. Two companies operated two mines and mills in McKinley and Sandoval Counties during 1991. Humate was used chiefly in soil conditioners and as an additive in drilling muds.

Sulfur was recovered as a nondiscretionary byproduct of natural gas production. Shipments rose from 48,000 metric tons reported in 1990 to 53,502 metric tons. Average value, however, dropped from $3 million to $2.8 million. Production was from Lea, Eddy, and Roosevelt Counties in southeastern New Mexico and from San Juan County in the Four Corners area.

Exfoliated vermiculite was produced by Solico in Bernalillo County. Its product was used in making plaster, in horticulture, in loose-fill insulation, in concrete, and as packing material.

Beginning in 1990, St. Cloud began production and test marketing of a natural zeolite occurrence about 2 miles from the St. Cloud mill near Winston in Sierra County. During 1991, the company used its existing mining, crushing, and sizing facilities to process clinoptilolite. The clinoptilolite occurs in flat-lying beds and was extracted by conventional open pit methods. Goldfield Corp. noted in its 1991 annual report that the company sold 1,848 short tons of zeolites during 1991, compared with 334 tons sold in 1990.

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[1]State Mineral Specialist, U.S. Bureau of Mines, Denver, CO. She has 13 years of mineral-related work with government and industry. This author gratefully acknowledges the assistance of Pat LaTour, editorial assistant, in the preparation of this chapter.

[2]Senior Mining Engineer, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM.

[3]The lead author thanks the New Mexico Mining Association for material in this section.

[4]Petroleum Information Corp. Resume 1991.

[5]Energy Information Administration. Coal Production 1991. Oct. 1992.

[6]Hatchell, W. New Mexico Uranium Fact Sheet. New Mexico Dep. Energy, Miner., and Nat. Resour.

[7]Unless noted, specific production data in this section were excerpted from company annual or from 10-K reports.

[8]Jolly, J. L. W. Copper. U.S. Bureau of Mines 1991 Annual Report.

[9]Work cited in footnote 8.

[10]Hatton, K. S. Private communication. New Mexico Dep. Energy, Miner., and Nat. Resour. Dec. 3, 1992.

[11]———. New Mexico Industrial Minerals Fact Sheet. New Mexico Dep. Energy, Miner., and Nat. Resour. May 1992.

[12]———. New Mexico Potash Fact Sheet. New Mexico Dep. Energy, Miner., and Nat. Resour. May 1992.

[13]———. New Mexico Selected Industrial Minerals Fact Sheet. New Mexico Dep. Energy, Miner., and Nat. Resour. May 1992.

[14]New Mexico Mineral Industries Data. Pamphlet distributed by New Mexico Dep. Energy, Miner., and Nat. Resour.

NEW MEXICO

LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Au	Gold
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper
Cu	Copper plant
D-L	Dimension Limestone
D-S	Dimension Sandstone
Fe	Iron
Gem	Gemstones
Gyp	Gypsum
K	Potash
Mica	Mica
Mica	Mica Plant
Mo	Molybdenum
Per	Perlite
Pum	Pumice
Salt	Salt
SG	Sand and Gravel
Si	Silica
Volc	Volcanic cinder

Concentration of mineral operations

Principal Mineral-Producing Localities

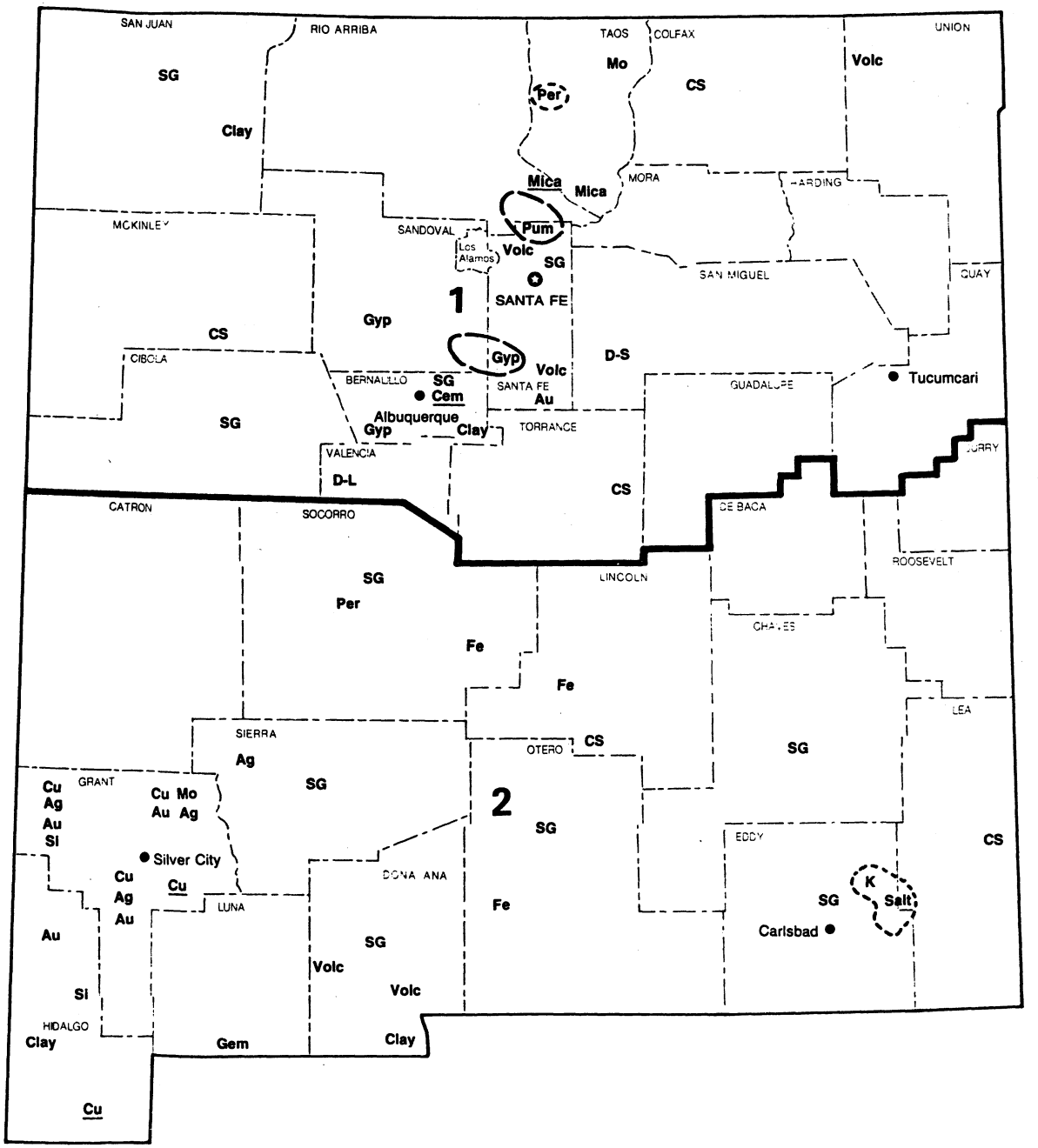

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Holnam Inc. (formerly Ideal Basic Industries Inc.)[1]	Box 100 Tijeras, NM 87059	Dry process, two rotary-kiln plants	Bernalillo.
Clays:			
El Paso Brick Co. Inc.	Box 12336 El Paso, TX 79913	Pit	Dona Ana.
New Mexico Brick Co. Inc. (doing business as Kinney Brick Co. Inc.)	100 Prosperity Ave., SE Albuquerque, NM 87102	do.	Bernalillo.
Copper:			
Burro Chief Copper Co., a subsidiary of Phelps Dodge Corp.	Drawer B Tyrone, NM 88065	Solvent-extraction electrowinning plant	Grant.
Chino Mines Co., a subsidiary of Phelps Dodge Corp.-Mitsubishi Metal Corp. partnership[2 3]	Box 7 Hurley, NM 88043	Surface mine, flotation mill, precipitation plant, smelter	Do.
Cyprus Pinos Altos Corp.[4]	Box 2198 Silver City, NM 88062	Underground mine and mill	Do.
Phelps Dodge Corp.:			
Hidalgo Smelter[5]	Box 67 Playas, NM 88009	Smelter	Hidalgo.
Tyrone Branch[3 5]	Drawer B Tyrone, NM 88065	Surface mine, mill, solvent extraction-electrowinning plant	Grant.
Gold:			
Mount Royal Mining & Exploration Co.[6]	100 Mesquite Ave. Duncan, AZ 85534	Underground mine	Do.
Gypsum:			
Centex American Gypsum Co.	Box 90820 Albuquerque, NM 87199	Pit and plant	Bernalillo and Sandoval.
Humate:			
Agronics Inc.	3620 Wyoming NE., #207 Albuquerque, NM 87110	Surface mine	Do.
Mesa Verde Resources	Box 8632 Albuquerque, NM 87198	Surface mine and mill	McKinley and Sandoval.
Mica:			
Franklin Limestone Co., a subsidiary of Franklin Industries Inc. (formerly Mineral Industrial Commodities of America Inc.)	Box 3648 Fairview, NM 87533	Pit and mill	Rio Arriba and Taos.
Perlite:			
Grefco Inc., Mineral Div., a subsidiary of General Refractories Co.	Box 308 Antonito, CO 81120	Surface mines; crushing, screening, air separation	Socorro and Taos.
Cellite Corp.	Box 338 Antonito, CO 81120	do.	Taos.
United States Gypsum Co., a subsidiary of USG Corp.	Box 216 Grants, NM 87020	Surface mine and crushing plant	Cibola.
Potash:			
Horizon Potash Corp.	Box 279 Carlsbad, NM 88220	Underground mine and plant	Eddy.
Eddy Potash Inc., a subsidiary of Trans-Resources Inc.	Box 31 Carlsbad, NM 88220	do.	Do.
IMC Fertilizer Inc.	Box 71 Carlsbad, NM 88220	do.	Do.
Mississippi Chemical Corp.	Box 101 Carlsbad, NM 88220	do.	Do.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Potash—Continued			
New Mexico Potash Corp., a subsidiary of Trans-Resources Inc.[7]	Box 610 Hobbs, NM 88240	Underground mine and plant	Eddy.
Western Ag-Minerals Co., a subsidary of Rayrock Yellowknife Resources Inc.	Box 511 Carlsbad, NM 88220	do.	Do.
Pumice:			
Copar Pumice Co. Inc.	Box 38 Espanola, NM 87532	Surface mines and crushing and sceening plant	Sandoval and Santa Fe.
General Pumice Corp.	Box 5135 Santa Fe, NM 87502	Surface mine and crushing and screening plant	Rio Arriba and Santa Fe.
Salt:			
New Mexico Salt & Minerals Corp.	Box 2262 Carlsbad, NM 88220	Tailings treatment	Eddy.
Unichem International Co.	707 N. Leach Hobbs, NM 88321	Solution mining	Lea.
United Salt Corp., Carlsbad Div.	Box SS Carlsbad, NM 88220	Tailings treatment	Eddy.
Williams Brine Co.	2501 Dona Ana Carlsbad, NM 88220	do.	Lea.
Sand and gravel:			
Arco Materials Inc.[1]	Box 2439 Farmington, NM 87499	Pit and plant	San Juan.
CalMat Co.	Box 829 Albuquerque, NM 87103	do.	Bernalillo.
Colony Materials Inc.	Box 4337 Santa Fe, NM 87502	do.	Sandoval.
Connie H. Danley Construction Inc.	Drawer K Alamogordo, NM 88310	do.	Otero.
Espanola Transit Mix Co.	Box 38 Espanola, NM 87532	do.	Rio Arriba.
James Hamilton Construction Co.	Box 1287 Silver City, NM 88062	do.	Dona Ana, Eddy, Lea, Luna, Roosevelt, San Miguel.
Mountain States Constructors Inc.	Box 6325 Albuquerque, NM 87197	do.	Bernalillo, Cibola, McKinley.
Rio Grande Rock Inc.	Box 633 Las Cruces, NM 88004	do.	Dona Ana.
San Juan Concrete Co.	Box 135 Farmington, NM 87499	do.	San Juan.
Western Mobile New Mexico Inc.	Box 91570 Albuquerque, NM 87199	do.	Bernalillo and Sandoval.
Silver:			
St. Cloud Mining Co.[8]	Box 1670 Truth or Consequences, NM 87901	Underground and surface mines, mill	Sierra.
Stone:			
Crushed:			
Big Chief Stone Inc.	900 North Morton Lane Las Cruces, NM 88005	Quarries	Colfax, Dona Ana, Santa Fe.
Gallup Sand & Gravel Co.	Box 1119 Gallup, NM 87305	do.	Dona Ana and McKinley.
Hamilton Brothers Inc.	Box 1110 Gallup, NM 87305	Quarry	McKinley.

See footnotes at end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone—Continued:			
Crushed—Continued:			
Rose Gravel Co.	2605 Hidalgo Rd. Carlsbad, NM 88220	Quarry	Eddy.
Western Rock Products Inc.	Box 135 Encino, NM 88321	do.	Torrance.
Wylie Corp.	Box 3921 Albuquerque, NM 87190	do.	Chaves.
Dimension:			
Apache Springs Co.	Box 1 Radium Springs, NM 88054	do.	Dona Ana.
Daniel F. Guillen Construction Inc.[1]	4007 Mission Bell Las Cruces, NM 88001	do.	Do.
Rocky Mountain Stone Co.	Box 6608 Albuquerque, NM 87197	Quarries	Socorro and Valencia.
Uranium-vanadium:			
Quivira Mining Co., a subsidiary of Rio Algom Ltd.	Box 218 Grants, NM 87020	Underground mines, concentrator, ion-exchange from mine waters	Do.

[1]Also crushed stone.
[2]Also byproduct molybdenum.
[3]Also gold and silver.
[4]Also gold, silver, and zinc.
[5]Also fire clay and quartzite.
[6]Also copper, lead, and silver.
[7]Also salt.
[8]Also copper, gold, and lead.

THE MINERAL INDUSTRY OF NEW YORK

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the New York State Education Department, New York Geological Survey, for collecting information on all nonfuel minerals.

By Donald K. Harrison[1] and William M. Kelly[2]

The value of nonfuel mineral production in New York in 1991 was $698.7 million, a $74 million decrease from that of 1990. The decrease was largely the result of lower sales of cement, construction sand and gravel, crushed stone, wollastonite, and zinc. Leading mineral commodities in terms of value were crushed stone, salt, portland cement, construction sand and gravel, and zinc. Other commodities produced included masonry cement, clays, garnet, gypsum, peat, industrial sand and gravel, dimension stone, byproduct lead and silver, and talc.

Nationally, the State ranked 14th in the value of nonfuel minerals produced. New York was the only State in the Nation that produced wollastonite and one of only two States where garnet was mined. The State ranked third in output of salt and zinc and fourth in crude talc production. Of the minerals processed in the State, New York ranked second in synthetic graphite and sixth in primary aluminum production.

EMPLOYMENT

In 1991, the average number of workers[3] employed in the mineral extractive industries in New York was 4,984, about 1,000 less than that of 1990. This included 2,883 at surface mine operations, two-thirds of which worked at sand and gravel operations. The average number of workers at underground mines was 576, primarily in nonmetal mining. A total of 1,525 employees worked at mineral-related mills and preparation plants in the State.[4]

REGULATORY ISSUES

Construction of a resource recovery facility in the town of Huntington was almost complete. The plant, on 13 acres at the East Northport Landfill in Huntington, Long Island, was scheduled to be operational early in 1992. The facility will burn 750 tons of municipal, residential, and commercial solid waste per day. Electricity produced by the facility will be sold to the Long Island

TABLE 1
NONFUEL MINERAL PRODUCTION IN NEW YORK[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	531,559	$3,429	490,552	$2,906	421,003	$2,417
Gemstones		NA	350	NA	365	NA	125
Peat	thousand short tons	W	10	W	W	1	21
Salt	do.	5,424	161,427	5,401	162,900	4,998	173,837
Sand and gravel:							
Construction	do.	e31,600	e118,500	29,750	121,525	e23,700	e95,500
Industrial	do.	53	633	W	W	W	W
Stone:							
Crushed	do.	39,851	201,749	e39,900	e207,600	34,871	195,639
Dimension	short tons	23,756	3,575	e23,437	e3,589	18,624	2,978
Combined value of cement, garnet (abrasive), gypsum (crude), iron ore [includes byproduct material (1989)], lead, silver, talc and pyrophyllite, wollastonite, zinc, and values indicated by symbol W		XX	255,495	XX	273,954	XX	228,142
Total		XX	745,168	XX	772,839	XX	698,659

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Lighting Co. The Huntington facility is a mass-burn incinerator. Similar facilities are operating elsewhere in New York State, including Hempstead, Babylon, and Westchester. Most of the ash produced will be sent to a landfill in Pennsylvania. Ferrous metals will first be removed from the ash before its shipment and final disposal.[5]

A tungsten and molybdenum processing plant, formerly operated by the now defunct Li Tungsten Corp. on Long Island, was proposed in August for inclusion on the Federal Superfund Cleanup List. The plant, in Glen Cove, was shut down in 1985 when Li Tungsten filed for chapter 11 creditor protection. The facility reportedly contained at least 20 tons of ammonium paratungstate (APT), some of which is radioactive. The 20-acre plant produced approximately 1,000 tons of APT and similar amounts of tungsten metal and tungsten powder annually, in addition to molybdenum products. Being on the list does not automatically mean a site will be cleaned up by the Government, but instead ensures it will be further investigated by the U.S. Environmental Protection Agency (EPA).[6]

LEGISLATION AND GOVERNMENT PROGRAMS

Senate bill 6079, "Environmental Conservation Law For Mining and Reclamation Amendment," was signed into law. The law, which amended the State's Environmental Conservation Law for mining and reclamation, became effective on September 1, 1991. It supersedes local town law and gives the Department of Environmental Conservation (DEC) total jurisdiction over mining activities and reclamation.

The new law also recognizes the legitimate role of local governments to zone permissible land uses as well as to enact and enforce laws of general applicability for all land uses within zoned areas. Localities may require special use permits that address ingress and egress to local roads; routing of trucks on local roads; and enforcement of DEC mining permit conditions governing setbacks, rights of way, constructed barriers such as berms, dust control, and hours of operation. They may also enforce DEC permit reclamation requirements as part of the special use permit. The law also gives local governments an opportunity to review and comment on permit applications for new mines. New fees for mining permits and penalties for mining violations were also increased. Fees are now $400 for projects of less than 5 acres to $2,000 on mines larger than 30 acres. Maximum mining penalties increased from $1,000 to $5,000 per violation.

The New York State Geological Survey, an agency affiliated with the New York State Museum, continued programs that included beach erosion studies on Long Island; investigations of environmental impacts of waterfront revitalization projects; earthquake history and disaster preparedness studies; evaluation of low-level radioactive waste disposal sites; bedrock and surficial mapping in the Adirondacks and Hudson Highlands; publication of bedrock maps at 1:1,000,000 and surficial maps at 1:250,000; paleontologic and stratigraphic investigations in eastern New York; and geologic studies of dimension sandstone-producing areas.

The Geologic Survey carried on a program to study nonfuel mineral resources on the continental shelf. Grab samples recovered between the south shore of Long Island and the shelf edge and from the Hudson Canyon to Martha's Vineyard revealed a broad area of coarse sand and localized gravel concentrations. These materials are suitable for use as construction aggregates. Analysis of the heavy-mineral suite contained in the grabs indicate an immature, poorly weathered assemblage present in amounts unsuitable for economic development under current market conditions. Semiquantitative chemical analyses were carried out for 56 elements on approximately 160 heavy-mineral concentrates.

To encourage State support for basic research in the mineral sciences and engineering, the U.S. Bureau of Mines awarded a basic allotment grant of $145,000 to Columbia University's Henry Krumb School of Mines. The allotment was part of the mineral institute's program created by Public Law 98-409, The State Mining and Mineral Resources Research Institute Program Act. Additional monies were also provided for mineral waste treatment and pyrometallurgy studies. Under stipulations of the act, the State of New York was required to match this grant on a 2:1 basis.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—New York ranked 9th of 38 States that produced portland cement; it ranked 12th in the Nation in masonry cement output. Four companies operated cement plants in the State. Both portland and masonry cement were produced by Atlantic Cement Co. Inc. at Ravena, Lehigh Portland Cement at Cementon, and the Glens Falls Cement Co. Inc. at Glens Falls. Only portland cement was produced by Independent Cement Corp. at its Catskill plant. All of the plants used the wet process except for Glens Falls, which used the dry process. In 1991, estimated shipments of portland and masonry cement fell 18% and 25%, respectively. The cement was used primarily for ready-mix concrete and concrete products and by building material dealers and highway contractors. Most of the cement was shipped by barge; the remainder was shipped by rail and truck.

In November, Atlantic Cement Co. announced the completion of a new stone crushing facility at its Ravena plant. The Ravena quarry supplies the cement plant with 2.5 million short tons of limestone each year. The new crushing facility will also process a portion of the overburden removed at the quarry. The overburden has become troublesome to the company because removing it has been increasing annual quarry operating costs. The company expects to sell the processed overburden as a construction aggregate to

the construction industry. The new business venture should provide the company with an additional source of income and should help absorb some of the increased costs associated with its quarry operation.[7]

Clays.—In 1991, production of common clay decreased 14% from that of 1990. Common clay was produced by five companies at five operations in four counties. Leading counties, in order of output, were Albany, Ulster, Orange, and Onondaga. The clay was used principally in the manufacture of portland cement, face brick, and lightweight aggregate for use in structural concrete and block.

Garnet.—New York was only one of two States that produced garnet in 1991; Idaho was the other State. Garnet was produced by three companies in New York. Barton Mines Corp. operated a surface mine near North Creek, Warren County, and produced technical-grade garnet for use in coated abrasives, glass grinding and polishing, and metal lapping. The NYCO Div. of Processed Minerals Inc., Essex County, recovered andradite garnet as a byproduct from its wollastonite mining operation. The garnet was sold to a garnet producer for further refinement. It was marketed for use in water filtration and other applications. International Garnet Abrasives Inc., Essex County, processed almandine garnet supplied by NYCO primarily for use as blasting and filtration media.

Gemstones.—Value of mineral specimens and gemstones collected by mineral dealers and amateur collectors in New York, based on a survey of the curator of mineralogy of the New York State Museum, was estimated at $147,000 in 1991. Of this amount, approximately $103,000 entered the market as specimens and educational-grade samples and $44,000 remained in private collections and museums. Zinc mines operating at Balmat and Pierrepont in St. Lawrence County yielded specimens in larger number and finer quality than in past years. Other favored gem- and mineral-collecting areas include Gore Mountain near North Creek, Warren County, and dolomite quarries near Rochester in Monroe County. Southern Herkimer and western Montgomery Counties remain attractive locales for collection of "Herkimer diamonds" (doubly terminated quartz crystals) but diminished popular interest in "crystal healing" and the metaphysical properties of minerals reduced demand and slackened the rate of price increase for this material.

Gypsum.—USG Corp., the State's only crude gypsum producer, mined crude gypsum from a 3- to 4-foot-thick bed at an underground mine in Oakfield, Genesee County. Output remained essentially the same as that of 1990. The crude gypsum was calcined and made into wallboard at an adjoining plant.

Imported gypsum was also calcined at three plants in the State. USG calcined gypsum imported from Nova Scotia, Canada, at Stony Point, Rockland County. In terms of total output, the Stony Point plant ranked ninth of 71 plants that calcined gypsum in the United States. The two other companies that calcined gypsum using imported ore were National Gypsum Co. in Rensselaer, Rensselaer County, and Georgia-Pacific Corp. at Buchanan, Westchester County.

In addition to the calcined gypsum produced in the State, the Paul Blum Co. Inc., Greene County, resold byproduct gypsum that the company purchased from other processors.

Peat.—Two companies mined peat in 1991; one in Seneca County and one in Broome County. All of the peat was sold in bulk and was used for soil improvement and as an ingredient in potting soils.

Salt.—New York ranked third in the Nation in salt sold or used; it was first in value. Salt sold or used totaled almost 5 million short tons (13% of the Nation's total) and was valued at $173.8 million. Rock salt was produced by Akzo Salt Inc. in Livingston County and by Cargill Inc. in Tompkins County. Both companies also produced evaporated salt at plants in Schuyler County. Morton International Inc. also produced evaporated salt in Wyoming County, and Texas Brine Corp. produced brine in Wyoming County for use as feedstock to chlor-alkali producers in the region.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Based on these estimates, output and value of construction sand and gravel declined 20% and 19%, respectively. More than 350 companies and government agencies mined construction sand and gravel from 410 operations in 51 counties. Leading counties, in order of output, were Suffolk, Cattaraugus, and Dutchess. Main uses were for road base and coverings, concrete aggregate, and fill.

The Sidney Town Board granted a mining permit to Burton F. Clark Inc. to mine half a million cubic yards of sand and gravel at a controversial site within the town. The Turtle Clan of the Onondaga Nation and others concerned with Native American history had asked the Town Board not to allow the mining because they contended that the site was a possible Indian burial mound. The Town Board had decided that evidence provided by Clark's engineers did not suggest burial remains were present at the site. Under the mining permit, the company will operate from April 1 to November 1, 5 days per week. Board members also stipulated that the excavating company will have to have an archaeologist present during mining operations.[8]

Industrial.—Two companies produced industrial sand in 1991. Whitehead Bros. Inc. operated one pit in Oneida County and one pit in Saratoga County. G. W. Bryant Core Sand Inc. operated a pit in

TABLE 2
NEW YORK: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	109	1,019	$9.35
Riprap and jetty stone	461	3,230	7.01
Filter stone	98	612	6.24
Coarse aggregate, graded:			
Concrete aggregate, coarse	4,206	30,181	7.18
Bituminous aggregate, coarse	5,814	39,076	6.72
Bituminous surface-treatment aggregate	832	4,903	5.89
Railroad ballast	99	689	6.96
Other graded coarse aggregate	W	W	4.80
Fine aggregate (-3/8 inch):			
Stone sand, concrete	265	1,909	7.20
Stone sand, bituminous mix or seal	2,145	14,956	6.97
Screening, undesignated	304	1,645	5.41
Coarse and fine aggregates:			
Graded road base or subbase	4,654	25,248	5.43
Unpaved road surfacing	63	405	6.43
Terrazzo and exposed aggregate	W	W	34.47
Crusher run or fill or waste	2,656	12,594	4.74
Other construction materials[2]	286	4,274	14.95
Agricultural:			
Agricultural limestone	198	1,922	9.71
Poultry grit and mineral food	7	165	23.57
Other agricultural uses	W	W	1.65
Chemical and metallurgical: Cement manufacture	4,440	14,762	3.32
Special: Other fillers or extenders	3	166	55.33
Other miscellaneous uses[3]	372	615	1.65
Unspecified:[4]			
Actual	5,357	25,183	4.70
Estimated	2,502	12,087	4.83
Total	34,871	[5]195,639	5.61

W Withheld to avoid disclosing company proprietary data: included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes dolomite, granite, limestone, limestone and dolomite, marble, miscellaneous stone, sandstone, and traprock.
[2]Includes withheld amounts for coarse aggregate, graded, coarse and fine aggregates, and roofing granules.
[3]Includes withheld amounts for agricultural and special.
[4]Includes production reported without a breakdown by use and estimates for nonrespondents.
[5]Data do not add to total shown because of independent rounding.

Oneida County. Both output and value increased over 1991 levels. Major uses for the industrial sand were for molding and core, glassmaking, and traction.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

New York crushed stone statistics are compiled by geographical districts as depicted in the State map. Table 3 presents end-use data for the commodity in the eight New York districts.

Crushed.—New York ranked 15th in output and 10th in value of 49 States that reported crushed stone production in 1991. Crushed stone was the State's leading commodity produced and accounted for 28% of the State's total nonfuel mineral value. In 1991, production decreased 13% from the 1990 estimated output. However, average unit value per ton rose 41 cents from $5.20 to $5.61.

Limestone accounted for the majority of the crushed stone produced in the State. Other rock types quarried were dolomite, granite, sandstone, traprock, and marble. Leading counties, in order of output, were Dutchess, Albany, Niagara, Genesee, Greene, and Onondaga. The crushed stone was used for bituminous and concrete aggregate cement manufacture, and road base and fill.

In April, the Saratoga Springs City Council approved Pompa Bros. Inc.'s request to rezone 55 acres of land near the Petrified Sea Gardens, a nearby fossil site and one of the country's National Natural Landmarks. Pompa had been trying since 1988 to have the area rezoned from rural residential to industrial. They intend to operate a crushed stone quarry on 32 of the 55 acres. The company's current nearby quarry was running low on reserves. Opponents of the rezoning maintained that further blasting in the area will damage the fossil area and nearby wells.

Lancaster Stone Products Co.'s Alabama Quarry in Basom was one of 25 aggregate mining operations nationwide to receive the National Stone Association's (NSA) Showplace Award in NSA's About Face Program. The purpose of the ongoing program is to recognize and reward crushed stone operators who have made constructive and positive efforts to enhance the appearance of their property and to call attention to these efforts through publicity within the aggregates industry and the local communities.

Dimension.—Dimension stone was produced by 13 companies operating 17 quarries. Sandstone accounted for the majority of the stone quarried, followed by slate, granite, and limestone. Sandstone was quarried in Albany,

TABLE 3

NEW YORK CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregates (+1 1/2 inch)[1]	—	—	173	1,614	161	999	W	W
Coarse aggregates, graded[2]	—	—	4,891	43,287	1,602	9,802	1,154	5,521
Fine aggregates (-3/8 inch)[3]	—	—	1,257	10,702	773	4,206	245	1,422
Coarse and fine aggregates[4]	—	—	1,021	8,569	994	4,853	654	2,550
Other construction materials	—	—	24	225	—	—	587	1,902
Agricultural[5]	—	—	W	W	392	670	11	27
Chemical and metallurgical[6]	—	—	—	—	3,928	13,278	W	W
Special[7]	—	—	—	—	—	—	—	—
Unspecified:[8]								
Actual	—	—	17	43	114	636	—	—
Estimated	—	—	389	2,358	—	—	11	121
Total[9]	—	—	7,771	66,797	7,965	34,443	2,662	11,543

	District 5		District 6		District 7		District 8	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregates (+1 1/2 inch)[1]	92	617	45	297	147	743	W	W
Coarse aggregates, graded[2]	1,264	6,305	W	W	980	4,928	W	W
Fine aggregates (-3/8 inch)[3]	W	W	194	1,159	W	W	—	—
Coarse and fine aggregates[4]	955	6,868	280	1,201	1,846	8,272	W	W
Other construction materials	234	918	410	2,458	67	361	—	—
Agricultural[5]	34	470	W	W	W	W	W	W
Chemical and metallurgical[6]	—	—	—	—	—	—	—	—
Special[7]	3	166	—	—	—	—	—	—
Unspecified:[8]								
Actual	894	4,302	1,318	6,590	1,600	8,002	1,413	5,610
Estimated	188	1,027	383	1,398	1,394	6,752	137	431
Total[9]	3,664	20,673	2,630	13,103	6,034	29,058	4,144	20,022

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap and jetty stone, and filter stone.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, railroad ballast, and other graded coarse aggregate.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[4]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run (select material and fill), and roofing granules.
[5]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[6]Includes cement manufacture.
[7]Includes other extenders and fillers.
[8]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[9]Data may not add to totals shown because of independent rounding.

Delaware, Franklin, and Tompkins Counties. Granite was quarried in Essex and Westchester Counties. Slate was quarried in Washington County, and Onondaga County accounted for all of the State's dimension limestone production.

Talc.—New York ranked fourth in output and second in value of eight States that produced talc in 1991. The Gouverneur Talc Co., a subsidiary of R. T. Vanderbilt Co. Inc., mined talc from both an underground and surface operation in St. Lawrence County. The ore was ground and processed at an on-site mill. The talc occurs in northeasterly trending metasedimentary rocks in the Northwest Adirondack lowlands and is interbedded with marble and various calcsilicates. Most of the talc is used in ceramics and paints. Some of it is exported to other countries.

Wollastonite.—New York was the only State in the Nation that produced wollastonite. Two companies mined wollastonite in 1991. The largest producer, NYCO, operated the Lewis surface mine 14 miles west of Willsboro. The ore was sent to a nearby mill for processing. In March, the company approved a $14.4 million rehabilitation and expansion project at its Willsboro plant. The project will increase the

TABLE 4
NEW YORK: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone[1]	61	29,514	$132,522	$4.49	68	24,565	$116,359	$4.74
Dolomite	10	3,719	19,985	5.37	10	7,852	58,695	7.48
Marble	1	W	W	1.99	1	85	3,354	39.46
Granite	4	3,604	28,151	7.81	6	1,006	5,697	5.66
Traprock	4	1,890	14,616	7.73	2	W	W	9.61
Sandstone	7	1,000	6,141	6.14	4	W	W	6.09
Slate	1	W	W	10.00	—	—	—	—
Miscellaneous stone	1	W	W	2.23	1	17	43	2.53
Total[2]	XX	39,851	201,749	5.06	XX	34,871	195,639	5.61

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Includes "Limestone/dolomite," reported with no distinction between the two.
[2]Data may not add to totals shown because of independent rounding.

productivity of the plant by 50% over the next 5 years. Improvements will involve installing new primary and secondary crushers and adding a statistical process control.

R. T. Vanderbilt, the State's other producer, operated the Valentine No. 4 underground mine near Harrisville, Lewis County. The material was shipped to a company-owned mill in St. Lawrence County. Some of the wollastonite produced by Vanderbilt was shipped to the Netherlands for further processing and sold in the European markets. Major uses of wollastonite were as a filler in ceramic tile, marine wallboard, paint, plastics, and refractory liners in steel mills.

Other Industrial Minerals.—In addition to the commodities listed in table 1, the production and value of certain processed or manufactured mineral commodities were surveyed by the U.S. Bureau of Mines.

High-purity fused aluminum oxide was produced by Washington Mills Electro Minerals (US) Inc. and by General Abrasives, a division of Sterling Operations Products Co., both in Niagara Falls. General Abrasives also produced regular fused aluminum oxide. Cut wire shot used for abrasives was produced by Pellets Inc. at a plant in Tonawanda, Erie County.

Elkem Metals Co., a Norwegian-owned company, produced a calcium-silicon-barium-aluminum alloy at its plant in Niagara Falls. SKW Alloys Inc., Niagara Falls, produced alloys of ferrosilicon and silicon for use by the steel industry.

New York continued to rank second of 13 States that produced synthetic graphite. A total of three companies, all in Niagara County, produced and shipped graphite. Principal uses were for electrodes; anodes; unmachined graphite shapes, and crucibles and vessels; and motor brushes.

Indium Corp. of America was one of two indium producers in the United States. The company produced indium primarily from imported zinc residues, low-grade indium bullion, and indium scrap at a plant in Utica.

Crude iodine was shipped into New York by three companies and was used to produce specialty organic chemicals, pharmaceuticals, catalysts, and sanitation products.

Electric-furnace-fused mullite was produced by Electro Minerals U.S. Inc. at Niagara Falls. The mullite was used primarily by the steel industry for furnace linings.

Crude perlite shipped from out-of-State was expanded by Scolite International Corp., Rensselaer County, and sold for cavity fill insulation and soil conditioning.

Buffalo Crushed Stone Corp., Buffalo, processed air-cooled, iron-blast-furnace slag and sold the material for road base and asphaltic concrete aggregate.

Buffalo Tungsten Inc., a subsidiary of Cleveland Tungsten Inc., Cleveland, OH, operated a tungsten processing plant in Depew. The company converted ammonium paratungstate into tungsten powder and tungsten carbide powder for use in drill bits and cutting tools.

Metals

Aluminum.—In 1991, New York ranked sixth in output among the 14 States that produced primary aluminum. Primary aluminum was produced by two companies, both in Massena, St. Lawrence County. Reynolds Metals Co. operated a 123,000-metric-ton-per-year smelter, and Aluminum Co. of America (Alcoa) operated a 127,000-metric-ton-per-year plant.

In July, Alcoa pleaded guilty to four violations of New York State pollution laws at its Massena aluminum smelting and fabricating plant. The Alcoa plant was charged with storing, shipping, and disposing of polychlorinated biphenyls (PCB's) and other toxic wastes at the Massena operations. The company reported that it will pay criminal and civil penalties of $7.5 million for the 1989 misdemeanor violations.

Alcoa also announced that it has earmarked $160 million to cover anticipated cleanup costs at the Massena complex. In 1991, Alcoa carried out interim remedial measures to remove contaminated sediments near the plant. The full-scale cleanup is expected to take nearly a decade to complete.

Lead and Silver.—Lead and silver were recovered as byproducts at Zinc Corp. of America's (ZCA) zinc operations in St. Lawrence County.

Zinc.—New York continued to rank third behind Alaska and Tennessee in zinc output. Although output remained essentially the same as that of 1990, value decreased because of lower zinc prices. ZCA was the only producer in the State. The company operated two mines (Balmat and Pierrepont) and a 3,900-metric-ton-per-day mill at Balmat, St. Lawrence County. In 1991, the Balmat Mine was the Nation's fourth leading mine in terms of total output; the Pierrepont Mine ranked fifth. Concentrate from the Balmat mill was shipped by rail to a company-owned smelter in Monaca, PA.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related experience and has covered the mineral activities in New York for 9 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]Senior scientist, New York Geological Survey, Albany, NY.

[3]"Average number of workers" is a summary of the average number of workers at individual mining establishments during periods (not necessarily continuous) of active operations.

[4]U.S. Department of Labor, Mine Safety and Health Administration. Mine Injuries and Worktime Quarterly, Jan.-Dec. 1991, 33 pp.

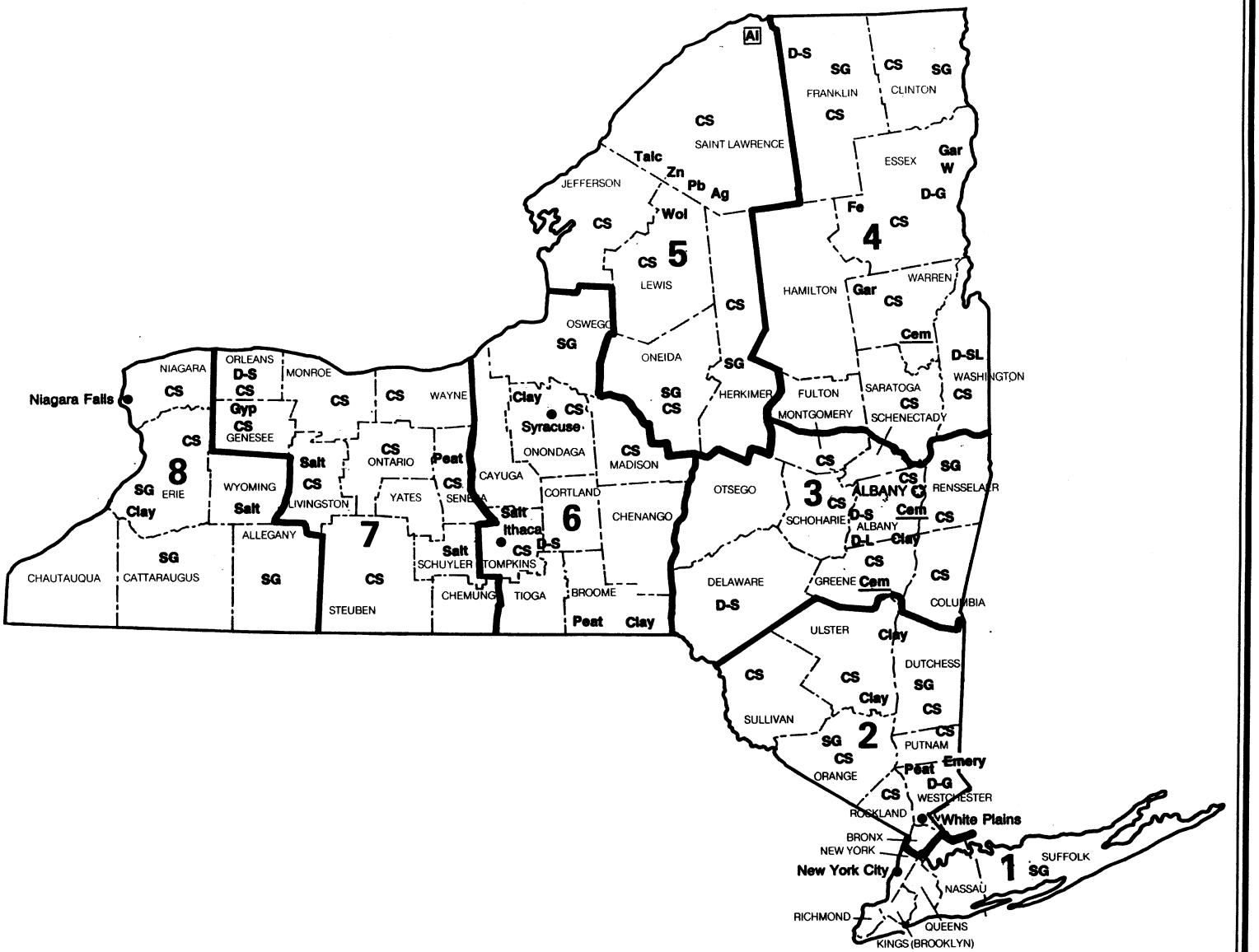
[5]Waste Line. L.I. Resource Facility To Open Soon. NY State Dep. of Environmental Conservation, v. 4, No. 3, Fall-Winter 1991.

[6]American Metal Market. Li Tungsten Site on Superfund List. V. 99, No. 153, Aug. 12, 1991, p. 3.

[7]News Herald. Stone Crushing Facility Now Complete at B.C. Cement. Nov. 21, 1991.

[8]Reporter (Walton, NY). Sidney Passes Mining Permit. Jan. 23, 1991, p. 8.

NEW YORK



Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Abrasives:			
General Abrasives Div. of Sterling Operation Products Co.	2000 College Ave. Niagara Falls, NY 14305	Plant	Niagara.
Pellets Inc.	531 South Niagara St. Tonawanda, NY 14150	do.	Erie.
Washington Mills Electro Minerals (US) Corp.	1801 Buffalo Ave., Box 423 Niagara Falls, NY 14302	do.	Niagara.
Aluminum (primary):			
Aluminum Co. of America	1210 Alcoa Bldg. Pittsburgh, PA 15222	Smelter	St. Lawrence.
Reynolds Metals Co.	Box 27003-2A Richmond, VA 23215	do.	Do.
Cement:			
Atlantic Cement Co. Inc., a subsidiary of Blue Circle Ind., PLC[1 2]	Box 3 Ravena, NY 12143	Quarry and plant	Albany.
The Glens Falls Portland Cement Co. Inc., a subsidiary of Dyckerhoff AG[1]	Box 440 Glens Falls, NY 12801	Quarries and plants	Schoharie and Warren.
Independent Cement Corp., a subsidiary of St. Lawrence Cement Inc.	Box 12-310 Albany, NY 12212	Quarry and plant	Greene.
Lehigh Portland Cement Co., a subsidiary of Heidelberger Zement AG[1]	718 Hamilton Mall Allentown, PA 18105	do.	Do.
Clays:			
Grosso Materials	R.D. 2, Collabar Rd. Box 391 Montgomery, NY 12549	Pit	Orange.
Norlite Corp., a subsidiary of P. J. Keating Co.	Box 367 Fitchburg, MA 01420	Pit	Albany.
Northeast Solite Corp., a subsidiary of Solite Corp.	Box 27211 Richmond, VA 23261	Pit	Ulster.
Powell & Minnock Brick Works Inc.	Route 144 Coeymans, NY 12045	Pit	Albany.
Syracuse Pottery Inc.	6551 Pittery Rd. Warners, NY 13164	Pit	Onondaga.
Garnet:			
Barton Mines Corp.	Box 400 North Creek, NY 12853	Pit	Warren.
Gypsum:			
Calcined:			
Georgia-Pacific Corp.	Box 105605 133 Peachtree St., NE Atlanta, GA 30348	Plant	Westchester.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	do.	Rensselaer.
Crude:			
USG Corp.[4]	101 South Wacker Dr. Chicago, IL 60606	Underground mines plant	Genessee and Rockland.
Peat:			
Malcuria Bros Inc.	1436 Gates Rd. Geneva, NY 14456	Bog	Seneca.
Bob Murphey Inc.	3129 Vestal Rd. Vestal, NY 13850	Bog	Broome.
Perlite (expanded):			
Scolite International Corp.	6 Madison St. Troy, NY 12181	Plant	Rensselaer.

See footnotes at the end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Perlite (expanded):			
Scolite International Corp.	6 Madison St. Troy, NY 12181	Plant	Rensselaer.
Salt:			
Akzo Salt Inc.	Abington Executive Park Clarks Summit, PA 18411	Underground mine	Livingston and Schuyler.
Cargill Inc.	Box 5621 Minneapolis, MN 55440	do.	Tompkins.
Morton International Inc.	110 North Wacker Dr. Chicago, IL 60606	Well	Wyoming.
Texas Brine Corp.	2000 West Loop South Houston, TX 77027	Wells	Do.
Sand and gravel (1990):			
Construction:			
Broad Hollow Construction Estates Inc.	Box 483 Farmingdale, NY 11735	Pit	Suffolk.
Carlson Sand & Gravel Corp.	Town Line and Old Northpoint Rd. Kings Park, NY 11754	Pit	Do.
Clemente Latham Concrete Corp.	R.D. No. 5, Box 56 Troy, NY 12108	Pit	Rensselaer.
Dan Gernatt Gravel Products	Richardson Rd. Collins, NY 14034	Pits	Cattaraugus and Erie.
Roanoke Sand & Gravel	Box 8H Middle Island, NY 11953	Pit	Suffolk.
Troy Sand & Gravel	Box 189 Watervliet, NY 12189	Pit	Rensselaer.
Industrial:			
Whitehead Bros. Inc.	Box 259, River Rd. Leesburg, NJ 08327	Pits	Oneida and Saratoga.
Slag (iron):			
Buffalo Crushed Stone Corp.[2 3]	2544 Clinton St. Buffalo, NY 14224	Plant	Erie.
Stone:			
Crushed:			
Beazer East Inc., a subsidiary of Beazer USA[3]	Koppers Building Pittsburgh, PA 15219	Quarries	Various (11 counties)
Blue Circle Atlantic Inc.	Box 3 Ravena, NY 12143	Quarry	Albany.
Buffalo Crushed Stone Corp.	Box 710 West Seneca, NY 14224	Quarries	Erie.
Callahan Industries Inc.	South St. South Bethlehem, NY 12161	do.	Albany, Madison, Montgomery, Rensselaer, Ulster.
Dolomite Products Inc.	1150 Penfield Rd. Rochester, NY 14625	do.	Genesee, Monroe, Ontario, Wayne.
New York Trap Rock Corp., a subsidiary of Lone Star Industries Inc.	Box 432 Montvale, NJ 07645	do.	Dutchess and Rockland.
Dimension:			
Champlain Stone Ltd.	Box 852 Glens Falls, NY 12801	Quarry	Washington.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone—Continued:			
Dimension—Continued:			
Finger Lakes Stone Co. Inc.	Box 401 Ithaca, NY 14850	Quarry.	Thompkins.
New York Quarries Inc.	Box 43, Box 111 Alcove, NY 12007	Quarries.	Albany and Delaware.
Rainbow Quarries Inc.	132 East Main St. Malone, NY 12953	Quarry	Franklin.
Ritchie Bros. Slate Co.	Box 22 Middle Granville, NY 12849	Quarries	Washington.
Talc:			
Gouverneur Talc Co. Inc., a subsidiary of R. T. Vanderbilt Co. Inc.	Box 89 Gouverneur, NY 13642	Underground and surface mine	St. Lawrence.
Wollastonite:			
NYCO Div. of Processed Minerals Inc.[5]	Box 368 Willsboro, NY 12996	Surface mine	Essex.
R. T. Vanderbilt Co. Inc.	30 Winfield St. Norwalk, CT 06855	Underground mine	Lewis.
Zinc:			
Zinc Corp. of America[6]	Sylvia Lake Rd. Balmat, NY 13607	Underground mines	St. Lawrence.

[1]Also clays.
[2]Also stone.
[3]Also sand and gravel.
[4]Also calcined gypsum.
[5]Also garnet.
[6]Also byproduct lead and silver.

THE MINERAL INDUSTRY OF NORTH CAROLINA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Division of Land Resources, North Carolina Department of Environment, Health, and Natural Resources, for collecting information on all nonfuel minerals.

By Steve W. Sikich,[1] P. Albert Carpenter III,[2] and Leonard S. Wiener[3]

The value of nonfuel minerals produced in North Carolina decreased 6.2% from that of 1990. The value dropped from $589.7 million[4] in 1990 to $552.9 million in 1991, largely as a result of the recession that has impacted the Nation in recent years. Decreases in the sales of the State's leading mineral commodity, crushed stone, as well as clays, feldspar, gemstones, scrap mica, olivine, construction sand and gravel, and pyrophyllite, more than offset small to moderate increases in the sales of lithium minerals, peat, phosphate rock, and industrial sand and gravel.

Despite the decline in total mineral output, North Carolina continued to lead the Nation in the quantity and value of feldspar, lithium minerals, scrap mica, olivine, and pyrophyllite produced. The State also led the Nation in the production of clay used for the manufacture of bricks and ranked second in the production of phosphate rock. Despite the drop in mineral output, North Carolina's national ranking rose from 20th in the value of all mineral commodities produced in 1990 to 18th in 1991.

TRENDS AND DEVELOPMENTS

The decrease in mineral production marked the second consecutive year of declining output following 8 years in which North Carolina's mineral production had attained record-high values.

Major corporate changes and new operations affecting the North Carolina minerals industry in 1991 included the takeover of Beazer PLC by another English company, Hanson PLC. Beazer was the parent of one of North Carolina's

TABLE 1

NONFUEL MINERAL PRODUCTION IN NORTH CAROLINA[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Clays	metric tons	2,270,384	$15,529	[2]2,179,428	[2]$9,356	[2]2,063,875	[2]$9,015
Feldspar	do.	435,845	14,024	418,402	r14,460	402,448	13,027
Gemstones		NA	784	NA	1,057	NA	785
Mica (scrap)	thousand metric tons	73	4,192	65	3,796	64	3,747
Peat	thousand short tons	W	W	13	W	21	W
Sand and gravel:							
Construction	do.	e11,200	e43,700	11,733	44,872	e9,900	e35,000
Industrial	do.	1,627	19,902	1,177	15,338	1,174	15,565
Stone:							
Crushed	do.	51,519	257,976	e52,900	e276,200	[3]46,514	[3]243,920
Dimension	short tons	62,665	10,477	e66,531	e11,551	32,489	10,128
Combined value of clays [kaolin (1990-91)], lithium minerals, olivine, phosphate rock, stone [crushed volcanic cinder (1991)], talc and pyrophyllite, and values indicated by symbol W		XX	214,984	XX	r213,112	XX	221,711
Total		XX	581,568	XX	r589,742	XX	552,898

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.

[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2]Excludes certain clays; value included with "Combined value" figure.

[3]Excludes certain stones; value included with "Combined value" figure.

leading aggregate producers, Nello L. Teer Co. Another of North Carolina's major aggregate producers, Martin-Marietta Aggregates, announced the move of its corporate headquarters from Bethesda, MD, to Raleigh. The sale of Feldspar Corp.'s crystal silica plant in Spruce Pine to Unimin was finalized. Unimin subsequently announced an expansion of its existing ultrahigh-purity silica sand plant, which is also in Spruce Pine. A new mica mining company, Rednour Mining Corp., received a permit to open a mica mine and processing facility near Grover in the Kings Mountain Mining District. A coalition headed by Titan Cement Co. of Greece purchased the inactive Ideal Cement Co. plant at Castle Hayne and announced plans to invest $75 million to make it operational by 1993.

EMPLOYMENT

Preliminary data reported[5] by the Mine Safety and Health Administration (MSHA) showed an average of 3,967 people directly employed by North Carolina's mining industry in 1991. This represents a 15.3% decrease from the 4,685 reported for 1990. Of the total number, 2,274 were employed in surface mines and 1,693 were employed in mills and preparation facilities. No fatalities occurred in North Carolina's mining industry in 1991.

The North Carolina State Ports Authority laid off 12 of 57 full-time workers at its Morehead City facilities in January. The layoffs were directly related to reduced exports of dry-bulk phosphates by Texasgulf Inc. For the fiscal year ended in June 1991, the port handled approximately 1.9 million short tons of bulk cargo, which was almost 20% less than its budgeted estimate of 2.3 million tons.

REGULATORY ISSUES

Major environmental issues directly affecting the mining industry focused on protests against the use of hazardous waste for fuel by a lightweight aggregates producer and against the permitting of new or expanded mining operations. Carolina Solite Co., the lightweight aggregates producer, discontinued the burning of hazardous waste in August. The company converted to pulverized coal to fuel its burners to meet new Federal regulations that required it to install additional pollution control equipment. In October, Solite received a State permit that would allow it to install the necessary equipment and resume burning hazardous waste. However, the company appealed selected provisions of the permit in November, and at yearend the appeal was pending.

Drilling of an offshore natural gas well by the Mobil Oil Co. was delayed pending the submission of a report evaluating oceanographic, ecological, and socioeconomic data to Congress by Interior Secretary Manuel Lujan. The report being prepared by the North Carolina Environmental Sciences Review Panel (ESRP) was expected to be completed by January 1992. ESRP was mandated by Congress to assess the adequacy of existing data and to review data needs related to future leasing off the North Carolina shore.

EXPLORATION ACTIVITIES

Exploration for titanium-rich heavy minerals diminished during the year because of a softening of demand for titanium products and delays experienced by companies applying for mining permits. Southeast Tisand Co., a joint venture of Becker Minerals Inc. (United Kingdom) and Consolidated Rutile Ltd. (Australia), was in the permitting stage of the planned development of its prospect near Roanoke Rapids. RGC (USA) Minerals Inc., a subsidiary of Renison Goldfields Consolidated Inc. (Australia), was also preparing a mining permit application for property it had leased in the Aurelian Springs area. Piedmont Mining Co., Charlotte, and Corona Corp., Toronto, Ontario, ended their joint-venture agreement to explore for titanium-bearing heavy-mineral sands in the Carolinas.

Companies holding active prospecting permits/preferential right leases in U.S. National forests in North Carolina include Appalachian Properties Inc., Thomas E. Morris, Pikes Peak Mining Co., and Piedmont Mining Co. Appalachian's permit is for olivine in the Nantahala National Forest, while the remaining are for gold, silver, and base metals in the Uwharrie National Forest. Companies that have applications for prospecting permits pending include ASARCO Incorporated and Battle Mountain Exploration Co. for gold, silver, and base metals in the Uwharrie National Forest.

Other companies reported exploring for gold and base metals included Noranda Inc.[6] and Piedmont Mining Corp.[7] Noranda, which has been active in the Carolina Slate Belt for the past 4 years, reported 10 active gold prospects in North and South Carolina.

LEGISLATION AND GOVERNMENT PROGRAMS

The North Carolina Legislature did not enact any laws directly affecting the minerals industry in 1991. Thirty bills related to environmental issues were ratified during the year. One of the most important allowed the State to set standards more stringent than national air- and water-pollution regulations. Another doubled the maximum State fine for air-pollution violations.

The North Carolina Geological Survey (NCGS) published the results of several projects completed during 1991. Included were open file reports on permitted mining operations in North Carolina, a coalbed methane test well drilled in Lee County, and a progress report on the stratigraphic framework and heavy-mineral resource potential of the inner continental shelf in the Cape Fear area. An information circular on the subsurface Cenozoic strata in Brunswick and New Hanover Counties and a small-scale, generalized geologic map of North Carolina were also published. Ninety thousand copies of the map, which contained information on the geology and mineral resources of the State on the reverse side, were distributed to earth science teachers. NCGS also completed

a diamond-lamproite model to explain the occurrence of diamonds in western North and South Carolina. A report on the project was scheduled for publication in early 1992. Also scheduled for publication in 1992 was a geochemical atlas of North Carolina listing more than 12,800 sites with analyses for 45 elements.

Geologic mapping, in cooperation with the U.S. Geological Survey (USGS), continued on the Raleigh and Asheville 1:100,000 quadrangles. A continuing cooperative program between NCGS and USGS included photorevision, limited revision, and complete revision of selected older 7.5-minute topographic maps. Also continuing was the heavy-mineral resource assessment on the inner continental shelf with funding from the American Association of State Geologists/Minerals Management Service (MMS) cooperative program. NCGS also conducted, with MMS funding, shallow high-resolution seismic studies to locate possible sources of beach nourishment sand off the Outer Banks.

The NCGS staff also completed a comprehensive review of Chem-Nuclear Systems Inc.'s characterization plans for potentially suitable sites for a low-level radioactive waste facility in Wake-Chatham or Richmond Counties. NCGS was also involved in the siting of a hazardous waste facility that will include an incinerator, solvent recovery plant, and a landfill for the Hazardous Waste Management Commission (HWMC). Numerous delays from litigation and public protests hindered HWMC in evaluating potential sites.

The Division of Occupational Safety and Health, North Carolina Department of Labor, performed routine safety inspections on mining operations within the State. The division also provided safety training and certification for miners and published a variety of brochures and circulars related to mine safety.

The Intermountain Field Office of the U.S. Bureau of Mines, Denver, CO, completed a summary of mineral resources in the national forests of eight southeastern States, including North Carolina. The information will be used to help the U.S. Forest Service update land and resource plans for the areas covered. The summaries included printouts and overlay maps of mineral locations.

The University of North Carolina Mathematics and Science Network received a $10,000 grant from the North Carolina Mining Commission (NCMC). The money, derived from fees and fines collected by NCMC from the mining industry, enabled 200 kindergarten through 12th grade science teachers to study the State's landforms, mineral resources, and mining industry. The North Carolina Department of Labor, Mine and Quarry Div., in cooperation with MSHA, conducted a 2-day conference in Raleigh in April designed to enhance mine safety and health.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Thirteen industrial mineral commodities were mined in North Carolina in 1991. At least nine additional industrial mineral commodities were produced from raw materials mined within the State, shipped from other States, or imported. These included andalusite, barite, synthetic graphite, byproduct gypsum, calcined gypsum, iodine, expanded perlite, sodium sulfate, and steel slag. The 13 mined commodities accounted for all of the value of minerals reported in table 1.

Clays.—Nationally, North Carolina ranked 8th in the quantity of clay mined, but ranked only 14th in value. The quantity of clay, excluding kaolin, mined in North Carolina continued to decline in 1991 after reaching a record-high level in 1989. Production was 2.0 million tons (5.3% less than that of 1990) valued at slightly more than $9 million. The value showed a drop of 3.6% from that of 1990. Kaolin, data for which are withheld, showed significantly larger decreases in both quantity and value. Common clay and kaolin were the only types of clay produced in 1991.

Common Clay and/or Shale.—Nationally, North Carolina ranked 3d in the quantity and 5th in the value of common clay mined. The State continued to lead the Nation in the production of common clay used in the manufacture of brick. Production decreased 6.6% to 1.7 million metric tons, although the value remained unchanged at $5.3 million. Texas, the 2d leading State in production, mined only 1.1 million tons of common clay for the manufacture of brick; however, it was valued at $6.6 million. The second major use of common clay was in the manufacture of lightweight aggregate. North Carolina, with a production of 327,000 metric tons valued at $3.7 million, ranked 3d nationally behind Alabama and Arkansas. Its 1991 production of common clay used for lightweight aggregate was unchanged from the revised figures reported for 1990. The principal uses of lightweight aggregate were in the manufacture of concrete blocks and structural concrete. The principal producers of clay used in the manufacture of lightweight aggregate were the Carolina Solite Corp., Stanly County; Virginia Solite Corp., Rockingham County; and Carolina Stalite Corp., Rowan County. Minor uses of clay included floor, wall, and quarry tile; ceramics; and miscellaneous clay products.

Nineteen companies reported the mining of common clay in 1991, 13 of which belonged to the Brick Association of North Carolina. The largest producers, in terms of quantity of common clay mined, were Boren Clay Products Co., Cherokee Sanford Group, Hammill Construction Co. Inc., Pine Hall Brick and Pipe Co., and Solite Corp.

Kaolin.—Kaolin was recovered as a byproduct of Unimin's quartz and mica processing operation at Spruce Pine from ore mined at the Brushy Creek Quarry, Avery County. Recovery of marketable kaolin from the other feldspar operations in the area was not reported. The only other kaolin production reported was a

byproduct from KMG Minerals Inc.'s mica operation at Kings Mountain, Cleveland County. The kaolin was sold primarily for the manufacture of white brick.

Feldspar.—The quantity of feldspar produced was 402,448 metric tons, a drop of 3.8% from production in 1990. Feldspar production has declined by 15.8% since reaching a record high of 477,800 tons in 1986. The value of feldspar produced decreased to $13.0 million, a decrease of 9.9% from the 1990 value and 24.8% from the peak value of $17.3 million attained in 1988.

Hecla Mining Co.'s purchase of Indusmin's feldspar operations in Spruce Pine, which was announced in December 1990, was approved by the Justice Department in early 1991. The quarry and plant operate as the K-T Feldspar Co., a division of Hecla's Kentucky-Tennessee Clay Co. subsidiary. According to data published at the time of the sale,[8] the plant has a capacity of 100,000 short tons per year of feldspar. K-T installed six rare-earth magnetic roll separators to remove iron-bearing contaminants such as garnet, mica, biotite, and process metal. K-T was also exploring other process changes that would enable it to supply a more purified feldspar to customers in the ceramics, fillers, and glass markets.

In the latter part of 1991, preliminary reviews were made by the U.S. International Trade Commission (ITC) and the International Trade Administration to determine whether imported nepheline syenite from Canada was being sold at less-than-fair value. The action was brought by the Feldspar Corp. of Spruce Pine. The Bureau's feldspar commodity specialist provided information on feldspar at the meetings. A final public hearing was to be held by ITC in March 1992.

Gemstones.—Gemstone production in North Carolina fell 25.7% from an alltime high of more than $1 million in 1990 to $785,000 in 1991. As a result of the decrease, North Carolina dropped from 7th to 12th nationally in the value of gemstones produced. The decline may be attributable in part to the closing in 1990 of the only company attempting to commercially mine emeralds. The failure was the latest of at least five attempts to commercially mine emeralds since they were discovered at Hiddenite in 1875. Historically, North Carolina is the only State in which all four major gem minerals, diamond, ruby, sapphire, and emerald, are found; however, the last year that all four were found was 1988. Rubies and sapphire are found primarily in the Cowee Valley where numerous dig-for-fee operations exist. Many people pay to dig or purchase buckets of gravel to wash hoping to recover gem corundum, garnets, rubies, sapphires, and other gemstones. Every year publicity concerning the finding of large and valuable rubies and sapphires appears, but reports of their size and value tend to be overstated. When commercial mines operated in the area, gemstones that would cut fine-quality 3- to 4-caret stones were found. Today, the amount of quality gem material has greatly declined and most of the rubies found are not of top color and on average are suitable for cutting stones of 1 carat or less. Sapphires tend to be somewhat larger, and high-quality sapphires are found more often than high-quality rubies.

North Carolina ranked sixth out of eight States in which synthetic or simulant gem material was produced.

Lithium.—North Carolina continued to lead the Nation in the production of lithium compounds. The only other domestic lithium production was from geothermal brine deposits in Nevada. The lithium in North Carolina is produced from the mineral spodumene, a lithium aluminum silicate that occurs in pegmatites in the Kings Mountain area. Two companies, FMC-Lithium Div. and Cyprus Foote Mineral Co., mine spodumene and process it for lithium carbonate. FMC produces a full range of downstream lithium compounds at a nearby plant in Bessemer City. Cyprus Foote continued to operate on a scaled-down basis in 1991. Lithium carbonate produced at Kings Mountain is shipped primarily to a sister plant in New Johnsonville, TN, where a full range of lithium chemicals and compounds is produced.

Mica.—Scrap mica production decreased slightly from 65,000 metric tons valued at $3,796,000 in 1990 to 64,000 tons valued at $3,747,000 in 1991. Mica was produced by six companies in 1991. Cyprus Foote Minerals Co. recovered mica as a byproduct of its lithium operations in Cleveland County. The Feldspar Corp. recovered mica from three pits in Mitchell County. FMC-Lithium Div. recovered mica from spodumene pegmatites in Gaston County. K-T Feldspar Co., a subsidiary of Hecla Mining Co., mined mica from one pit in Mitchell County. KGM Minerals recovered mica from pegmatites in Cleveland County. Unimin Corp. produced mica from quarries in Avery and Mitchell Counties. The mica produced by the Feldspar Corp., K-T Feldspar, and Unimin in the Spruce Pine area was recovered from alaskite deposits. Alaskite is a generally coarse-grained granitic rock that is relatively free of iron-bearing minerals. Typically, it is composed of 45%-55% plagioclase feldspar, 20% microcline feldspar, 15% quartz, and 10% muscovite mica. Feldspar and high-purity quartz sand are usually recovered along with the mica. Kaolin may also be recovered from deeply weathered alaskite bodies.

Cyprus Foote, FMC, and KGM recovered mica from pegmatites in the Kings Mountain-Bessemer City area of Cleveland and Gaston Counties. Feldspar, kaolin, lithium, and industrial sand were recovered in addition to the mica.

The dry-ground plants of Deneen Mica Co. at Micaville in Yancey County and J. M. Huber at Kings Mountain remained inactive during the year. Huber offered its operation for sale on April 1, 1990; as of yearend 1991, the operation was still for sale.

The Land Quality Section of the North Carolina Department of Environment,

Health, and Natural Resources issued a permit allowing Rednour Mining Co. to mine and process mica from a 10-acre tract near Grover, Cleveland County. The permit was issued despite strong opposition from local residents and environmentalists that did not appear to abate after the permit was issued. As of yearend, Rednour had not begun operations at the site.

Junaluska Mica Co. began processing scrap mica in Andrews, Cherokee County. The plant features a wet concentrator built by the firm's owner that reportedly[9] recovers 80% of the mica. The company's primary market was the roofing industry with a majority of sales to an asphalt products manufacturer in Tuscaloosa, AL.

Olivine.—North Carolina remained the leading producer of olivine in the United States, although both the quantity produced and its value declined as it has each year since 1984. In past years, most of the decrease resulted from increased imports from Norway. Much of the decline in olivine production in the past 2 years resulted from a decline in steel production, which is the largest user of olivine in the United States. Olivine acts as a flux and as a slag conditioner, improving the performance of sinter and reducing coke consumption.

Applied Industrial Minerals Corp. (AIMCOR), headquartered in Deerfield, IL, operated the Daybrook Mine in Yancey County and remained North Carolina's sole olivine producer. AIMCOR's mine in Avery County was worked on a limited basis, but its Jackson County mine remained idle during 1991.

Peat.—Nationally, North Carolina ranked third of 19 States in the quantity of peat produced. The only company mining and processing peat was American Peat Co. Inc. from pits in Hyde County. The peat was sold for horticultural applications.

Phosphate Rock.—North Carolina ranked second nationally, behind Florida, in both the quantity and value of phosphate produced. Phosphate was the second most valuable mineral commodity mined in North Carolina, ranking below crushed stone. According to Bureau projections, planned phosphate rock production in North Carolina will hold at 5.5 million metric tons from 1990 through 1994, then increase to 6.8 million metric tons for 1995 and 1996.

Phosphate was mined in North Carolina by one company, Texasgulf Inc. (Tg), a subsidiary of the French conglomerate, Elf Aquitaine. Tg's North Carolina operation was responsible for approximately 10% of domestic phosphate production and ranked third among 17 U.S. phosphate manufacturers in production and sales.[10] Products were sold in 35 States and 10 foreign countries.

In July, Tg submitted a permit application and an environmental impact report (draft EIS) to the U.S. Army Corps of Engineers (USCE), the primary agency of several Federal and State agencies that will have to approve the application. In the application, Tg seeks approval to mine approximately one-third of a 14,200-acre tract it acquired when it purchased North Carolina Phosphate Co. in 1988. Approximately 3,000 of the acres to be affected is under USCE jurisdiction as wetlands. At yearend, the documents were still being reviewed by USCE.

Working with the forestry department of North Carolina State University and the Hardwood Research Cooperative, Tg began in October a restoration program designed to demonstrate that the science and technology exists to restore and create wetlands. If successful, Tg believes the program will satisfy requirements on the no-net-loss of wetland policy and allow it to continue mining operations in the area for the next 50 plus years. The project would have two goals: first, to recreate a 25-acre hardwood-swamp wetland as it existed before being mined, and second, to create a wetland on a tract where none existed.[11] Tg also continued reclamation begun in 1987 on a 2,065-acre tract. The tract is scheduled to be developed as 535 acres of wetland and 1,530 acres of habitat for hardwood trees. As of August 1991, 330 acres of trees had been planted with 119,000 seedlings. Total reforestation is scheduled for completion in the year 2001.

In October, Tg hosted an open house that attracted more than 8,000 visitors, 6,000 of whom toured the company's mining, processing, and reclamation operations. The event promoted a greater understanding by the general public of the necessity for and the benefits derived from mining. Tg also stressed that with proper planning and diligent reclamation, mining can be conducted on a large scale with minimal long-term impact on the environment.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Based on Bureau estimates, production of construction sand and gravel decreased 15.6% from 11.7 million short tons in 1990 to 9.9 million tons in 1991. Correspondingly, its value decreased 22.0% from $44.9 million to $35.0 million.

During 1991, MSHA inspected 130 construction sand and gravel pits operated by 104 companies in 51 of North Carolina's 100 counties. Of the 130 pits inspected, 17 were listed as permanently closed and 36 operated on an intermittent basis.

Construction sand and gravel operations owned by Nello L. Teer Co. and it subsidiary, Larco Construction Co., were included in the properties acquired by Hansen PLC when it purchased Beazer PLC. Applications by Nello L. Teer for a special use permit from the city of Lexington and a State mining permit for a proposed construction gravel pit in Davidson County were pending at yearend. Organized opposition to the operation was responsible for delays in issuing the permits.

A 2-year moratorium on the issuance of mining permits was lifted by the Currituck County Board of Commissioners in March when new mining regulations became effective. The moratorium was established in 1989 after Outer Banks Contractors requested the rezoning of a tract they planned to mine for sand and gravel. The new regulations set minimum setbacks and buffer zones from property lines, residences, schools, and churches; set hours of operation; and imposed other restrictions on mining operations.

The NC Mining Commission presented its annual reclamation award to Neuse Sand & Gravel Co. for reclamation of a 52-acre mine site near Kinston, Lenoir County. The tract was restored as a wetlands wildlife habitat and lake.

Industrial.—The value of industrial sand and gravel produced in 1991 was $15.6 million, 1.5% more than that of 1990. The quantity mined remained virtually unchanged at 1.2 million short tons. North Carolina's national ranking improved to 6th in quantity and 7th in value after ranking 9th and 11th, respectively, in 1990. The unit value of industrial sand produced in North Carolina averaged $13.26 per ton, almost $2 less than the national average of $15.25.

Industrial sand and gravel was mined by six companies in 1991: Becker Sand and Gravel Co., W. R. Bonsal Inc., B. V. Hedrick Gravel and Sand Co., KMG Minerals Inc., Southern Production and Silica Co., and Unimin Corp. Becker, Bonsal, and Hedrick produced gravel for ferrosilicon manufacture. Becker's operation is near Lillington, Harnett County; Bonsal and Hedrick have operations near Lilesville in Anson County. KMG produces industrial sand as a coproduct at its mica operation in Kings Mountain. Major applications are in the blasting and glass container industries. Southern Production supplies specialty sand and gravel products for water and chemical filtration applications, sandblasting media, and decorative aggregate from an operation near Hoffman, Richmond County. Unimin produced sand for glass, blasting, roofing granules, and related applications at its plant near Marston, Richmond County. It also produced an ultrahigh-purity sand for its Quintus and Iota quartz grain and other highly refined quartz products at its feldspar operation in Spruce Pine. Unimin's purchase of Feldspar Corp.'s high-quality silica plant in Spruce Pine, announced in December 1990, was finalized by the signing of a definitive agreement in March 1991. The sale is subject to certain closing conditions, including government approval, as specified in the agreement. Included in the sale were certain land, easements, buildings, and equipment, along with trademarks and technology relating to the

TABLE 2
NORTH CAROLINA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	47	178	$3.79
Riprap and jetty stone	503	3,507	6.97
Filter stone	123	718	5.84
Other coarse aggregate	W	W	1.65
Coarse aggregate, graded:			
Concrete aggregate, coarse	2,599	15,635	6.02
Bituminous aggregate, coarse	2,047	13,758	6.72
Bituminous surface-treatment aggregate	501	2,775	5.54
Railroad ballast	2,031	8,468	4.17
Fine aggregate (-3/8 inch):			
Stone sand, concrete	299	1,541	5.15
Stone sand, bituminous mix or seal	151	842	5.58
Screening, undesignated	1,492	6,991	4.69
Coarse and fine aggregates:			
Graded road base or subbase	7,828	34,925	4.46
Unpaved road surfacing	126	607	4.82
Terrazzo and exposed aggregates	W	W	12.17
Crusher run or fill or waste	1,392	6,232	4.48
Other construction materials[2]	1,184	7,318	6.18
Agricultural:			
Agricultural limestone	W	W	4.36
Poultry grit and mineral food	W	W	1.11
Special:			
Mine dusting or acid water treatment	W	W	6.90
Asphalt fillers or extenders	W	W	5.04
Other fillers or extenders	W	W	4.95
Other miscellaneous uses[3]	522	2,142	4.10
Unspecified:[4]			
Actual	24,276	131,881	5.43
Estimated	1,394	6,405	4.59
Total[5]	46,514	243,920	5.24

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and Other miscellaneous uses."
[1]Includes dolomite, granite, limestone, marl, and miscellaneous stone,
[2]Includes withheld amounts for coarse aggregate (+1 inch), coarse and fine aggregates, and roofing granules.
[3]Includes withheld amounts for agricultural and special.
[4]Includes production reported without a breakdown by use and estimates for nonrespondents.
[5]Data may not add to totals shown because of independent rounding.

high-purity sand operation.[12] Unimin subsequently announced plans to expand its existing silica facilities at Spruce Pine.[13]

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

North Carolina crushed stone statistics are compiled by geographic districts as depicted on the State map. These data are summarized by major-use category in table 2, by district and use in table 3, and by kind in table 4.

Crushed.—Crushed stone once again was the leading mineral commodity produced, accounting for more than 44% of the value of the State's total mineral output. Nationally, North Carolina ranked fifth in the value of crushed stone produced and seventh in quantity, improving from 1990 when it ranked eighth in both categories. This occurred despite a decline in value of 11.7% to $243.9 million and in volume of 12.1% to 46.5 million short tons.

Crushed stone production was reported by 29 companies from 93 quarries in 59 of 100 counties in the State. District 2, in the central part of North Carolina, once again led in crushed stone production with 51.7% of the total quantity and 52.2% of the value. District 3, western North Carolina, accounted for 31.3% and 31.8%, respectively, while the eastern portion, District 1, accounted for 17.0% and 16.0%.

The major producers, ranked in order of both production and value, were Martin Marietta Aggregates Corp. (33 quarries), Vulcan Materials Co. (18 quarries), Hanson PLC (6 quarries), Wake Stone Corp. (4 quarries), Harrison Construction Co. (4 quarries), and Becker Minerals Corp. (4 quarries).

End uses of crushed stone are given in table 2. The unit value of crushed stone sold in North Carolina varied from $1.11 per ton for poultry grit and mineral food to $12.17 per ton for terrazzo and exposed aggregates, with an overall average price of $5.26 per ton. Granite was the rock most often quarried for crushed stone, followed by limestone and traprock. Table 4 lists all of the types of rock quarried during 1991.

Martin Marietta Corp., a leading defense and materials company, moved the headquarters of its materials group from Bethesda, MD, to Raleigh. The group consists of the company's construction materials subsidiary, Martin Marietta Aggregates, and its magnesia production operations. The move, announced in September, became effective at yearend.

Dimension.—Dimension stone production was 32,489 short tons, 51.2% less than that estimated for 1990 and

TABLE 3
NORTH CAROLINA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[2]	W	W	W	W	130	573
Coarse aggregates, graded[3]	2,541	12,703	3,399	20,895	1,238	7,038
Fine aggregates (-3/8 inch)[4]	485	2,488	1,069	5,124	390	1,762
Coarse and fine aggregates[5]	2,856	13,450	4,567	19,484	1,921	8,829
Other construction materials	485	2,955	1,426	9,634	167	301
Agricultural[6]	—	—	—	—	—	—
Special[7]	—	—	W	W	—	—
Other miscellaneous uses	44	216	—	—	127	181
Unspecified:[8]						
Actual	1,319	6,529	12,602	68,000	10,355	57,351
Estimated	173	685	970	4,268	251	1,452
Total[9]	7,902	39,027	24,033	127,405	14,579	77,487

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Excludes quartzite, volcanic cinder and scoria, and slate; withheld to avoid disclosing company proprietary data.
[2]Includes macadam, riprap and jetty stone, and filter stone.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[5]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run (select material or fill), roofing granules, and other construction and maintenance uses.
[6]Includes agricultural limestone and poultry grit and mineral food.
[7]Includes asphalt fillers or extenders, mine dusting or acid water treatment, and other fillers or extenders.
[8]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[9]Data may not add to totals shown because of independent rounding.

TABLE 4
NORTH CAROLINA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991[1]			
	Number of quarries	Quantity (thousands) short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand (short tons)	Value (thousands)	Unit value
Limestone	13	4,898	$26,306	$5.37	8	3,827	$20,941	$5.47
Dolomite	1	W	W	5.74	1	176	1,075	6.11
Calcareous marl	2	W	W	5.59	4	294	331	1.13
Granite	60	39,398	193,664	4.92	69	38,095	198,834	5.22
Traprock	5	3,761	19,634	5.22	4	2,539	14,374	5.66
Sandstone and quartzite	2	W	W	9.69	—	—	—	—
Slate	2	W	W	5.24	—	—	—	—
Volcanic cinder and scoria	1	W	W	5.18	—	—	—	—
Miscellaneous stone	2	W	W	5.13	3	1,583	8,365	5.28
Total[2]	XX	51,519	257,976	5.01	XX	46,514	243,920	5.26

W Withheld to avoid disclosing company proprietary data, included in "Total." XX Not applicable.
[1]Excludes quartzite, volcanic cinder and scoria, and slate: withheld to avoid disclosing company proprietary data.
[2]Data may not add to totals shown because of independent rounding.

48.2% less than that of 1989, the last year the industry was surveyed. The 1991 value of $10.1 million showed more modest decreases of 12.3% from that of 1990 and 3.1% from that of 1989. Part of the decrease in 1991 resulted from the NC Granite Co. fulfilling its contract to supply granite to replace the Italian marble facing on the Amoco Building in Chicago, IL. This one-time order for approximately 600,000 square feet of cut veneer stone raised North Carolina's dimension stone production to a record high in 1990.

Dimension stone was mined by 6 companies from 14 quarries at 13 operations in 8 counties. In addition to the companies listed in the principal producers table, dimension stone was produced by L. S. Starrett Co., White Camelia Granite Co., and O. J. Wilson Stone Co. The principal rock type quarried was granite. The only other rocks quarried were quartzite, sandstone, and slate.

Talc and Pyrophyllite.—North Carolina remained the only State in which pyrophyllite was mined. Pyrophyllite is a naturally occurring hydrous aluminum silicate formed during hydrothermal alteration of felsic volcanic rocks. It is often confused with talc because of its appearance and physical properties, such as a creamy white to translucent green color, a pearly luster, and a soapy or waxy feel. It is used in making pesticide diluents and carriers (particles to which pesticide chemicals adhere), rubber foam, paints, wall tiles, and refractories.

Pyrophyllite was mined by two companies, Piedmont Minerals Div. of Resco Inc. and Standard Mineral Co. Inc., a subsidiary of R. T. Vanderbilt Co. Piedmont operated the Hillsborough mill in Orange County. Standard Mineral Co. mined pyrophyllite at the Glendon and Robbins pits in Moore County and processed the ore at Robbins Mill.

Titanium.—Exploration for titanium-bearing heavy-mineral sands slowed in 1991 because of a worldwide oversupply of heavy minerals and titanium products, especially zircon and TiO_2 pigments,[14] and the general recession in the United States. However, two companies proceeded with plans to develop deposits found in North Carolina. Southeast TiSand Joint Venture, formed by Becker Minerals Inc. of England and Consolidated Rutile Ltd. of Australia, continued development work on its leases in the Roanoke Rapids area. RGC Minerals Inc. announced[15] in August that a study to determine the economic feasibility of locating an operation in the area had been extended 2 years past the company's original deadline of December 1991. As of yearend, neither company had applied for mining permits.

Teledyne Allvac supplied titanium billet to the company's new, fully automated bar and rod mill at Richmond, SC, from its melting and forging facility at Monroe, Union County. The Monroe plant had a capacity of 5.7 million metric tons of titanium metal ingot in 1991. Included in the capacity was 2.1 million tons of single-melt capacity.

Other Industrial Minerals.—Several industrial minerals mined in other States or countries were marketed or processed into higher value products. Their quantity and value are included in the data for the State or country in which they were mined and are not included in table 1 for North Carolina.

In May, a group of investors led by Titan Cement Co. of Greece announced the purchase of 908 acres, which included the former Ideal Cement plant in Castle Hayne, New Hanover County. The purchase was part of a $75 million investment designed to put the plant back into production by 1993. The partnership, known as Carolinas Cement Co. LP, plans to process 600,000 tons of portland and masonry cement per year for markets in the Carolinas and Virginia. The company plans to quarry limestone from a tract included in the land purchase that adjoins Martin Marietta's existing crushed stone quarry. More than 100

workers were expected to be employed at the facility when it is in operation.[16]

Two boron-rich minerals imported from Turkey, colemanite and ulexite, were used by PPG Industries Inc. in its fiberglass manufacturing facilities at Shelby and Lexington. Other mineral commodities used in PPG's manufacturing process included kaolin from Georgia and South Carolina, boric acid from California, and industrial sand from North Carolina.

Carbon bushings, electrodes, electric motor brushes, or machined and unmachined graphite shapes were produced by Great Lakes Carbon Corp., at Morganton, Burke County; Morganite Inc., Dunn, Harnett County; and Cronatron Welding Systems Inc., Charlotte, Mecklenburg County.

Gypsum, imported from Nova Scotia, was calcined and used to manufacture wallboard by National Gypsum Co., Wilmington. Byproduct gypsum produced during the phosphoric acid manufacturing process was mixed with clay overburden to backfill mined areas prior to reclamation by Texasgulf Inc.

Crude iodine was imported by Mallinckrodt Inc., Raleigh, to manufacture potassium iodate, calcium iodate, and diatrizoic acid.

Carolina Perlite Co. Inc. expanded perlite for use as horticultural aggregate, cavity-fill insulation, concrete aggregate, oil-water absorbent, filter aid, and fillers at Gold Hill, Rowan County.

Sodium sulfate was produced from lithium carbonate ore by FMC, Lithium Div., at Bessemer City. Sodium sulfate was also produced during the sodium dichromate manufacturing process by Occidental Chemical Co., Castle Hayne.

Heckett Div. of Harsco Corp. processed steel slag obtained from Florida Steel Co.'s plant in Charlotte for use as aggregate.

Metals

Although there were no metals mined in North Carolina, a variety of foreign and domestic ores, intermediate metal products, and scrap were processed into higher value finished products. Economically, aluminum, steel, and ferroalloys were most valuable, but numerous other metals were processed.

Aluminum.—The only primary aluminum produced in North Carolina was manufactured by Aluminum Co. (Alcoa) of America at Badin, Stanly County. Alcoa Kobe Steel Tube Specialties Ltd., a joint venture between Alcoa and Kobe Steel Ltd. of Tokyo, Japan, began the production of aluminum photoreceptor tubes and automotive components at its new 40,000-square-foot plant at Charlotte in mid-November. The tubes are used in facsimile laser printers, copy machines, personal computers, and word processors. The second phase of development at the plant, to be completed by 1993, includes the installation of a 2,500-metric-ton press to supply stock for the tube line. The extrusion press would also produce automotive heat-exchanger components.

Ferroalloys and Steel.—Numerous facilities manufacturing or processing steel and ferroalloys were also part of the mineral industry in North Carolina. Florida Steel, Charlotte, produced steel using a 70-ton electric arc furnace in which scrap is preheated and continuously refined. The system, which was completed in 1990 and became fully operational in 1991, was designed by Intersteel Technology Inc., Matthews, Union County. A similar Intersteel system was formerly used by Nucor Steel Corp., Charlotte, at its minimill in Charleston, SC. Nucor, the Nation's leading minimill steel producer, expended $217 million on plant improvements in 1991.[17] Timken Co. broke ground for a $135 million bearing plant in Asheboro in November. The plant, which will produce tempered steel bearings from carbon and alloy bar, was scheduled to become operational in 1992.

Other Metals.—Kennametal Inc. produced tungsten carbide wear parts for cutting tools at its plant in Roanoke Rapids. Occidental Chemical Corp. completed installation of a $5 million wet-electrostatic precipitator as part of its program to reduce toxic air emissions from its chromium chemical manufacturing plant in Castle Hayne.

Carolmet Inc., a subsidiary of Acer Union Miniere of Belgium, produced extra-fine cobalt powders used as binder material in the production of carbide-tipped cutting tools, drill bits, tools, and other machinery, as well as for wear parts. Its plant at Maxton, Robeson County, completed the partial automation of its furnace in June. Glidden Metals Div. of SCM Corp. produced atomized copper powder at its Durham County plant. The copper powder is used to fabricate oil-retaining bearings and parts for the automotive and appliance industries. Halstead Industries Inc. manufactured innergrooved copper tubing, primarily used for air conditioning applications, at Pine Hall, Stokes County.

Lithium metal was manufactured by FMC, Lithium Div., at its Cherryville plant in Cleveland County.

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[1]State Minerals Officer, U.S. Bureau of Mines, Tuscaloosa, AL. He has 33 years of mineral-related experience in industry and government and has covered the mineral activities in North Carolina since 1989. Assistance in the preparation of the chapter was given by Maylene E. Hubbard, editorial assistant.

[2]Senior Geologist, North Carolina Geological Survey, Raleigh, NC.

[3]Senior geologist, North Carolina Geological Survey, Asheville, NC.

[4]Feldspar value for 1990 was revised from $13,389,000 to $14,460,000.

[5]U.S. Department of Labor. Mine Injuries and Work Time, Quarterly. Jan.-Dec. 1991, p. 13.

[6]The Northern Miner (Toronto, Canada). U.S. Midwest, Appalachian Districts Attract Noranda. V. 76, No. 48, Feb. 4, 1991, p. 36.

[7]Mining Business Digest (Denver, CO). Piedmont Mining Co.-Russell Coggins Exploration. Sept. 1982, p. 16.

[8]Mining Engineering. US and International Mineral News Briefs—Hecla Mining Co. V. 43, No. 2, Feb. 1991, p. 195.

[9]The Andrews (NC) Journal. Mica. Apr. 25, 1991, p. 1.

[10]Tg Times (Aurora, NC). Tg Executive Discusses Phosphate Business. Feb. 1992, p. 4.

[11]Daily News (Washington, NC). Wetlands Restoration Project Underway. Nov. 28, 1991.

[12]Asheville (NC) Citizen. Zemex To Sell Assets. Mar. 20, 1991.

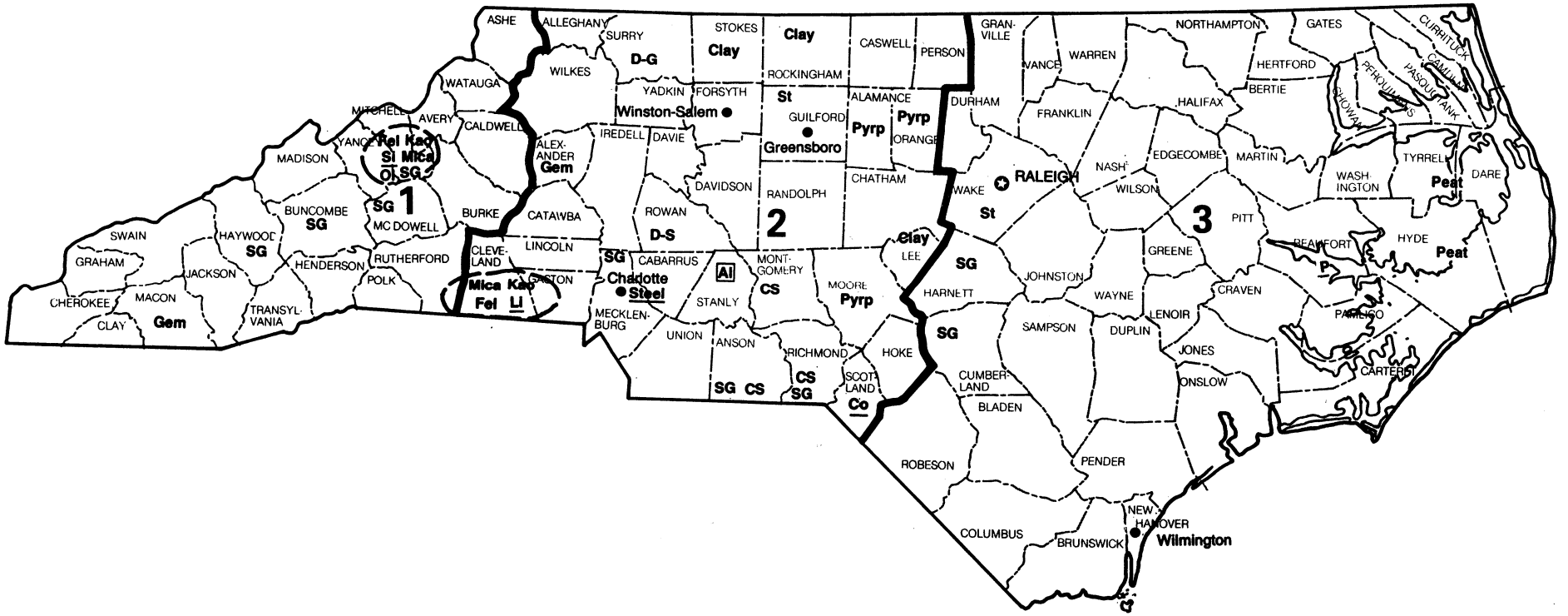
[13]Industrial Minerals (London, United Kingdom). Crystal Silica Sale. No. 285, May 1991, p. 98.

[14]———. Shifting Sands. No. 283, Apr. 1991, p. 7.

[15]Daily Times (Wilson, NC). Feasibility Study of Titanium Operation Extended 2 Years. Aug. 22, 1991.

[16]Morning Star (Wilmington, NC). Coalition Buys Castle Hayne Cement Plant. May 3, 1991, p. 1A.

[17]Iron Age. Minis Confront Capital Spending Quandary. Iron Age, Sept. 1992, p. 30.



NORTH CAROLINA

LEGEND

State boundary
County boundary
Capital
City
Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Al	Aluminum plant
Clay	Clay
Co	Cobalt plant
CS	Crushed Stone
D-G	Dimension Granite
D-S	Dimension Sandstone
Fel	Feldspar
Gem	Gemstones
Kao	Kaolin
Li	Lithium mine and plant
Mica	Mica
Ol	Olivine
P	Phosphate rock
Peat	Peat
Pyrp	Pyrophyllite
SG	Sand and Gravel
Sl	Silica plant
St	Stone
Steel	Iron and Steel plant

Concentration of mineral operations

Principal Mineral-Producing Localities

TABLE 5

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum, smelter:			
Aluminum Co. of America	Box 576 Badin, NC 28009	Plant	Stanly.
Clays:			
Boren Clay Products Co.	Box 368 Sanford, NC 27330	Open pit mines and plant	Chatham, Guilford, Henderson, and Sampson.
Carolina Solite Corp.	Box 987 Albemarle, NC 28001	do.	Rockingham and Stanly.
Pine Hall Brick Co. Inc.	Box 836 Madison, NC 27025	do.	Rockingham and Stokes.
Feldspar:			
The Feldspar Corp., subsidiary of Zemex Corp.[1]	Box 99 Spruce Pine, NC 28777	do.	Mitchell.
K-T Feldspar Corp.,[1] Div. of Hecla Mining Co.	Box 309 Spruce Pine, NC 28777	do.	Do.
Unimin Corp.[2 3]	23157 Sanders Rd. Northbrook, IL 60062	do.	Do.
Lithium:			
Cyprus Foote Mineral Co.[4]	Box 689 Kings Mountain, NC 28086	Open pit mine and plant	Cleveland.
FMC Corp., Lithium Div.[1 4]	Box 795 Bessemer City, NC 28016	do.	Gaston.
Mica:			
KMG Minerals Inc.[2 3 4]	Box 729 King Mountain, NC 28086	do.	Cleveland.
Olivine:			
AIMCOR	Route 2, Box 167-C Green Mountain, NC 28740	do.	Avery and Yancey.
Peat:			
American Peat Co. Inc.	RFD #1, Box 79 Pantego, NC 27860	Mine	Hyde.
Perlite (expanded):			
Carolina Perlite Co. Inc.	Box 158 Gold Hill, NC 28071	Plant	Rowan.
Phosphate rock:			
Texasgulf Inc.[5]	Box 48 Aurora, NC 27806	Open pit mine and plant	Beaufort.
Pyrophyllite:			
Piedmont Minerals Co., Div. of Resco Products Inc.[6]	Box 7247 Greensboro, NC 27407	do.	Orange.
Standard Minerals Co. Inc., subsidiary of R. T. Vanderbilt Co.	Box 278 Robbins, NC 27325	do.	Moore.
Sand and gravel:			
Becker Sand & Gravel Co.[3]	Box 698 Lillington, NC 27546	Pits	Anson and Harnett.
W. R. Bonsal Co.[3]	Box 38 Lilesville, NC 28091	do.	Anson.
B. V. Hedrick Gravel and Sand Co.[3]	Box 8 Lilesville, NC 28091	do.	Buncombe.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Steel:			
Florida Steel Corp.	2126 Garner Road Raleigh, NC 27611	Plant	Mecklenburg.
Stone:			
Crushed:			
Martin Marietta Corp.	Box 30013 Raleigh, NC 27622	Quarries and plants	Various.
Nello L. Teer Co., subsidiary of Hansen, PLC	Box 1131 Durham, NC 27702	do.	Do.
Vulcan Materials Co., Mideast Div.	Box 7497 Winston-Salem, NC 27109	do.	Do.
Dimension:			
Granite Panelwall Co.	Box 898 Overton, GA 30635	do.	Rowan.
Jacob's Creek Stone	Box 608 Denton, NC 27339	do.	Davidson, Montgomery, Stokes.
The NC Granite Co.	Box 988 Mt. Airy, NC 27030	do.	Cabarrus and Surry.

[1]Also mica.
[2]Also clay.
[3]Also industrial sand.
[4]Also feldspar.
[5]Also byproduct gypsum.
[6]Also sericite.

THE MINERAL INDUSTRY OF NORTH DAKOTA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the North Dakota Geological Survey for collecting information on all nonfuel minerals.

By Eileen K. Peterson[1] and Robert F. Biek[2]

The value of North Dakota's nonfuel mineral industry in 1991 was about $17 million, a decrease of 35% from that of 1990. The State ranked 48th nationally in nonfuel mineral production, accounting for less than 1% of the Nation's total mineral value for the year.

The decrease in value from that reported in 1990 was due to substantial decreases in reported production of clay, sand and gravel, and stone, the principal construction minerals produced in the State. Construction sand and gravel contributed the greatest amount to the State's nonfuel mineral value, accounting for 70% of the total. Other nonfuel mineral commodities produced, in order of decreasing value, included lime, clays, stone, and gemstones. Elemental sulfur was recovered from natural gas processing.

TRENDS AND DEVELOPMENTS

Most of North Dakota's nonfuel mineral production was used in construction. According to the U.S. Department of Commerce, 2,106 permits for residential units were issued in 1991, an increase of 594 over the number issued in 1990. The value of nonresidential construction awards for offices, motels, stores, industrial plants, etc., was $128 million, an increase of about $22 million compared with that of 1990. Much of the construction minerals used in North Dakota were obtained from out-of-State sources.

The North Dakota State Soil Conservation Committee reported that in 1991 there were 88 noncoal pits affecting 166 hectares (411 acres) in the State. The pits ranged in size from 0.05 hectare to 12.9 hectares (0.125 of an acre to 32 acres). Minerals mined included 2.1 million cubic meters (2.8 million cubic yards) of sand and gravel, scoria, clay, and stone with the removal of 507,668 cubic meters (664,000 cubic yards) of overburden. Production was down about 21% from the 1990 figure of 2.7 million cubic meters (3.5 million cubic yards).[3]

EMPLOYMENT

After showing its largest increase in 5 years in 1990, mining employment, including fuel and nonfuel extractive industries, increased by only 24 workers in 1991. Nonfuel mining employment remained nearly steady at 378, with only a small increase in sand and gravel industries. Coal mining employment remained steady at 1,050 workers, and oil and gas industries were down slightly with 2,800 employees. The State's total unemployment rate rose slightly to 4.06% from 3.9% in 1990. Total nonagricultural employment topped 270,000 for the first time.

TABLE 1
NONFUEL MINERAL PRODUCTION IN NORTH DAKOTA[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	47,903	W	50,485	W	27,825	W
Gemstones		NA	$10	NA	$10	NA	$6
Lime	thousand short tons	107	5,439	82	4,623	98	5,360
Sand and gravel (construction)	do.	e3,600	e8,100	7,644	17,219	e5,000	e12,000
Stone (crushed)	short tons	—	—	e1,000	e4,600	11	W
Combined value of other industrial minerals and values indicated by symbol W		XX	111	XX	116	XX	(2)
Total		XX	13,660	XX	26,568	XX	3,17,366

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Value excluded to avoid disclosing company proprietary data.
[3]Partial total, excludes values that must be concealed to avoid disclosing company proprietary data.

Average annual wages in 1991 for nonfuel mining employees was $26,174, up about 2% from that of 1990. Coal mining wages averaged $46,064, up almost 4% from 1990.[4]

LEGISLATION AND GOVERNMENT PROGRAMS

The 1991 State legislature passed several bills impacting the mineral industry. House bill 1111 exempts certain wastes from the State's hazardous waste laws. Exemptions include: (1) fluids and wastes generated through exploration, development, or production of crude oil, natural gas, or geothermal energy; (2) wastes generated primarily from the combustion or gasification of coal or other fossil fuels; (3) solid waste resulting from extraction, beneficiation, and processing of ores and minerals; and (4) cement kiln dust waste. House bill 1480 established legislative intent and program parameters for use of lignite coal research funds. The State Industrial Commission will consult with the Lignite Research Council in matters of policy affecting the administration of the lignite research funds. House bill 2303 allows County Commissioners to temporarily close or relocate section line roads because of surface coal mining activities.

The North Dakota Industrial Commission granted $60,000 to Dakota Gasification Co. to study the feasibility of converting the Great Plains Coal Gasification plant to a coal liquefaction facility. Converting the plant to make liquid fuels instead of synthetic natural gas could result in the production of 30,000 barrels of oil per day and use 2.72 million metric tons (3 million short tons) of lignite per year.

The North Dakota Industrial Commission also granted $16,160 to continue a North Dakota State University Land Reclamation Research Center. Research Center staff will conduct a study of soil depth and quality requirements for rangeland reclamation subsequent to completion of surface mining activities.

At the Energy and Environmental Research Center (EERC), North Dakota Mining & Mineral Resources Research Institute (NDMMRRI) of the University of North Dakota, research continued on North Dakota's mineral and energy resources. In fiscal year 1991, an allotment grant of $148,000 from the U.S. Bureau of Mines was received by NDMMRRI under provisions of Public Laws 98-409 and 100-483. Bureau-sponsored work under the grant included: a mine reclamation program concentrating on work at three coal mines and one uranium mine, rare elements in coal and coal ash, use of bacteria for mineral extraction, coal correlation studies, and underground coal gasification mineralogy studies.[5]

The North Dakota Geological Survey participated in a regional industrial minerals conference cosponsored by the U.S. Bureau of Mines. Mineral resource demands and availability, land use conflicts, and research needs in the region were major topics evaluated. The survey continued geologic mapping programs and evaluation of horizontal drilling possibilities in North Dakota oilfields and gasfields, and issued a narrated video intended mainly for earth science teachers. In cooperation with the North Dakota State Departments of Health and Agriculture and a private company, the survey established a Geographic Information System (GIS) laboratory that should prove useful for managing mineral resource information for North Dakota.

In 1991, the Public Service Commission's Abandoned Lands Div. completed backfilling abandoned underground coal mines near Williston. Under a $1.3 million Federal grant from the U.S. Office of Surface Mining Reclamation and Enforcement, a mixture of sand, water, fly ash, and cement was pumped into the mines to stabilize the area and protect 17 homes on properties overlying the mines. Additional projects are expected to stabilize other abandoned coal mines in the western part of North Dakota in upcoming years.[6]

North Dakota received $5.9 million in Federal royalties for all minerals produced on Federal lands within State borders. The money represented the State's share of bonuses, rents, and royalties collected by the U.S. Department of the Interior's Minerals Management Service. North Dakota also received about $558,000 in Payments in Lieu of Taxes through the U.S. Bureau of Land Management.

FUELS

The North Dakota Lignite Council estimated 1991 lignite coal production in the State to be 26.3 million metric tons (29 million short tons). North Dakota has about 32 billion metric tons (35 billion short tons) of recoverable lignite coal reserves.[7]

Basin Cooperative Services, a subsidiary of Basin Electric Power Cooperative, announced it will phase out mining at the Glenharold Mine by 1993. The coal mine has operated since the 1960's, supplying the Leland Olds Station powerplant. High Federal royalties were cited as a contributing factor to the decision to leave about 4.5 million metric tons (5 million short tons) of coal unmined at the site. Federal royalties amount to about $1.65 per ton while royalty fees on privately held land range from 8 cents to 66 cents per ton.[8]

Coteau Properties' Freedom Mine north of Beulah, Mercer County, mined its 68th million metric ton (75 million short tons) of coal since opening in 1983. The mine is the largest producer in North Dakota history and the 10th largest coal mine in the country.[9]

The North Dakota Petroleum Council reported oil production declined to 35.9 million barrels, down 2% from that of 1990. Natural gas production was 54.8 billion cubic feet.[10] Only 195 wells were completed during 1991, a significant drop from the 1990 figure of 251 wells.[11] Horizontal drilling was used on 48 wells compared with 77 during 1990. Less-than-hoped-for success was cited as the reason for the dramatic decrease in horizontal drilling. One crude oil refinery and 10 natural gas processing plants were operating in North Dakota.

TABLE 2

NORTH DAKOTA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse and fine aggregate: Graded road base or subbase	11	W	W

W Withheld to avoid disclosing company proprietary data.
[1]Includes volcanic cinder and scoria, quantity only.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Four industrial minerals were mined or manufactured in North Dakota in 1991. Construction sand and gravel continued as the leading commodity, both in value and tonnage, accounting for about 70% of the State's total value.

Clays.—Hebron Brick Co. mined clay from three pits in Morton County for processing into brick and tile. D. H. Blanter & Sons mined clay from one pit in McLean County. Reported clay production dropped about 45% to 27.8 thousand metric tons (30.7 thousand short tons) from 50.5 thousand metric tons (55.6 thousand short tons) in 1990. Value also showed a substantial decrease. Most of the decrease was reported from Hebron Brick.

Lime.—American Crystal Sugar Co. operated two plants and Minn-Dak Farmers Cooperative operated one plant to produce quicklime for use in sugar beet refining. Both output and value rose from 1990 figures.

Peat.—No peat production was reported for 1991. In 1990, and previously, production came from a reed-sedge peat from a bog in Bottineau County in the northern part of the State.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1990 and estimates for 1989 and 1991.

In 1991, the production of construction sand and gravel was estimated to be down about 35%, with the total value down about 30% from that of 1990.

Stone (Crushed).—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1990 and actual data for 1989 and 1991. Only "scoria" (clinker, or natural brick) production was reported to the Bureau.

Sulfur (Recovered).—Elemental sulfur was recovered from four natural gas processing plants in Billings, McKenzie, and Williams Counties in western North Dakota. Sulfur also was recovered from the State's only oil refinery, in Morton County. Sulfur recovered amounted to 88,400 metric tons (97,000 short tons) valued at $4.4 million; both output and value increased from that reported in 1990.

Other Industrial Minerals.—VolAsh of North Dakota Inc., producer of volcanic ash near Linton, Emmons County, began shipments to 3M Co. for use in a ceramic material used to contain burning oil spills. The ash was chosen for its buoyancy and fire resistant quality.

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[2]Geologist, North Dakota Geological Survey, Bismarck, ND.
[3]North Dakota State Soil Conservation Committee. Surface Mining Report 1991, 9 pp.
[4]North Dakota Employment and Wages, 1991. Job Service North Dakota.
[5]Annual Report, Energy & Environmental Research Center, University of North Dakota.
[6]Daily Herald, Williston, ND. Fall Target Set for Scenic East Mine Work. Aug. 11, 1991.
[7]Lignite Energy Facts, 1991-1992, Lignite Energy Council, 4 pp.
[8]Beulah Beacon, Beulah, ND. Plans Continuing for Phaseout of Glenharold Mine Operations. Jan. 24, 1991.
[9]News, Underwood, ND. Coteau Mines 75th Million Ton. Sept. 12, 1991.
[10]North Dakota Oil and Gas Industry, Facts & Figures, 1992 Edition, North Dakota Petroleum Council.
[11]North Dakota Geological Survey Newsletter, Summer 1992.

TABLE 3
NORTH DAKOTA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousands) short tons)	Value (thousands)	Unit value
Volcanic cinder and scoria	—	—	—	—	1	11	W	W

W Withheld to avoid disclosing company proprietary data. XX Not applicable.

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
Hebron Brick Co.	Box 5 Hebron, ND 58638	Pit and plant	Morton.
Lime:			
American Crystal Sugar Co.	Box 190 Drayton, ND 58225	Shaft kilns at beet sugar refineries	Pembina and Traill.
Minn-Dak Farmers Co-op	Wahpeton, ND 58075	do.	Richland.
Peat:			
Peat Products Co.	821 4th St. Bismarck, ND 58501	Bog	Bottineau.
Sand and gravel (construction, 1990):			
Aggregate Construction Inc.	Box 1034 Minot, ND 58206	Pit	Ward.
Des Lacs Sand and Gravel Inc.	Box 1254 Des Lacs, ND 58733	Pits	McIntosh and McKinzie.
Fisher Sand and Gravel Co.	Box 1034 Dickinson, ND 58602	Pit and plants	Various.
Gravel Products Inc.	Route 1, Box 5 Minot, ND 58701	Pits	Eddy and Ward.
Schriock Construction Inc.	3009 South Broadway Minot, ND 58701	Pit and plant	Various.
Sulfur (recovered):			
Amerada Hess Corp.	1185 Avenue of the Americas New York, NY 10036	Plant	Williams.
Chevron USA Inc.	Box 1589 Tulsa, OK 74101	do.	Billings.
Koch Hydrocarbon Co.	Box 2256 Wichita, KS 67201	Plants	McKenzie and Williams.
Western Gas Processors Ltd.	10701 Melody Dr. Northglenn, CO 80234	Plant	Billings.

NORTH DAKOTA

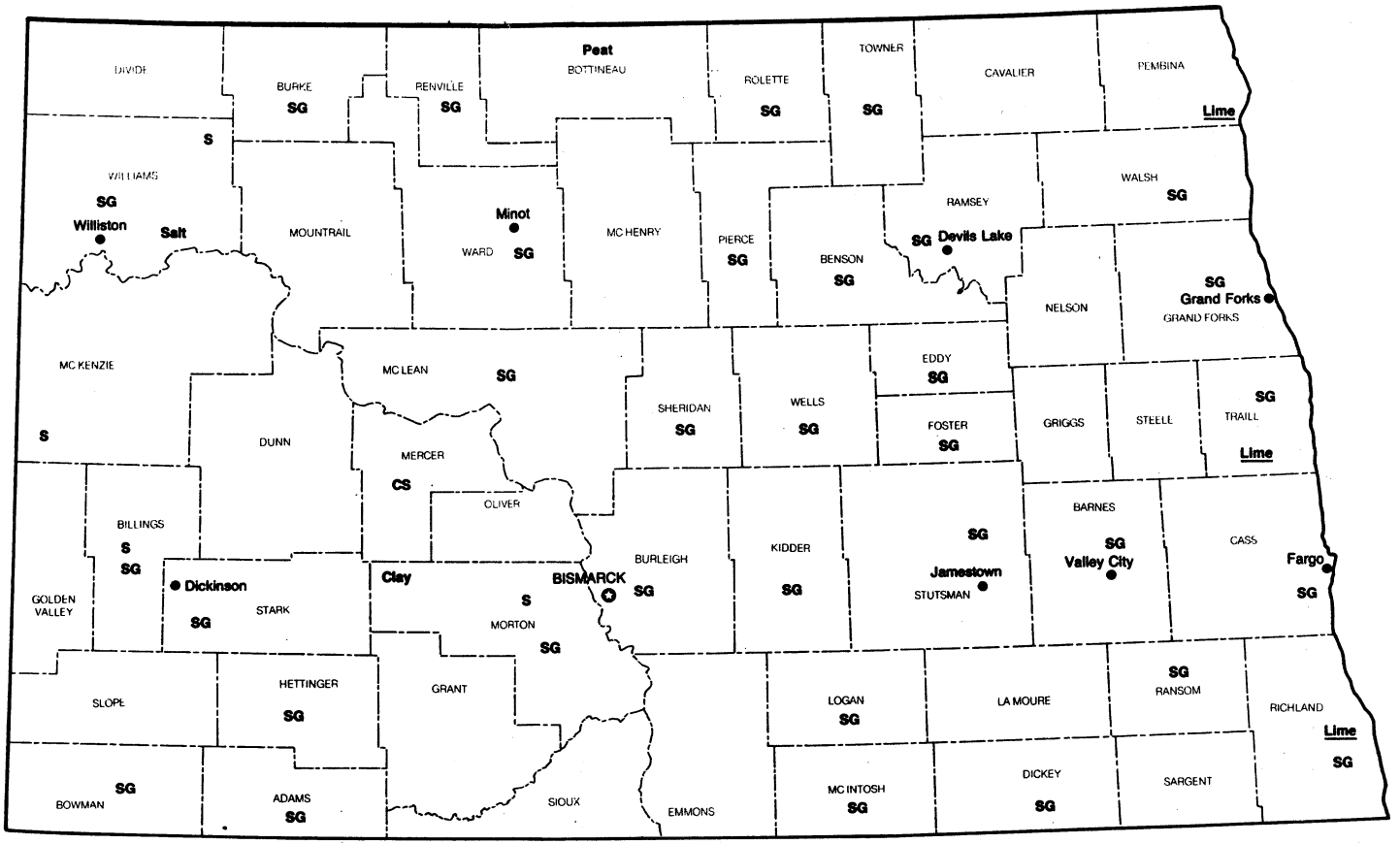
LEGEND

- State boundary
- County boundary
- Capital
- City

MINERAL SYMBOLS

Clay	Clay
CS	Crushed Stone
Lime	Lime plant
Peat	Peat
S	Sulfur
Salt	Salt
SG	Sand and Gravel

Principal Mineral-Producing Localities



THE MINERAL INDUSTRY OF OHIO

By L. J. Prosser, Jr.[1]

The value of nonfuel mineral production in Ohio in 1991 was about $684 million. Value declined by about $45 million as output of most commodities declined for the year. Significant decreases in production, those of more than 25%, were reported for salt and dimension stone. However, declines in the State's leading mineral commodities, including portland cement, lime, sand and gravel, and crushed stone, were only moderate at about 5% or less.

Nationally, Ohio ranked 15th in value of nonfuel mineral production, accounting for about 2.3% of the U.S. total.

EMPLOYMENT

Mining employment continued on a downward trend that began in 1985. In 1991, the mining sector employed 14,300 workers, which was 2,200 fewer jobs than that in 1990. Also declining in 1991 was employment in construction, which dropped from an alltime high of about 200,000 workers in 1990 to about 152,000 employees in 1991.[2]

LEGISLATION AND GOVERNMENT PROGRAMS

Responding to enactment of amendments to the Federal Clean Air Act, the Ohio Legislature passed Senate bill 143. The new State bill was directed toward lowering the cost of using the high-sulfur coal mined in Ohio. The legislation provides a $1-per-ton tax credit for electric utilities that burn Ohio coal, authorizes the Ohio Air Quality Development Authority to issue bonds for clean air facilities such as scrubbers, and requires faster permit processing by the Ohio Environmental Protection Agency for disposal of scrubber sludge.

The Ohio Division of Geological Survey (DGS), Department of Natural Resources, was the primary State agency involved in mineral resource and research investigations. The 1991 DGS Report on Ohio Mineral Industries listed 514 active

TABLE 1
NONFUEL MINERAL PRODUCTION IN OHIO[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Cement:							
Masonry	thousand short tons	128	$11,233	124	$10,880	e109	e$9,591
Portland	do.	1,446	73,230	1,426	72,883	e1,356	e69,156
Clays	metric tons	3,519,668	14,983	2,546,151	13,334	2,204,635	11,015
Gemstones		NA	18	NA	W	NA	57
Lime	thousand short tons	1,888	94,157	1,884	92,817	1,783	85,976
Peat	do.	8	182	12	182	9	222
Sand and gravel:							
Construction	do.	e44,400	e148,700	44,552	165,394	e42,300	e160,100
Industrial	do.	1,394	24,662	1,349	24,205	1,294	23,462
Stone:							
Crushed	do.	46,426	183,190	e48,400	e190,900	[2]47,310	[2]184,177
Dimension	short tons	59,923	3,455	e61,783	e3,468	[2]42,355	[2]2,279
Combined value of abrasives, gypsum (crude), salt, stone [crushed limestone and dolomite (1991), dimension limestone (1991)], and value indicated by symbol W		XX	145,346	XX	154,777	XX	137,550
Total		XX	699,156	XX	728,840	XX	683,585

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain stones; kind and value included with "Combined value" data.

TABLE 2
OHIO: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1990		1991	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Steel, basic oxygen	991,566	$50,927	923,449	$44,678
Other[1]	892,252	41,890	859,850	41,298
Total	1,883,818	92,817	1,783,299	85,976

[1]Includes, agriculture, alkalies, calcium carbide and cyanamide, electric steel, finishing lime, glass, magnesium from seawater or brine, mason's lime, metallurgy, open-hearth steel, other chemical and industrial, other environmental, refractory, sewage treatment, soil stabilization, sugar refining, sulfur removal, and water purification.

industrial mineral operations, an increase of 27 operations from the 1990 total. The number of active coal mines declined, however, from 217 in 1990 to 199 in 1991.[3]

The DGS completed two special publications relating to the historic significance and use of mineral resources in the State. One of the reports details the building stones of Cleveland, including type of rock and source.[4] The other publication provides detailed information on mineral locations for 28 sites, including areas of Findlay Arch and Serpent Mound districts.[5]

The Ohio Coal Development Office (OCDO), established by voter referendum in 1985, continued its program aimed at accelerating the development and commercialization of technologies that can use high-sulfur Ohio coal. Coal production in Ohio has declined from 40.7 million short tons in 1980 to 29.4 million tons in 1991. The factor most responsible for this decline is the comparatively high sulfur content of coal mined in Ohio. Use of low-sulfur coal to comply with amendments to the Clean Air Act of 1990 has and is expected to continue to erode the market for Ohio coal.

In 1991, OCDO reported the completion of three projects: Sulfur Release Dynamics for Fluidized Bed Combustion of Ohio Coals; Agglomerate Column Flotation for Cleaning and Desulfurization of Ohio Coal Fines; and Characterization of the Performance of a Limestone Injection, Dry Scrubbing System.[6] Funding for these projects totaled about $1.3 million, of which OCDO contributed about 50% and private industry and the Federal Government 50%.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Industrial minerals were produced in Ohio at about 409 operations according to data reported to the U.S. Bureau of Mines and listed in table 1. Construction sand and gravel was produced at 219 pits, crushed stone at 110 quarries, clays and shale at 37 pits, dimension stone at 15 quarries, industrial sand at 7 pits, lime at 9 plants, cement at 4 plants, salt at 4 operations, peat at 3 bogs, and gypsum at 1 mine. Output from these operations accounted for the State's value of nonfuel mineral production of $684 million in 1991.

In addition, the following mineral commodities were processed in Ohio: calcined gypsum, iron and steel slag, iron oxide pigments, expanded perlite, sulfur (recovered), talc, and exfoliated vermiculite. The combined value of these commodities as reported to the U.S. Bureau of Mines was about $47 million.

Clays.—Although production declined in 1991, Ohio ranked second in the Nation in output of common clay and shale. In 1991, production was reported from 34 pits in 17 counties. Leading counties, in order of output, were Tuscarawas, Cuyahoga, Paulding, and Marion. About 65% of Ohio's clay production came from district 5 as shown on the principal mineral-producing localities map. The drop in output reflected the decline in demand for brick used in residential and commercial construction.

Ohio's fire clay industry also continued to decline in 1991 as output dropped by about 60% compared with that of 1990. Nationally, fire clay production also dropped significantly by about 25%. Demand for fire clay used as a refractory by the steel industry has fallen because of changing technology in that industry. Despite the decline, Ohio ranked second in the United States in output and combined with Missouri and Alabama to produce nearly four-fifths of the Nation's total.

Lime.—Ohio again ranked second nationally in lime output, accounting for about 10% of U.S. production. Martin Marietta Corp.'s Woodville plant in Sandusky County was again among the top 10 lime-producing plants in the Nation.

Salt.—The sharpest decline reported in production in Ohio in 1991 was for salt. Output dropped because of mild winter weather, which reduced the demand for salt used in highway deicing. Also, one of the State's producers, Morton International Inc., was involved in a labor dispute at its Fairfield Mine in Lake County that began in May and continued through yearend. The State dropped from fourth to fifth nationally in production and was 1 of 14 States producing salt in 1991.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

In 1991, Ohio produced about 42.3 million short tons of construction sand and gravel. Nationally, the State ranked fourth in output, accounting for about 5% of the U.S. total.

TABLE 3
OHIO: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	403	1,479	$3.67
Riprap and jetty stone	1,189	6,055	5.09
Filter stone	287	1,226	4.27
Coarse aggregate, graded:			
Concrete aggregate, coarse	4,218	16,629	3.94
Bituminous aggregate, coarse	2,912	10,993	3.78
Bituminous surface-treatment aggregate	435	2,407	5.53
Railroad ballast	1,608	5,281	3.28
Fine aggregate (-3/8 inch):			
Stone sand, concrete	345	1,217	3.53
Stone sand, bituminous mix or seal	887	3,145	3.55
Screening, undesignated	594	2,112	3.56
Coarse and fine aggregate:			
Graded road base or subbase	12,939	46,014	3.56
Unpaved road surfacing	4,539	19,137	4.22
Crusher run or fill or waste	1,246	4,675	3.75
Other construction materials[2]	572	2,355	4.12
Roofing granules	372	1,545	4.15
Agricultural: Agricultural limestone[3]	1,255	4,881	3.89
Chemical and metallurgical:			
Cement manufacture	2,624	10,943	4.17
Lime manufacture	W	W	5.33
Dead-burned dolomite manufacture	W	W	2.75
Flux stone	979	3,462	3.54
Special:			
Asphalt fillers or extenders	W	W	9.24
Whiting or whiting substitute	W	W	9.89
Other fillers or extenders	W	W	3.44
Other miscellaneous uses[4]	789	2,646	3.35
Unspecified:[5]			
Actual	7,753	31,200	4.02
Estimated	1,361	6,773	4.98
Total[6]	47,310	184,177	3.89

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[1]Includes dolomite, limestone, quartzite, sandstone, and sandstone and quartzite; excludes a minor amount of limestone and dolomite withheld to avoid disclosing company proprietary data.
[2]Includes building products.
[3]Includes poultry grit and mineral food.
[4]Includes withheld amounts for chemical and metallurgical, and special.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.
[6]Data may not add to totals shown because of independent rounding.

Stone (Crushed).—Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Ohio crushed stone statistics are compiled by geographical districts as depicted in the State map. Table 4 presents end-use statistics for Ohio's six districts.

Crushed stone production in Ohio in 1991 dropped slightly, by about 2%, compared with that of 1990. Nationally, output decreased by about 10%. In 1991, Ohio ranked 5th in the United States in crushed stone production, improving from 11th in 1990. The improved ranking was indicative of conditions in Ohio's crushed stone industry during the year.

For the second time in 4 years, one of the State's top crushed stone producers was purchased. In 1988, Beazer PLC of the United Kingdom had purchased Koppers Co., which operated in Ohio as The France Stone Co. In 1991, Hanson PLC, also of the United Kingdom, purchased Beazer. The transaction included six limestone quarries in Ohio. Also during the year, American Aggregate Corp. purchased a limestone quarry in Delaware County from Owens Stone Co. Inc. (Delaware County Materials).

The Rogers Group Inc. invested $4 million in expanding its operations. The expansion included the purchase of Norwalk Sand & Gravel Co. in Huron County and improvements at the loading facilities of its limestone quarry (Sandusky Crushed Stone Co.) at Groton in Erie County.[7]

Other Industrial Minerals.—In addition to the mineral commodities discussed above, Ohio also produced abrasives, masonry and portland cement, gypsum, peat, industrial sand, and dimension stone.

For the year, production of portland and masonry cement declined, continuing a trend that has shown a drop of 22% and 28%, respectively, since 1987. Weak demand and higher operating costs have adversely affected the State's cement industry.

Ohio was 1 of 20 States in which crude gypsum was mined in the United States. The operation was in Ottawa County, and the gypsum was used in wallboard manufacture.

In 1991, three companies in Champaign, Cuyahoga, and Williams Counties, each with one operation, reported peat production. Three other bogs in Ashland, Logan, and Monroe

TABLE 4

OHIO: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[2]	1,014	5,194	461	1,659	166	800
Coarse aggregates, graded[3]	4,191	15,852	3,561	13,619	826	3,273
Fine aggregates (-3/8 inch)[4]	1,064	3,513	W	W	W	W
Coarse and fine aggregates[5]	10,600	38,655	2,671	8,887	1,503	6,490
Other construction materials	87	325	415	1,693	130	518
Agricultural[6]	(7)	(7)	192	454	124	948
Chemical and metallurgical[8]	1,684	4,799	(7)	(7)	(7)	(7)
Special[9]	(7)	(7)	(7)	(7)	(7)	(7)
Other miscellaneous uses	765	2,494	973	4,997	114	819
Unspecified:[10]						
Actual	89	393	293	1,835	1,967	7,199
Estimated	206	877	—	—	—	—
Total[11]	19,700	72,102	8,566	33,144	4,829	20,048

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[2]	73	287	71	387	94	432
Coarse aggregates, graded[3]	391	1,489	104	674	101	404
Fine aggregates (-3/8 inch)[4]	66	262	W	W	W	W
Coarse and fine aggregates[5]	1,855	6,170	992	4,841	1,104	4,783
Other construction materials	436	1,750	501	1,952	70	361
Agricultural[6]	172	810	(7)	(7)	109	534
Chemical and metallurgical[8]	(7)	(7)	(7)	(7)	—	—
Special[9]	(7)	(7)	—	—	—	—
Other miscellaneous uses	274	858	1,241	5,220	—	—
Unspecified:[10]						
Actual	4,712	19,668	—	—	694	2,105
Estimated	295	867	395	2,935	465	2,094
Total[11]	8,273	32,162	3,303	16,009	2,637	10,713

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Excludes limestone/dolomite; withheld to avoid disclosing company proprietary data.
[2]Includes macadam, riprap and jetty stone, and filter stone.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand (concrete), stone sand (bituminous mix or seal) and fine aggregate (screening-undesignated).
[5]Includes graded road base or subbase, unpaved road surfacing, crusher run (select material or fill), roofing granules, and building products.
[6]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[7]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[8]Includes cement manufacture, lime manufacture, dead-burned dolomite, and flux stone.
[9]Includes asphalt fillers or extenders, whiting or whiting substitute, and other fillers or extenders.
[10]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[11]Data may not add to totals shown because of independent rounding.

Counties were inactive in 1991.

Ohio ranked sixth nationally in production of industrial sand. In 1991, six companies operated seven pits, with Geauga County the leading county in output.

In dimension stone, Ohio ranked eighth nationally. Most of the stone was sandstone, which was sold as rough blocks. A small quantity of stone was also produced for use as a grindstone.

Metals

No metals were mined in Ohio in 1991. Information on processed and manufactured metals is presented in this section. In 1991, primary and fabricated metal industries employed about 224,000 workers in Ohio, according to the Ohio Bureau of Employment Services. The 1991 total was about 4,000 less than that reported in 1990. These metal-related industries accounted for about 22% of the

TABLE 5
OHIO: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991[1]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	105	41,197	$166,161	$4.03	95	42,523	$166,791	$3.92
Dolomite	11	5,121	16,747	3.27	10	4,480	16,297	3.64
Sandstone and quartzite	3	108	281	2.60	5	307	1,089	3.55
Total[2]	XX	46,426	183,190	3.95	XX	47,310	184,177	3.89

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Excludes limestone/dolomite; withheld to avoid disclosing company proprietary data.
[2]Data may not add to totals shown because of independent rounding.

State's manufacturing work force.

Aluminum.—Ohio ranked fifth among the 14 States reporting primary aluminum production in 1991. In 1991, output increased by about 10% at the State's only aluminum smelter at Hannibal, Monroe County.

Iron and Steel.—Production of steel fell below the 16-million-short-ton level for the first time since 1986. Output dropped to about 14.2 million tons in 1991, according to the American Iron and Steel Institute. The decline in steel production of about 15% was attributed to a drop in sales in the automotive and appliance industries.

Developments in Ohio's steel industry in 1991 included the completion of a $115 million modernization project in August by Armco Steel Co. L.P. at its Middletown facilities. Work on the new line at Middletown started in 1989 and added 290,000 short tons per year of zinc or zinc-nickel coated steel when operating at peak capacity.

Warren Consolidated Industries Inc. completed installation of a $100 million continuous slab caster. The plant in Warren had a 1.5-million-short-ton capacity and was purchased from LTV Steel Co. Inc. in 1988.

Titanium.—RMI Titanium Co. announced plans in October to close its titanium sponge plant in Ashtabula in late January 1992. Weak demand from the aerospace industry, reduced military spending, and a general slowdown in the economy were among the reasons cited by the company for the shutdown. The plant began operation in 1957 and had a labor force of about 300 workers in 1991. RMI's facilities at Ashtabula had the annual capacity to produced 10,900 short tons of titanium sponge, 140,000 tons of sodium chloride, and 22,700 tons of sodium and sodium hypochlorite.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related and government experience and has covered the mineral activities in Ohio for 6 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]Ohio Labor Market Information. Labor Market Review, Columbus, OH, Jan. 1992, p. 3.

[3]Weisgarber, S. L. 1991 Report on Ohio Mineral Industries. Dep. Nat. Resour., Div. Geol. Surv., 138 pp.

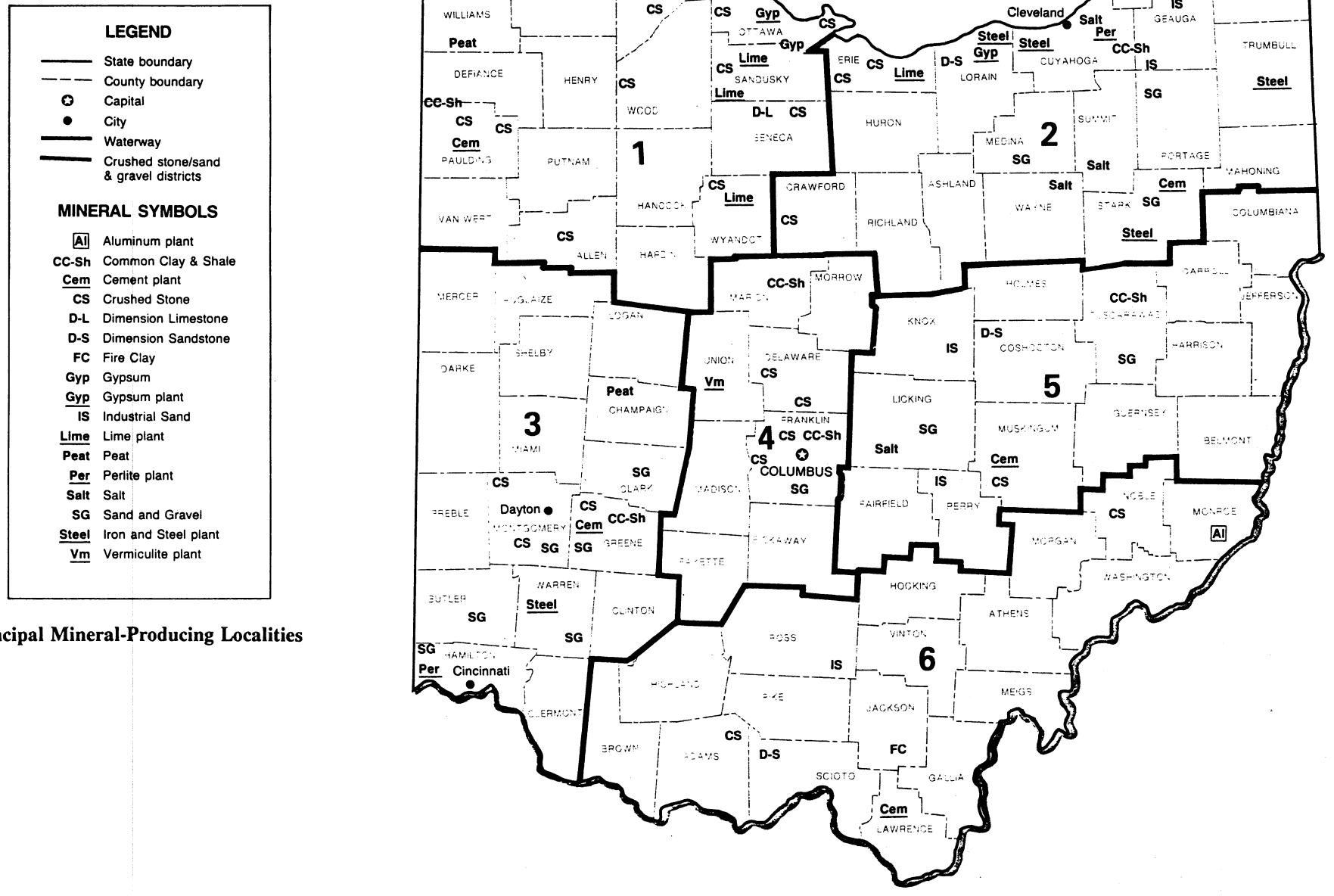
[4]Hannibal, J. T., and M. T., Schmidt. Guide to the Building Stones of Downtown Cleveland: A Walking Tour. Dep. Nat. Resour., Div. of Geol. Surv., Guidebook No. 5, 33 pp.

[5]Carlson, E. H. Minerals of Ohio. Dep. of Nat. Resour., Div. of Geol. Surv., Bull. 69, 155 pp.

[6]Ohio Coal Development Agenda. Ohio Coal Development Office, Ohio Dep. of Dev., Columbus, OH, 1992, 210 pp.

[7]Sandusky (OH) Register. Tax Break Allows Quarry To Expand. July 31, 1991, p. 1.

OHIO



Principal Mineral-Producing Localities

TABLE 6
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Abrasives (natural):			
Cleveland Quarries Co.[1]	Box 261 Amherst, OH 44001	Quarry and plant	Lorain.
Cement:			
Essoroc Materials Inc.[2]	8282 Middlebranch Rd. Middlebranch, OH 44652	Plant	Stark.
Lafarge Corp.[2 3 4]	Box 160 Paulding, OH 45879	do.	Paulding.
Midwest Portland Cement Co.	Box 1531 Zanesville, OH 43702	do.	Muskingum.
Southwestern Portland Cement Co.	Box 191 Fairborn, OH 45324	do.	Greene.
Clays:			
Common:			
Belden Brick Co.	Box 910 Canton, OH 44701	Pits	Tuscarawas.
Glen-Gery Corp.	Box 207 Iberia, OH 43325	Pit	Marion.
Hydraulic Press Brick Co.	Box 31330 Independence, OH 44131	Pit	Cuyahoga.
Kimble Clay & Limestone Co.[5]	Route 1, Box 386 Dover, OH 44622	Pits	Tuscarawas.
Fire:			
Cedar Heights Clay Co.	Box 295 Oak Hill, OH 45656-0295	do.	Jackson.
Waterloo Coal Co. Inc.	Box 626 Jackson, OH 45640	Pit	Do.
Gypsum:			
Crude:			
Celotex Corp.	Box 280 Port Clinton, OH 43452	Pit and plant	Ottawa.
Lime:			
Huron Lime Co.	Box 451, 100 Meeker Huron, OH 44839	Quarry and plant	Erie.
LTV Steel Co. Inc.	Box 298 Grand River, OH 44045	Plant	Lake.
Martin Marietta Corp.	Box 187 Woodville, OH 43469	Quarry and plant	Sandusky.
Ohio Lime Co.	128 East Main St. Woodville, OH 43469	Quarries and plants	Do.
Peat:			
Sphagnum Moss Peat Farm	9797 Thompson Rd., Route 1 West Liberty, OH 43357	Bog	Champaign.
Salt:			
Akzo Salt Inc.	Box 6920 Cleveland, OH 44101	Underground mine, well, and plants	Cuyahoga and Summit.
Morton International Inc.	Box 337 151 South Industrial St. Rittman, OH 44270	Underground mine, wells, and plants	Lake and Wayne.

See footnotes at end of table.

TABLE 6—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Construction:			
American Aggregates Corp.	Box 147515 Dayton, OH 45413	Pits and plant (13 operations)	Butler, Champaign, Clark, Franklin, Greene, Hamilton, Licking, Montgomery, Pickaway, Warren.
Boyd Gravel Co.	24270 Township Rd. Coshocton, OH 43812	Pits	Clark, Coshocton, Fairfield, Knox, Meigs.
Dravo Basic Materials Co. Inc.	5253 Wooster Rd. Cincinnati, OH 45226	Pits and plants	Hamilton and Meigs.
Hilltop Basic Resources Inc.	630 Vine St. Cincinnati, OH 45202	do.	Clark, Greene, Montgomery.
Olen Corp.	4755 South High St. Columbus, OH 43207	Pits	Franklin and Knox.
S&S Aggregates Inc.	Box 1585 Zanesville, OH 43702	Pits and plants	Knox, Portage, Richland, Ross, Summit.
Watson Gravel Inc.	Box 277 2728 Hamilton-Cleves Rd. Ross, OH 45061	Pits	Butler, Hamilton, Warren.
Industrial:			
Fairmont Minerals Ltd. (Best Sand Corp.)	Box 87, 11830 Ravenna Rd. Chardon, OH 44024	Pit	Geauga.
Oglebay Norton Co. (Central Silica Co.)	Box 4477 Zanesville, OH 43702	Pits and mill	Knox and Perry.
Stone:			
Crushed:			
American Aggregates Corp.	Box 147515 Dayton, OH 45413	Quarries and plants	Darke, Delaware, Fayette, Franklin, Montgomery.
Hanson PLC (The France Stone Co.)	Box 278, 8130 Brint Rd. Sylvania, OH 43560	do.	Lucas, Paulding, Seneca, Wood.
National Lime & Stone Co.	Box 120 Findlay, OH 45839	do.	Allen, Auglaize, Crawford, Delaware, Hancock, Marion, Wyandot.
Rogers Group Inc.	Box 527 Sandusky, OH 44870	Quarry	Erie.
Steetley Quarry Products Inc.	128 East Main St. Woodville, OH 43469	Quarries	Sandusky.
Stoneco Inc.	Box 29A, 1345 Ford St., Maumee, OH 43537	Quarries and plants	Lucas, Ottawa, Paulding, Van Wert, Williams, Wood.
Wagner Quarries Co.	4203 Milan Rd. Sandusky, OH 44870	Quarry and plant	Erie.
Dimension:			
Briar Hill Stone Co.	Box 148, State Route 520 Glenmont, OH 44628	Quarries and plant	Coshocton, Holmes, Knox.
Waller Bros. Stone Quarry Co.	134 County Rd. McDermont, OH 45652	Quarry	Scioto.

[1]Also dimension stone.
[2]Also crushed stone.
[3]Also common clay and shale.
[4]Also sand and gravel.
[5]Also fire clay.

THE MINERAL INDUSTRY OF OKLAHOMA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Oklahoma Geological Survey for collecting information on all nonfuel minerals.

By Jeanne E. Zelten[1] and Robert H. Arndt[2]

The value of nonfuel mineral production in Oklahoma in 1991 was $275.5 million, an increase of $15.3 million over that reported to the U.S. Bureau of Mines by the State's mineral producers in 1990 and a new State record. The primary reason for this increase was improved sales of crushed stone and portland cement. The value of the top three commodities produced, crushed stone, portland cement, and iodine, exceeded that reported in 1990 by about $9.6 million. Although the State was one of a limited number of States whose nonfuel mineral value increased during the recessionary period, its mineral industry was obviously impacted by the recession. The growth curve for several minerals produced in the State was minimal, and for several it decreased. Oklahoma continued to rank 35th nationally in total nonfuel mineral value. The State ranked first in the Nation in gypsum production and was the only State producing iodine.

TRENDS AND DEVELOPMENTS

Production of aggregate in the State, hard-hit by the economic recession in 1991, was similar to that throughout the Midwest. Production was expected to increase as much as 5% in 1992 as construction activity begins to rebound. Increased highway construction, resulting from recent State and Federal legislation, could result in increases into the mid-1990's. Proposed highway work and other construction would be expected to increase demand for aggregate and cement. Despite the projected turnaround in the industry, however, companies continued to experience difficulties.

Lone Star Industries Inc. continued reorganization procedures during its first full year of operation under chapter 11 of the Federal Bankruptcy Code and the fifth consecutive year of decreased activity for the construction industry. In the late 1980's, Lone Star was the largest cement producer in the United States in terms of clinker capacity. The company filed for

TABLE 1
NONFUEL MINERAL PRODUCTION IN OKLAHOMA[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	1,236	$39,360	1,544	$60,457	e1,620	e$63,180
Clays	metric tons	565,956	1,619	631,302	3,156	e824,176	e4,178
Gypsum (crude)	thousand short tons	2,523	14,369	2,184	11,154	2,356	12,925
Iodine (crude)	kilograms	1,505,714	23,947	1,972,849	30,486	1,998,914	31,389
Sand and gravel:							
Construction	thousand short tons	e8,500	e20,000	9,235	21,993	e9,000	e22,300
Industrial	do.	1,216	18,310	1,258	22,984	1,241	20,918
Stone:							
Crushed[2]	do.	23,598	81,969	e25,300	e89,500	25,678	95,509
Dimension	short tons	8,290	762	e8,138	e684	[2]3,836	[2]596
Tripoli	metric tons	W	W	18,801	155	15,885	141
Combined value of cement (masonry), feldspar, gemstones, lime, salt (1990-91), stone [crushed dolomite, dimension sandstone (1991)], and values indicated by symbol W		XX	18,695	XX	19,608	XX	24,389
Total		XX	219,031	XX	260,177	XX	275,525

eEstimated. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain stones; kind and value included with "Combined value" figure.

reorganization in December 1990 and announced plans to sell its marginal cement operations, including the portland cement plant at Pryor, in Mayes County. The company also owned two distribution terminals, both of which were listed for sale. One of the terminals was at Oklahoma City, in Oklahoma County, and the other was at Woodward, in Woodward County. At yearend, the Woodward facility was shut down. Lone Star officials stated that a combination of subsidized imports and a downturn in the construction industry were the major reasons for the reorganization and sales.

In January, Eagle-Picher Industries Inc. and seven of its domestic subsidiaries filed for reorganization under chapter 11 of the U.S. Bankruptcy Code in the U.S. Bankruptcy Court for the Southern District of Ohio. The filings resulted from the company's involvement in asbestos-related personal injury litigation related to an insulation product the company made more than 50 years ago. Company officials stated that business operations continued in the ordinary course, that all divisions were not affected by this action, and that the company continued to fulfill its obligations. Operations continued at the company's gallium and germanium recovery plant in Ottawa County.

Surface mining permit applications were approved for a number of new sand, gravel, and limestone quarries throughout the State. Many other companies also received approval for the expansion of existing operations. Three companies received permits for 4- and 5-acre sand and gravel quarries in Choctaw County. One company opened a 40-acre rock and gravel quarry in Pushmataha County. Limestone quarries, 20 and 62 acres in size, were opened in McCurtain and Caddo Counties. Two companies also opened limestone quarries in Sequoyah County. These quarries were permitted for 30 and 50 acres.

Investigation into the use of waste products as fuel in cement kilns increased as companies attempted to decrease their fuel costs, which constituted a major part of operating expenses. Industrial wastes and old tires were among the alternate fuels considered.

EMPLOYMENT

Persons employed in Oklahoma's mining industry in December 1991 numbered 40,700, a 3.3% decrease from the 44,000 employed in December 1990, and the State's lowest level in 15 years. The decline primarily resulted from a decrease in oil and gas employment, down 3.1% from 42,100 in December 1990, to 39,000 in December 1991.[3] In the coal industry, an average of 410 employees worked daily during 1991, with 379 working at surface operations, 31 working in underground mines,[4] and 4 working at mills and preparation plants.[5] In 1990, an additional five miners had been employed in underground coal mines.[6]

In the mineral-dependent construction industry, the annual average number of employees was about 35,300, a decrease of about 2.6% from the 37,900 workers reported in December 1990. This industry ended a 4-month decline by adding 200 jobs in December. Employment in the stone, clay, and glass products sectors decreased by 100 workers from the 9,800 employed in 1990. In the primary metal products sector, employees numbered about 4,600, about 300 fewer than those in 1990.[7]

According to the U.S. Department of Labor, injuries reported from Oklahoma nonfuel surface and underground mines totaled 66 injuries resulting in lost workdays, 24 injuries with no lost workdays, and 1 fatality during more than 3 million hours worked. Nearly 993,000 hours worked at mills and preparation plants resulted in an additional 34 injuries causing lost workdays and 41 injuries with no days lost. In addition, underground coal mine operators reported four injuries resulting in lost work days and one injury with no days lost during more than 50,000 hours worked. Surface coal mine operators reported 25 injuries resulting in lost work days and 27 injuries with no days lost during almost 746,000 hours worked. No injuries were reported during more than 8,000 hours worked at coal plants by an average of four employees.[8]

REGULATORY ISSUES

During an inspection at Sequoyah Fuels Corp., a uranium processing plant in Gore, Sequoyah County, 21,000 pounds of uranium (up to 35,000 times allowable levels) was found in the ground beneath the main processing building and at several other locations within the plant boundary. The inspection was part of an ongoing investigation to determine the extent of contamination, first discovered in August 1990. The company's license expired in September 1990, but because the company had filed for renewal it had been allowed to continue operations while the application was pending. Native Americans for a Cleaner Environment and the Cherokee Nation filed a petition with the Nuclear Regulatory Commission (NRC) to block the license renewal. More problems surfaced in October while the plant was shut down for routine maintenance. The company was prohibited from restarting operations until it submitted an acceptable health, safety, and environmental plan. By December, Sequoyah had made substantial progress in correcting the various problems, but was still lacking in some areas of concern. Because of this progress, the company did not fail the inspection, but rather the inspection remained listed as incomplete. In mid-December, a meeting to present the cases between Sequoyah representatives, the NRC, and the two groups opposing reopening the plant was approved; no date was set, however. At yearend, the company was working toward providing a bond to pay for the cleanup or decommission of the plant, a relatively new NRC requirement.

Sequoyah, owned by San Diego-based General Atomics Inc., was licensed to make uranium hexafluoride from refined ore, a step in producing a reactor fuel, and depleted uranium tetrafluoride, a step in producing solid depleted uranium. Sequoyah was one of four fuel plants on the Federal "watch list" because of various problems and one of only two hexafluoride plants in the country.

At yearend, residents of Latimer and Pittsburg Counties raised concerns over a proposed permit change sought by P&K Mining Co. The company requested that the Oklahoma Department of Mines reclassify 55.5 acres in the Gowen area from pasture land to industrial use and thereby permit the mining company to extract "iron and other unspecified minerals." The citizens were concerned that new mining would create new pollution problems in addition to local stream pollution by acid mine drainage from previous mining.

As a consequence of Alpine Construction Corp.'s failure to reclaim its coal mining operation in eastern Oklahoma to State standards, the Oklahoma Department of Mines filed suit to foreclose the company's bond, a real estate mortgage posted when the company obtained seven permits for mining the coal. The bond, 40 acres of vacant land, was valued at $3.8 million. Cleanup was estimated at $2.5 million.

LEGISLATION AND GOVERNMENT PROGRAMS

A State appellate court decision strengthened the State's ability to enforce reclamation of abandoned mine lands by ruling that an operator cannot be relieved of the obligation to reclaim lands as mandated by statute because of a previous agreement with the landowner not to reclaim the property. Reclamation was a condition of the mining permit, and neither the landowner nor the operator can violate the provisions as stated in the Mining Lands Reclamation Act.

The State received a $643,489 grant from the U.S. Department of the Interior to help pay for reclamation around abandoned coal mines that cover almost 30,000 acres in 16 eastern counties. The grant was to pay for all administrative costs, including equipment, supplies, and transportation, of the State's 1991 Abandoned Mine Lands work.

An abandoned coal mine site in Haskell County was reclaimed to pasture through the Federal Rural Abandoned Mine Program (RAMP). More than 47 acres was reclaimed at a cost of almost $221,000 ($4,700 per acre). Coal mines abandoned before August 3, 1977, qualified for RAMP funding if reclamation bonds had not been forfeited; the State hoped to reclaim about 100,000 acres of abandoned coal mines through this program. Under the Surface Mining Control and Reclamation Act of 1977, the Secretary of Agriculture, through the Soil Conservation Service, was authorized to reclaim eligible rural lands. Funding was provided by Federal taxes on mined coal.

Under the State Mining and Mineral Resources Research Institute Program Act (Public Law 98-409), the U.S. Bureau of Mines awarded a basic allotment grant of $148,000 to the University of Oklahoma. The monies were used to perform basic and applied research related to the State's mineral resources and for the general benefit of the Nation's mineral industry. Under stipulations of the act, the State was required to match this grant on a 2:1 basis.

Arguments presented to the U.S. Supreme Court by the State of Wyoming could end up costing Oklahoma hundreds of mining jobs. The Court was asked to decide whether the Oklahoma Legislature could continue to require coal-fired generators in the State to burn at least 10% Oklahoma-produced coal. Wyoming argued that the 1986 law violated the U.S. Constitution's interstate commerce clause, caused market disruptions and loss of revenues for the State of Wyoming, and discriminated against out-of-State coal producers. The Oklahoma law was passed to boost the State's economy and to reduce dependence on Wyoming coal, especially in the event of a disruption in supply. Prior to the enactment of the 1986 law, Wyoming coal accounted for almost 100% of the fuel consumed in Oklahoma's coal-fired utility plants. A special master appointed by the Court ruled in 1990 that the U.S. Constitution prohibits the Oklahoma Legislature from enhancing the production and sale of Oklahoma coal with regard to privately owned coal-fired generators. The 10% rule was not applicable to the State's three privately owned power companies—Oklahoma Gas and Electric, Public Service Co. of Oklahoma, and Oklahoma and Western Farmers Electric Cooperative. However, the law was ruled valid with regard to the Grand River Dam Authority, a State agency. The case was heard before the Supreme Court in November, and a ruling was expected by early 1992.

The U.S. Bureau of Land Management (BLM) proposed that the royalty rates for federally owned coal in nine Oklahoma counties be reduced. The BLM noted that the rates had been "out-of-line" with the eastern Oklahoma coal market for several years, resulting in Federal coal mined at a loss or bypassed by mining companies.

The Oklahoma Department of Health, the U.S. Environmental Protection Agency (EPA), and the Agency for Toxic Substances and Disease Control began what became known as the "Bartlesville Lead Project" to investigate possible heavy-metal contamination in and around Bartlesville, Washington County. Neighborhood surveys were conducted, and in November, blood samples were taken from children, pregnant women, and other concerned citizens to determine levels of lead and cadmium. Soil samples also were taken throughout a 36-square-mile area to evaluate high access areas such as schools, parks, day care centers, and other public facilities. Emissions from the Zinc Corp. of America smelter, formerly National Zinc Co., were blamed for the suspected contamination. The project, which will continue into 1992, is unique in that it involves Federal, State, and city agencies working together and because it is more comprehensive than previous lead studies, which have focused primarily on paint.

Senate bill 326, signed by the Governor in June, provided for a statewide general public environmental education program, a clearinghouse for environmentally related materials to be made available to the public and to public schools, and created the Joint Interim Task Force on Environmental Regulation. This task force was established to examine the quality and quantity of environmental regulations in the State and make recommendations to the legislature,

specifically with regard to the possible consolidation of environmental regulatory agencies. Nine State agencies, including the Department of Mines, regulate and manage environmental concerns. The 33-member task force, consisting of legislative members, environmental interest groups, industries subject to environmental regulation, professionals, and municipalities, held its first meeting in October. Suggestions considered included creating a new agency to handle most of the State's environmental functions, designating individuals to introduce newcomers to State agencies that regulate the environment, and creating a State siting commission to identify, obtain, and regulate waste disposal sites.

Energy-related legislation enacted during the year addressed petroleum production enhancement, oil and gas pollution, and other miscellaneous oil and gas issues. Much of this legislation could have a profound affect on oil and gas producers and production in the State. House bill 1193 amended the Oklahoma Alternative Fuels Conversion Act and the Alternative Fuels Technician Certification Act, passed in 1990. A variety of measures were included to "encourage and assist public and private entities to convert motor vehicles to alternative fuels, thereby enhancing natural gas production and improving the environment through the burning of cleaner fuels." The income tax credit was increased from 20% to 50% of the cost of the property for vehicles built or converted between December 31, 1990, and January 1, 1993. After December 31, 1993, the credit for private entities will revert back to 20%.

Senate Concurrent Resolution 39 established a 15-member Commission on Natural Gas Policy to examine the policies, regulations, and laws of Oklahoma, other States producing natural gas, and the Federal Government to create new State and national natural gas energy policies. A written report to the Governor and legislature, including recommendations and proposed legislation, was expected by January 31, 1992.

A variety of environmental and natural resources legislation was enacted; these addressed hazardous waste disposal and recycling, surface water and ground water protection, and miscellaneous environmental concerns. Much of this regulation was expected to be significant to cement producers, many of whom were investigating and in the process of converting their kilns to the use of tires and other hazardous wastes as fuel. Senate bill 28 established fees for the disposal and recycling of controlled industrial waste (hazardous or toxic waste). Fees collected in excess of what was needed to operate various State hazardous waste programs would, in part, be used to help pay the State's federally mandated part of the Superfund program. Locations of hazardous waste facilities were regulated, penalties for violations were increased, and a committee was set up to study and present legislative proposals concerning such wastes.

Senate bill 32 deleted the provision from the State's solid waste statutes that exempted fly ash and bottom ash from limitations on disposal in landfills. The bill also required that fly ash and bottom ash generated outside the State "in excess of 200 tons per day be constructively reutilized or disposed of only in a coal mining operation subject to regulation by the Department of Mines." A related bill, Senate bill 250, exempted fly ash, bottom ash, or any other such material produced by coal combustion facilities, from solid waste permitting requirements, provided the ash was reutilized or disposed of in an active or inactive mining operation, subject to regulation by the Department of Mines.

House bill 1340, the Manufacturer Recycling Incentive Act, provided for income tax credits to encourage industries involved in recycling solid waste to locate or expand operations in the State. House bill 1540 increased the rate at which waste tire recycling facilities could be compensated to pick up tires statewide on a periodic basis. For municipalities adjacent to State boundaries, Senate bill 94 allowed out-of-State customers of a solid waste service operated by a political subdivision or public trust to pay State solid waste fees.

A workshop, cosponsored by the U.S. Geological Survey, U.S. Bureau of Mines, Oklahoma Geological Survey, and eight other State Geological Surveys, was held in September in St. Louis, MO. Also in attendance were representatives from EPA, the Federal Highway Administration, land planners, and producers. The workshop focused on the role of industrial minerals in the rebuilding and expanding of the infrastructure of major cities in the midcontinental United States. Topics included resource evaluation, land use planning, the economics of industrial minerals, and environmental issues in resource availability.

Ten sites in the State were on EPA's National Priorities List. Included were landfills, abandoned refineries, the abandoned lead-zinc mining area of Tar Creek in Ottawa County, abandoned salvage yards, and an aircraft maintenance and rebuilding facility. All were in various stages of study and remediation.

Several Oklahoma Geological Survey projects provided information beneficial to mineral producers in the State. The Coal Geology of Tulsa, Wagoner, Creek, and Washington Counties, in northeastern Oklahoma, was the third in a series to evaluate the coal reserves and resources of Oklahoma counties. Project goals included locating and determining the quantity and quality of the coal, as well as studying the stratigraphy of the coal beds and associated strata. Estimated remaining resources of 338 million short tons and reserves of 50.6 million short tons were calculated. Work continued on the Ouachita Cooperative Geologic Mapping Program (COGEOMAP) Project, a joint effort between the U.S. Geological Survey, the Oklahoma Geological Survey, and the Arkansas Geological Commission. New geological maps of the Ouachita Mountains in Oklahoma and Arkansas, prepared under this program, could be used for resource exploration and development, land use planning, and university field trips and future theses.

FUELS

Oil, gas, and coal were produced in Oklahoma in 1991, primarily for use as fuels, adding an important dimension to the State's total mineral production. The State received mineral revenues, distributed to States by the Minerals Management Service and the Bureau of Land Management, for onshore mineral leases on Federal lands, totaling about $1.7 million in 1991. This was a decrease of $101,000 from 1990 distributions of $1.8 million.[9]

Oil and gas continued as a major portion of the Oklahoma mineral value produced. Approximately 10% of the total natural gas production in the United States was supplied by producers in the State.[10] Crude oil production, including condensate, was 107.6 million barrels in 1991, a 5.6% increase from the 101.9 million barrels produced in 1990. Natural gas production, including casinghead gas, totaled 2,065,729,000 thousand cubic feet (mcf) in 1991, a 1.4% increase over the 2,036,902,000 mcf produced in 1990.[11]

Oklahoma ranked second in oil and gas well drilling in the United States again in 1991, with a total of 2,206 completions. This was a decrease of nearly 1% from the 2,227 completions in 1990. Of the total, 917 were oil wells, 631 were gas wells, and 658 were dry holes. New field wildcats accounted for 96 wells, 75 of which were dry holes. On June 28, Exxon Corp. completed the Nation's deepest well for 1991, a 25,565-foot development gas well in Beckham County, in the Mayfield Northeast field.[12]

The Chautauqua Platform, in the northeastern part of the State, lead all provinces in drilling activities. The Ouachita thrust belt, in the southeastern corner of the State, remained an area of high activity, especially in the newly discovered South Panola gas field in Latimer County, within the thrust belt. Another new gas field was discovered, and several gas fields were extended in Latimer and Pittsburg Counties. Drilling for oil and gas occurred in 69 counties. Exploration and field expansions occurred in a number of oil and gas fields in 17 counties.

Drilling was expected to increase in 1992 due to Federal tax incentives. The Clean Air Act Amendments of 1990 mandated the use of alternative fuels for fleet vehicles in 22 urban areas of the country that do not meet air quality requirements. Conversion to compressed natural gas by vehicles in these areas could increase production and create jobs in Oklahoma.

In 1991, a total of almost 1.9 million short tons of bituminous coal was produced by 15 companies from 21 surface mines in 11 counties and from 1 underground mine in Okmulgee County. Continuous mining methods were used in the underground mine. In 1990, coal production totaled more than 1.6 million short tons. Production from surface mines increased more than 14%, from about 1.6 million short tons in 1990 to about 1.8 million short tons in 1991. Underground production of more than 26,000 short tons was a decrease of about 75% from the 1990 production of about 105,000 short tons. Three new surface mines opened in 1991.[13]

The 1990 production was a 22-year low. The trend was attributed to reduced demand for metallurgical coal, the loss of cement markets in Dallas, decreases in coal prices, high transportation costs, increased regulations, lack of financial incentives, lack of available local investment capital, and lower natural gas prices. In 1991, production increased for the first time in more than 10 years. The increase was due to the opening of a co-generation plant by Applied Energy Services Inc., near Shady Point, in Le Flore County.

Most of the coal was used by out-of-State utilities. Major in-State use was by utilities, the cement and lime industries, the paper industry, and process heat for industry. Coal resources occur in 19 counties in eastern Oklahoma, which was underlain by the Western Region of the Interior Coal Province of the United States. The coal was low, medium, and high volatile bituminous, coking and noncoking, contains 0.4% to 6.5% sulfur, and occurs in beds up to 7 feet thick.

Applied Energy Services Inc.'s (AES) new co-generation plant near Shady Point, Le Flore County, went into full production on January 15. The $475 million plant was specifically designed to burn high-sulfur Oklahoma coal, while meeting clean air standards. Wyoming coal will be used if a backup source is needed. Coal and limestone are burned in the combustor, forming gypsum and thereby reducing sulfur dioxide emissions. At various stages of the process, solids and heat are removed and recycled into the system. Combustion occurs in two stages and at relatively low temperatures, controlling nitrous oxide formation and allowing lime to more effectively capture sulfur dioxide from the flue gas. Ash was stored in silos and was expected to be disposed of offsite. AES supplies electricity to Oklahoma Gas and Electric, the State's largest power company.

The AES plant was designed to burn up to 1 million short tons of coal per year, which was expected to increase coal production in the State by at least 50%. Four to six new coal mining companies have started since the AES plant was first opened in the mid-1980's. By the end of 1991, several companies already had filed for mining permits, as well as permit revisions to expand coal mining operations in order to supply the plant demands of 3,000 short tons per day. In addition to coal, the plant also was expected to have an affect on limestone production, a great deal of which was mixed with the coal before use.

A new carbon dioxide plant, designed to produce 200 tons per day of liquified food-grade carbon dioxide, was constructed adjacent to the AES co-generation plant. Byproduct carbon dioxide was removed from flue gas from the co-generation plant boilers. The gas was then purified, liquified, and prepared for shipping to the contractor, Tyson Foods.

Heatherly Mining Co., a subsidiary of P&K Mining Co. Ltd., mined the first significant underground coal in Oklahoma since 1972 from the Pollyanna No. 4 mine in Henryetta, Okmulgee County. Opened in the late 1980's, it was the only

underground mining operation in the State. The company holds a 17-year contract with AES to supply 500,000 short tons of coal annually. In 1986, the year after plans of the AES co-generation plant were revealed, P&K experimented with an underground mine near Dow, in Pittsburg County. After producing only about 7,000 short tons of coal, the mine was abandoned because of a variety of problems. In 1988, P&K began construction of its current underground mine. In addition to the AES contract, P&K sold coal to cement and lime manufacturers. The company also operated surface mines, and another underground mine was planned.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Industrial mineral production in 1991 was affected by changes in the three major areas of construction: residential building, nonresidential building, and nonbuilding construction (including highways). Modest increases in home construction were not enough to offset substantial decreases in commercial, industrial, and highway construction. In 1991, Oklahoma slowly continued to recover economically from the recession. More significant improvements were anticipated for 1992.

Permit-authorized construction in 1991 totaled $871,490,000, a 3.3% decrease from the $901,574,000 in 1990. The number of single- and multi-family residential units 2increased about 3.8%, from 5,054 units in 1990 to 5,248 units in 1991. The value of nonresidential construction decreased about 24.7%, from $245,273,000 in 1990 to $184,587,000 in 1991. Nonbuilding construction, including highways, decreased about 11.9%, from $264,989,000 in 1990 to $233,404,000 in 1991.[14]

Passage in November of the $151 billion Intermodal Surface Transportation Efficiency Act (ISTEA), with its 6-year Federal highway funding provisions, was expected to contribute to increased aggregate production in 1992. Significant improvements to roads and highways were anticipated and could lead to significant increases in aggregate consumption. Cement consumption in the State was expected to increase 5% to 6% in 1992. The anticipated increase was attributed not only to anticipated increases in highway work, but also to an increase in residential building of up to 11%.

Environmental and zoning regulations were cited as the primary reasons for making it increasingly difficult for the construction aggregates industry to expand existing quarries and to develop new quarry operations. As operations must move further from market areas, transportation costs increase, ultimately affecting aggregate prices and competition.

Crushed stone continued as the leading nonfuel mineral commodity, in terms of value, in Oklahoma, followed by portland cement and iodine. The three accounted for 69% of the State's 1991 nonfuel mineral value.

Cement.—Oklahoma ranked 13th nationally in portland cement production and 16th in the production of masonry cement. Cement accounted for almost 23% of Oklahoma's 1991 total nonfuel mineral value. Portland cement sales were estimated at 1.6 million short tons and valued at an estimated $63.2 million. Production and value increased 76,000 short tons and $2.7 million, respectively, over totals reported by the State's cement producers in 1990. Masonry cement production increased 15.4% and value increased 14.6% above the reported 1990 levels.

Blue Circle Inc., in Tulsa, Tulsa County, and Lone Star Industries Inc., in Pryor, Mayes County, produced both portland and masonry cements from dry-process kilns. Holnam Inc.'s Ideal Cement Div., in Ada, Pontotoc County, produced portland cement from wet-process kilns.

Cement plant operators continued to explore the use of waste products as fuel in cement kilns. Faced with consistently low cement prices and a depressed economy, the industry investigated ways to cut fuel costs, which constituted approximately 25% of operating expenses. The high temperatures needed in cement kilns were used to burn waste materials, such as waste fuels, industrial wastes, spent organic solvents, and used tires. The canned wastes and tires were placed directly into the cement kilns along with the other raw materials, and the high temperature completely decomposed the organic material. Because portland cement clinker requires a certain amount of iron, the metal containers and the steel radial belts from the tires are simply incorporated into the clinker. Hazardous wastes have been burned in cement kilns for years, and in 1991, waste fuels accounted for about 6.6% of the energy used for making cement in the United States. It appeared to be an environmentally safe and efficient way to dispose of hazardous waste and other material that has long been a problem, thereby eliminating the need to mine other resources to satisfy fuel requirements.

Holnam Inc., a subsidiary of Holderbank Financiere Glaris, Ltd., a Swiss corporation, applied for a permit to burn hazardous waste fuels in the cement kilns at its cement plant at Ada, Pontotoc County.

Clays.—In 1991, Oklahoma ranked 11th nationally among the 32 States reporting clay production. Nine companies, operating 16 mines in 9 counties, reported production of common clay. An estimated 824,176 metric tons, valued at $4.2 million, exceeded the 1990 levels by 192,874 metric tons and more than $1 million. Production reported from companies in Oklahoma, Pontotoc, and Rogers Counties accounted for approximately 83% of the total. Clay and shale are found abundantly throughout the State and used mainly in the manufacture of portland cement (almost 53%), common brick (39%), concrete block (almost 6%), and structural concrete (almost 2%). Highway resurfacing, stoneware, and pottery manufacture accounted for a smaller portion of the clay usage. The

major production was near Oklahoma City and Tulsa.

Feldspar.—Oklahoma ranked second of seven States producing feldspar in 1991, with reported production and value increasing more than 28% and more than 22%, respectively, from 1990 totals. Arkhola Sand and Gravel Inc., a division of APAC Arkansas Inc., produced a feldspar-silica concentrate that was sold to the glass and ceramics industries. Alumina contained in the feldspar imparts corrosion resistance to the final products. Feldspathic sand was dredged from the Arkansas River near Muskogee, in Muskogee County. The sand was dried, iron impurities were removed by magnetic separation, and the sand was leached with acid to remove other impurities, redried, and bagged for shipment.

Gypsum.—Oklahoma ranked first among the 20 States reporting crude gypsum production and seventh among those reporting production of calcined gypsum in 1991. Crude gypsum production of almost 2.4 million short tons increased almost 8% over that reported by producers in 1990. The gypsum was valued at more than $12.9 million, an almost 16% increase over the 1990 value. Six companies reported crude gypsum production from mines in Blaine, Caddo, Comanche, Custer, Jackson, and Woodward Counties. Calcined gypsum production was reported by three of the companies in Blaine, Comanche, and Jackson Counties.

Gypsum was mined in western Oklahoma, from the Nescatunga and Shimer Gypsum Members of the Permian Blaine Formation and from the Permian Cloud Chief Formation. The mineral was used as plaster for interior walls and wallboard, retarders in cement manufacture, fillers, soil conditioners, and a variety of medical and other uses.

Iodine.—Oklahoma was the only State reporting iodine production in 1991. The State continued to produce about 8% of the world total. Production in 1991, almost 2 million kilograms, exceeded the 1990 production by 26,065 kilograms, or about 1.3%. Iodine value in 1991 was almost $31.4 million ($10.15 per kilogram), exceeding the 1990 value of nearly $30.5 million ($13.80 per kilogram) by about 3%. The decreased unit price reflected wide price fluctuations resulting from overcapacity and very slow growth in demand during the preceding 2 years. More stable prices were expected for 1992.

Three companies, IOCHEM Corp., North American Brine Resources, and Woodward Iodine Corp., in the northwestern part of the State, produced crude iodine from deep oilfield brines, supplying about 62% of domestic demand; the remainder was imported. The three companies operated wells in Dewey, Kingfisher, and Woodward Counties. Production was from the Pennsylvanian Morrow Group.

Major uses of iodine included animal feed supplements, catalysts, radiopaque media, inks and dyes, pharmaceuticals, photographic equipment and recycling processes, sanitary and industrial disinfectants, and stabilizers. Other uses included batteries, high-purity metals, iodized salt, cosmetics, motor fuels, and lubricants.

Lime.—In 1991, Oklahoma ranked 23d among the 32 States reporting lime production. St. Clair Lime Co. reported production from its plant in Marble City, Sequoyah County. The company also operated an underground mine, mining limestone from the Silurian St. Clair Limestone by room-and-pillar methods. The company produced crushed limestone, quicklime, and hydrated lime. Production and value decreased 0.8% and 0.6%, respectively, in 1991.

Growth in the lime and limestone industry was enhanced by the Clean Air Act Amendments and other environmental legislation, which required the installation of stack scrubbers at coal-fired powerplants. Lime and pulverized limestone are used in the scrubbers to remove sulfur oxides from stack gases. As the required scrubbers are installed and plants are brought into compliance with the new regulations, the demand for lime and limestone was expected to increase over the next several years. Other areas of continued growth in usage included water treatment, to achieve proper pH balances, and the treatment of hazardous wastes.

Salt.—Vast resources of salt underlie most of the northwestern part of the State. Salt brine, dissolved from underground deposits by ground water, was pumped to the surface, and salt was recovered through solar evaporation of the brine. Cargill Inc., a major U.S. salt producer, reported production of an evaporative salt from its operation near Freedom, in Woods County. Production was down about 39% from the reported 1990 total. The salt primarily was used for stock feed, water conditioning, agricultural uses, and road de-icing.

Sand and Gravel.—Both construction and industrial sand and gravel were mined in Oklahoma during 1991. Sand and gravel was produced in most counties from deposits found in and near rivers and streams. According to State records, 172 companies reported sand and gravel production in 1991, from mines in 54 of the State's 77 counties.[15]

Construction.—Construction sand and gravel production was surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1990 and estimates for 1989 and 1991. Estimated production decreased 2.5% and value increased 1.4% in 1991. Major uses included concrete aggregate, fill, road base and cover, asphaltic concrete, miscellaneous concrete products, and railroad ballast.

Industrial.—Three companies, Arkhola Sand and Gravel, UNIMIN Corp., and U.S. Silica Co., reported production from five mines in Muskogee, Pontotoc, and Johnston Counties. More than 1.2 million short tons of industrial sand, valued at almost $21 million, was

TABLE 2
OKLAHOMA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Riprap and jetty stone	226	1,008	$4.46
Filter stone	343	1,162	3.39
Coarse aggregate, graded:			
Concrete aggregate, coarse	2,518	10,342	4.11
Bituminous aggregate, coarse	445	1,911	4.29
Bituminous surface-treatment aggregate	384	1,936	5.04
Railroad ballast	789	4,398	5.57
Fine aggregate (-3/8 inch):			
Stone sand, bituminous mix or sea	189	576	3.05
Screening, undesignate	961	2,027	2.11
Coarse and fine aggregate:			
Graded road base or subbase	1,046	3,241	3.10
Unpaved road surfacing	635	1,894	2.98
Crusher run or fill or waste	735	2,184	2.97
Other construction materials	56	221	3.95
Agricultural: Agricultural limestone	134	484	3.61
Chemical and metallurgical:			
Cement manufacture	W	W	2.40
Flux stone	W	W	3.00
Chemical stone	W	W	3.89
Other miscellaneous uses:[2]	889	2,185	2.46
Unspecified:[3]			
Actual	14,617	52,000	3.56
Estimated	1,713	9,942	5.80
Total[4]	25,678	95,509	3.72

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[1]Includes limestone, sandstone, shell, and traprock, excludes a minor amount of granite, withheld to avoid disclosing company proprietary data.
[2]Includes withheld amounts for chemical and metallurgical uses.
[3]Includes production reported without a breakdown by use and estimates for nonrespondents.
[4]Data may not add to totals shown because of independent rounding.

produced. This was an increase of 17,000 short tons (almost 1.4%) over reported 1990 production. The value, however, decreased almost $2.1 million (almost 9%). Most of the industrial sand produced was from Johnston and Pontotoc Counties, in the Arbuckle Mountain region of south-central Oklahoma. The sand was mined by surface methods from the Ordovician Oil Creek and McLish Formations and Quaternary alluvium, and was used in making container and flat glass, in foundries, and for other chemical and industrial uses.

Since 1988, another company, Humble Sand and Gravel Co. of Picher, in Ottawa County, shipped between 3,000 and 6,000 bags of sand to Dammann, Saudi Arabia. In 1991, the demand was not affected by the United Nations-Iraq conflict. The sand was used to coat oil pipelines, providing corrosion protection against sulfuric acid in the oil. A flint abrasive contained in the sand makes it harder and more suitable for coating purposes than the fine-grained desert sand. The plant originally was in Joplin, MO, in the 1960's, then moved to Galena, KS, in the early 1970's to recover chat remaining from lead and zinc mining operations. The chat was washed, screened, dried, crushed, and packaged for shipment.

Stone.—Both crushed and dimension stone were produced in Oklahoma during 1991. Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1990 and actual data for 1989 and 1991. Oklahoma crushed stone statistics are compiled by geographical districts, as depicted on the State map. Tables 2, 3, and 4 present end-use data for this commodity in the five Oklahoma districts.

Crushed.—In 1991, 42 companies reported crushed stone production from 66 quarries in 36 counties. Production of 25,678,000 short tons was valued at more than $95.5 million. Production increased approximately 378,000 short tons (1.5%), and value increased $6 million (6.7%) over estimated 1990 totals. The three leading counties, Johnston, Murray, and Rogers, accounted for 32% of the production. Five companies, Anchor Stone Co., Arkhola Sand and Gravel, Boorhem-Fields Inc., Dolese Bros. Co., and Meridian Aggregates Co., together produced almost 56% of the State total. Stone produced included limestone and dolomite (86.6%), sandstone (6%), granite (4.5%), traprock (1.5%), and shell (1.5%). Chat also was produced.

Limestone is one of the most widely available mineral resources of the State and generally accounts for about 60% of the reported tonnage of nonfuel minerals mined. Crushed limestone and dolomite were produced by 34 companies operating 58 quarries and crushing facilities. Major end uses reported were concrete aggregate, graded road base, screening, railroad ballast, fill, and unpaved road surfacing.

Crushed sandstone production was reported by Amis Materials Co., Big Deal Construction Co. Inc., Heiskill Gravel Inc., Rock Producers Inc., and Stigler Stone Co. Inc. operating quarries in Atoka, Muskogee, Seminole, Le Flore,

TABLE 3

OKLAHOMA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[2]	—	—	225	1,047	56	204
Coarse aggregates, graded[3]	—	—	1,164	5,764	984	3,901
Fine aggregates (-3/8 inch)[4]	—	—	536	1,169	168	498
Coarse and fine aggregates[5]	—	—	1,242	3,789	384	1,285
Other construction materials	—	—	—	—	W	W
Agricultural[6]	—	—	65	224	W	W
Chemical and metallurgical[7]	—	—	—	—	W	W
Other miscellaneous uses	—	—	—	—	99	358
Unspecified:[8]						
Actual	—	—	2,285	6,647	1,981	3,903
Estimated	—	—	14	46	82	758
Total[9]	—	—	5,531	18,686	3,752	10,908

	District 4		District 5	
	Quantity	Value	Quantity	Value
Construction aggregates:				
Coarse aggregates (+1 1/2 inch)[2]	W	W	W	W
Coarse aggregates, graded[3]	1,062	4,760	924	4,161
Fine aggregates (-3/8 inch)[4]	290	503	157	433
Coarse and fine aggregates[5]	317	597	473	1,648
Other construction materials	—	—	W	W
Agricultural[6]	—	—	W	W
Chemical and metallurgical[7]	W	W	—	—
Other miscellaneous uses	1,104	2,868	99	358
Unspecified:[8]				
Actual	6,457	26,186	3,895	15,263
Estimated	1,263	7,759	354	1,379
Total[9]	10,493	42,673	5,901	23,242

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[1]Excludes granite; withheld to avoid disclosing company proprietary data.
[2]Includes riprap and jetty stone and filter stone.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand (bituminous mix or seal) and screening (undesignated).
[5]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run (select material or fill).
[6]Includes agricultural limestone.
[7]Includes cement manufacture, chemical stone for alkali works, and flux stone.
[8]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[9]Data may not add to totals shown because of independent rounding.

and Haskell Counties. End uses included fine screenings, concrete aggregate, fill, bituminous aggregate, riprap and jetty stone, graded road base, and railroad ballast.

Granite was mined and crushed at three quarries in the southern part of the State by Aggregate Materials, in Greer and Kiowa Counties, and by Meridian Aggregates Co., in Johnston County. Traprock was mined and crushed by Western Rock Products Inc., in Murray County. Crushed granite and traprock were used for railroad ballast, concrete aggregate, fill, roadbase and surfacing, fine screenings, bituminous aggregate, filter stone, riprap and jetty stone, and a variety of other uses. Shell was recovered in Pittsburg County by the Pittsburg County Highway Department and used for graded road base and unpaved road surfacing.

Large mounds of chat, fragments of siliceous rock, limestone, and dolomite waste remaining from lead-zinc milling operations, abound in Ottawa County. According to State records, Humble Sand Co. and S. & S. Materials reported total production of 108,678 tons of chat in 1991. Chat was used for railroad ballast, highway construction, and concrete production.[16]

TABLE 4
OKLAHOMA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991[1]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	53	21,511	$69,412	$3.23	57	23,835	$87,682	$3.68
Dolomite	4	W	W	9.70	—	—	—	—
Shell	—	—	—	—	1	5	5	1.00
Granite	2	W	W	3.55	—	—	—	—
Traprock	1	955	5,227	5.47	1	1,025	4,305	4.20
Sandstone	3	585	2,022	3.46	5	813	3,518	4.35
Total[2]	XX	23,598	81,969	3.47	XX	25,678	95,509	3.73

W Withheld to avoid disclosing company proprietary data, included in "Total." XX Not applicable.
[1]Excludes granite; withheld to avoid disclosing company proprietary data.
[2]Data may not add to totals shown because of independent rounding.

Dimension.—Five companies reported production of dimension granite and sandstone in 1991. Production and value declined 4,302 short tons and $88,000, respectively, from 1990 totals. Primary uses were for dimension stone and monument stone. Granite was quarried from the Arbuckle Mountains in Johnston County and from the Wichita Mountains in Greer and Kiowa Counties. Sandstone was quarried in Le Flore County.

Tripoli.—Oklahoma ranked second of four States producing tripoli in 1991. Tripoli is a microcrystalline form of high-purity silica primarily used in abrasive applications. Production of 15,885 metric tons was a decrease of 2,916 metric tons (15.5%) below that of 1990. Value decreased $14,000 (9%) in 1991. The Oklahoma deposits were mined by American Tripoli Inc., from the Mississippian Boone Formation. The company owns six surface mining operations in Ottawa County. Tripoli was used as an abrasive, in buffing and polishing compounds, in concrete, and as a paint filler.

Other Industrial Minerals.—Several other industrial mineral commodities were produced in or imported into the State and processed into higher value products.

Volcanic ash deposits occur in a number of counties in the western and central parts of the State. According to State records, Hope Minerals Co. and Kendon Co., in Okfuskee County, reported total production of 507 tons in 1991. The ash primarily was used for concrete mixtures, abrasives, and insulating compounds.[17]

Rhyolite was mined by Western Rock Products Inc. from a quarry in Murray County. Production was from the Carlton Rhyolite, and the material was used for construction aggregate, railroad ballast, and riprap.

A variety of gemstones, minerals, and fossils were collected by amateur collectors and professionals, both for private collections and for commercial sales. The materials were sold as specimens and formed into a variety of decorative items. Rock and mineral specimens included barite roses, flint, jasper, agate, dolomite pyramids, selenite crystals, quartz crystals, carving-quality alabaster, mica, gem-quality chert, and geodes of barite, claystone, or ironstone, containing crystals of quartz, calcite, barite, aragonite, or sand. Fossils included petrified wood, horn coral, crinoids, oyster shells, ferns, and many others.

Barite was shipped into the Elk City plant of Old Soldiers Minerals Ltd., Beckham County, and the Milpark Drilling Fluids Inc. plant, Ishita County, and ground for use as a weighing agent in oil- and gas-well drilling fluids. Milpark, a partnership of Milchem Inc. and Eisenman Chemical Co., closed its barite grinding plant at Clinton, Custer County, and another plant the company owned in Galveston, TX.

Slag, produced as a byproduct in the steelmaking process at the State's one steel producer, Sheffield Steel Corp., was sold for aggregate applications to International Mill Service Co., in Tulsa County. Dimension stone, primarily marble and granite, was shipped from other States and finished into monuments and miscellaneous shapes for a variety of construction uses. Sulfuric acid was a byproduct of the Zinc Corp. of America smelter at Bartlesville, in Washington County. Crude vermiculite was shipped from mines in South Carolina and used in concrete aggregate and soil conditioners.

Metals

A variety of metals were produced or refined in the State. As with industrial commodities, the sluggish economy weakened major markets, resulting in lower sales volumes.

Cadmium and Zinc.—Zinc Corp. of America was one of four companies in the country that recovered cadmium from lead and zinc smelters. Cadmium was precipitated from leached zinc electrolyte at the company's 60,000-metric-ton-per-year slab zinc smelter in Bartlesville, Washington County. The cadmium was filtered, briquetted, and processed to produce a commercial-grade cadmium

ball anode. Primary uses included a variety of industrial applications, including photodetectors and transparent conductors, and cadmium batteries.

Gallium and Germanium.—The Specialty Materials Div. of Eagle-Picher Industries Inc., with an office in Quapaw, Ottawa County, was involved in gallium, germanium, and environmental products. The company also reprocessed scrap.

Gallium was recovered and refined from primary and secondary source materials. Most of the gallium was used to make gallium arsenide, a material used in light-emitting diodes and high-speed integrated circuits.

Primary germanium was recovered from zinc smelter residues. The plant, with a 30,000-kilogram-per-year germanium capacity, produced germanium tetrachloride and germanium dioxide, along with polycrystalline and single-crystal germanium metal. Germanium is a strategic and critical material, used in infrared systems, fiber optics, radiation detectors, semiconductors, and other applications.

Steel.—Sheffield Steel Corp. operated a two-furnace, 400,000-short-ton-capacity minimill in Sand Springs, Tulsa County. The plant produced reinforcing bar and fence posts from scrap.

Uranium.—Uranium oxide, extracted during phosphoric acid manufacture in Florida, was shipped to Sequoyah Fuels Corp. for processing. Sequoyah, owned by San Diego-based General Atomics Inc., operated a uranium processing plant at Gore, Sequoyah County. Uranium hexafluoride, used in producing reactor fuel, was produced from refined ore. The company also produced uranium tetrafluoride, used in the production of solid depleted uranium.

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[1]State Mineral Officer, U.S. Bureau of Mines, Denver, CO. She has 14 years of mineral-related industry and government experience. Assistance in the preparation of the chapter was given by Pat LaTour, editorial assistant.

[2]Geologist IV, Oklahoma Geological Survey, Norman, OK.

[3]Labor Market Information Newsletter-Job Service of Oklahoma. V. 2, Issue 1, Jan. 1992.

[4]Energy Information Administration. Coal Production 1991. Oct. 1992.

[5]U.S. Department of Labor, Mine Safety and Health Administration. Mine Injuries and Worktime, Quarterly. Jan. to Dec. 1991.

[6]Work cited in footnote 4.

[7]Work cited in footnote 3.

[8]Work cited in footnote 5.

[9]Minerals Management Service. Mineral Revenues 1991.

[10]Oklahoma Business Bulletin. V. 59, Issue 6, June 1991.

[11]———. V. 60, Issue 3, Mar. 1992.

[12]Petroleum Information Corp. Resume 91.

[13]Work cited in footnote 4.

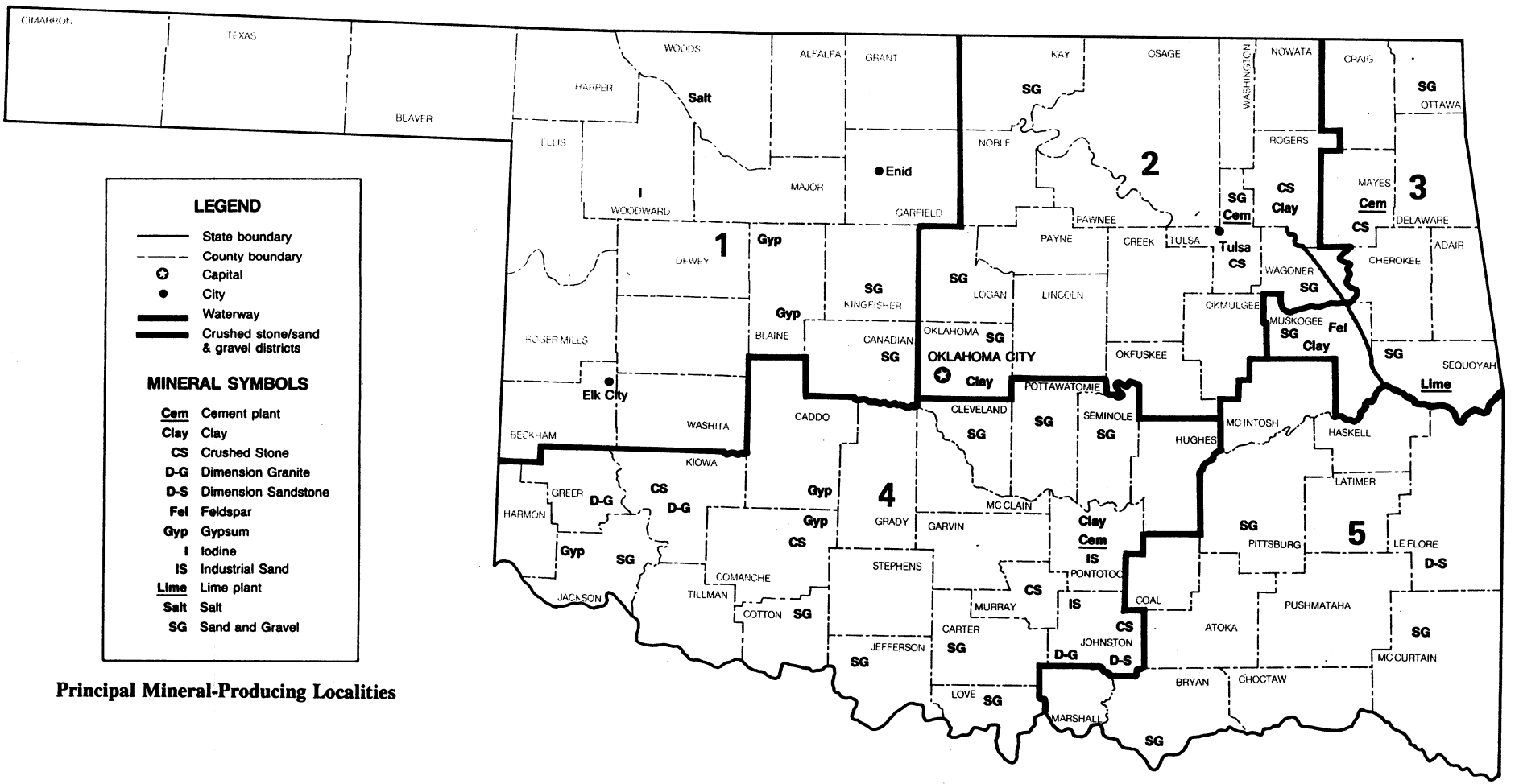
[14]Work cited in footnote 11.

[15]Oklahoma Mining Commission, Department of Mines. 81st report, for calendar year 1991.

[16]Work cited in footnote 15.

[17]Work cited in footnote 15.

OKLAHOMA



LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-G	Dimension Granite
D-S	Dimension Sandstone
Fel	Feldspar
Gyp	Gypsum
I	Iodine
IS	Industrial Sand
Lime	Lime plant
Salt	Salt
SG	Sand and Gravel

Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Barite:			
Milpark Drilling Fluids	5500 N. Western, Suite 225 Oklahoma City, OK 73118	Quarry and plant	Washita.
Old Soldiers Minerals Ltd.	Box 1607 Elk City, OK 73648	do.	Beckham.
Cement:			
Blue Circle Inc., a division of Blue Circle Industries Ltd.[1]	2609 N. 145th E. Ave Tulsa, OK 74116	do.	Rogers and Tulsa.
Holnam Inc., Ideal Cement Div., a subsidiary of Holderbank Financiere Glaris, Ltd.[2]	Box 190 Ada, OK 74820	do.	Pontotoc.
Lone Star Industries Inc.[3]	Box 68 Pryor, OK 74362	do.	Mayes, Oklahoma, Woodward.
Clays:			
Acme Brick Co., a division of Justin Industries Inc.	Box 14566 Oklahoma City, OK 73113	Pits and plants	Oklahoma.
Chandler Materials Co., Choctaw Div.	5805 East 15th St. Tulsa, OK 74112	do.	Oklahoma, Rogers, Tulsa.
Commercial Brick Corp.	Box 1382 Wewoka, OK 74801	Pit and plant	Seminole.
Frankoma Pottery Inc.	Box 789 Sapulpa, OK 74066	do.	Creek.
Magnum Brick Co. Inc.	Box 296 Magnum, OK 73554	Pits	Greer.
Washington County	5th and Johnstone Bartlesville, OK 74003	Pit	Washington.
Feldspar:			
Arkhola Sand and Gravel Co., a division of APAC Arkansas Inc., a subsidiary of Ashland Oil Co.[4]	Box 1401 Muskogee, OK 74402	Dredge and plant	Muskogee.
Gallium and germanium:			
Eagle-Picher Industries Inc., Specialty Materials Div.	Box 737 Quapaw, OK 74363	Refinery	Ottawa.
Gypsum:			
Harrison Gypsum Co. Inc.	Box 336 Lindsay, OK 73052	Quarry and plant	Caddo.
Heartland Cement Co., Div. of R.C. Cement Co.	Box 407 Watonga, OK 73772	do.	Blaine.
Republic Gypsum Co.	Drawer C Duke, OK 73532	Quarries and plant	Jackson.
Temple-Inland Forest Products Corp.	Box 101 Fletcher, OK 73541	Quarry and plant	Comanche.
United States Gypsum Co., a subsidiary of USG Corp.	Box 100 Southard, OK 73770	do.	Blaine.
Western Plaine Material	Box 979 Weatherford, OK 73096	Quarries	Blaine, Custer, Woodward.
Iodine:			
IOCHEM Corp.	6520 N. Western Ave. Suite 200 Oklahoma City, OK 73116	Oilfield brines and plant	Dewey and Woodward.
North American Brine Resources	5600 N. May, suite 200 Oklahoma City, OK 73112	do.	Kingfisher and Woodward.
Woodward Iodine Corp., a subsidiary of Asahi Glass Co. Ltd. and Ise Chemical Co.	Box 1245 Woodward, OK 73802	do.	Woodward.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Lime:			
St. Clair Lime Co.	Box 894 Oklahoma City, OK 73101	Underground mine and plant	Sequoyah.
Salt:			
Cargill Inc., Salt Div.	Box 167 Freedom, OK 73842	Solar evaporation	Woods.
Sand and gravel:			
Construction:			
Anchor Stone Co.	8835 South St. Louis Tulsa, OK 74133	Dredge, pit, plant	Tulsa.
Boorhem-Fields Inc.[5]	Box 206 Hugo, OK 74743	Quarries and plant	Bryan.
The Dolese Brothers[6]	Box 677 Oklahoma City, OK 73101	Dredge, pits plants	Canadian, Kingfisher, Logan, Oklahoma.
Gainesville Sand & Gravel Co.	518 E. Scott Gainesville, OK 76240	Pit and plant	Love.
Lemon Haskell Construction Co. of General Materials Co. Inc.	Box 75608 Oklahoma City, OK 73147	Pits and plant	Cleveland.
The Quapaw Co.[7]	Route 2, Box 1205 Cushing, OK 74023	Quarry	Creek.
Industrial:			
UNIMIN Corp.[8]	Box 159 Roff, OK 74865	Pit and plant	Pontotoc.
U.S. Silica Co.	Box 36, Hwy. 7 North Mill Creek, OK 74856	Pits and plant	Johnston.
Stone:			
Crushed:			
Aggregate Materials	Route 1, Box 220B Snyder, OK 73566	Quarry and plant	Greer and Kiowa.
Amis Materials Co.	Box 417 Atoka, OK 74525	Quarry	Atoka.
Anchor Stone Co. & Tulsa Rock Co., subsidiaries of Anchor Industries Inc.	66th St. N. & 145th E. Ave. Owassa, OK 74055	do.	Rogers and Tulsa.
Big Deal Construction Inc.	Box 302 Warner, OK 74469	do.	Muskogee.
Heiskill Gravel Inc.	Box 637 Okemak, OK 74859	do.	Okfuskee.
Humble Sand Co.	Box 217 Picher, OK 74360	Open pit and plant	Ottawa.
Meridian Aggregates Co., a subsidiary of Burlington Northern Railroad	Hwy. 1, Box 86 Mill Creek, OK 74856	Quarry	Johnston.
Pittsburg County	Box 268 Haileyville, OK 74546	Plant	Pittsburg.
Pryor Stone Inc.	Box 969 Pryor, OK 74362	Quarry	Mayes.
Rock Producers Inc.	Box 126 Spiro, OK 74959	do.	Le Flore.
S & S Sand	Box 338 Vian, OK 74962	Plant	Sequoyah.
Stigler Stone Co. Inc.	Route 3, Box 90 Stigler, OK 74462	Quarry	Haskell.

See footnotes at end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone—Continued:			
Dimension:			
Bodie L. Anderson Quarries Inc.	Box 106 Mill Creek, OK 74856	Quarry	Johnston.
Miller Stone Co.	Route 1 Hackett, AR 72937	do.	Le Flore.
Texas Granite Corp.	202 South 3d Ave. Cold Spring, OK 56320	Quarries	Greer and Kiowa.
Willis-Oklahoma Red Granite Inc.	900 Quarry Dr., Box 867 Granite, OK 73547	do.	Greer.
Tripoli:			
American Tripoli Co.	222 Oneida, Box 489 Seneca, MO 64865	Open pits	Ottawa.
Volcanic materials:			
Axtell Mining Corp.	Box 92 Gate, OK 73844	Open pit	Beaver.
Kendon Co.	Route 2, Box 122A Wetumka, OK 74883	do.	Okfuskee.
Western Rock Products Inc.[9]	Box 599 Davis, OK 73030	do.	Dewey and Murray.
Zinc:			
Zinc Corp. of America, a division of Horsehead Industries Inc.[10]	Box 579 Bartlesville, OK 74005	Electrolytic refinery	Washington.

[1]Also clay and crushed stone in Rogers County.
[2]Also clay and crushed stone in Pontotoc County.
[3]Also clay and crushed stone in Mayes County.
[4]Also industrial sand in Muskogee County and crushed stone in Cherokee, Kay, and Tulsa Counties.
[5]Also crushed stone in Choctaw, Johnston, Marshall, and McCurtain Counties.
[6]Also crushed stone in Atoka, Caddo, Carter, Coal, Comanche, Kiowa, Murray, Pittsburg, and Seminole Counties.
[7]Also crushed stone in Creek and Pawnee Counties.
[8]Also crushed stone in Pontotoc County.
[9]Also crushed stone in Murray County.
[10]Also sulfuric acid; copper, lead, and silver residues; and cadmium balls.

THE MINERAL INDUSTRY OF OREGON

By Rodney J. Minarik[1]

Nonfuel mineral production value in Oregon in 1991 was $197.9 million, a decrease of more than 3% from that of 1990, according to the U.S. Bureau of Mines. The bulk of the decrease was a result of a drop in the estimated value for cement production. The value of Oregon's nickel production was not included in the totals. Industrial minerals accounted for most of the State's total nonfuel mineral production value. The State ranked 38th in the Nation in that value. Oregon was the Nation's sole producer of emery and nickel. The State ranked first nationally in the quantity of pumice produced, third in the production of diatomite, and was a significant producer of processed natural zeolite.

Based on the 1991 Cominco Ltd. annual report, the Glenbrook Nickel Co. produced nickel worth an estimated $32.8 million in 1990 and $57.6 million in 1991. Including the estimated nickel value, Oregon's total nonfuel mineral production value rose to $256 million in 1991 from $237 million in 1990, an increase of almost 8%.

TRENDS AND DEVELOPMENTS

Construction materials—portland cement, construction sand and gravel, and crushed stone—continued to be the most valuable minerals produced, accounting for the bulk of the State's total mineral production. Nickel had the largest increase in both absolute value and percentage gain of all Oregon minerals, a result of expanding production at Glenbrook Nickel's recently reactivated mine and plant near Riddle, Douglas County. With the opening of Formosa Exploration Inc.'s Silver Peak Mine, copper and zinc production values are again being reported for Oregon.

EMPLOYMENT

According to the Oregon Employment Division, Department of Human Resources, the State's 1991 mining and quarrying employment was 1,500 workers, a decrease from the 1,600 workers reported for 1990. Reflecting the weakness of the State's aluminum reduction industry, employment in the nonferrous metals segment of Oregon's primary metals industry decreased to 5,300 workers from 5,500 in 1990. Blast furnace and iron and steel foundry employment rose to 6,000 in 1991, an increase of 300 over that of 1990. Weekly wages for primary metals industry workers averaged $533.18 for a 41.3-hour workweek.

TABLE 1
NONFUEL MINERAL PRODUCTION IN OREGON[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	W	W	W	W	e249	e$18,675
Clays	metric tons	210,893	$875	223,452	$1,390	213,356	1,086
Gemstones		NA	1,304	NA	1,683	NA	2,758
Nickel ore[2]	metric tons	NA	NA	330	NA	5,523	NA
Sand and gravel (construction)	thousand short tons	e14,400	e49,700	15,785	60,928	e15,600	e62,800
Stone (crushed)[3]	do.	18,407	81,204	e18,000	e86,600	20,608	89,322
Talc and pyrophyllite	metric tons	204	18	105	10	63	67
Zinc[4]	do.	—	—	—	—	751	873
Combined value of cement [masonry (1989-90)], copper (1991), diatomite, emery, gold (1989-90), lime, pumice, silver (1989-90), stone [crushed dolomite and quartzite (1989-90), crushed slate (1991)], value indicated by symbol W		XX	49,965	XX	r53,984	XX	22,347
Total		XX	183,066	XX	204,595	XX	197,928

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Data series revised to exclude non-nickel ore.
[3]Excludes certain stones; kind and value included with "Combined value" data.
[4]Recoverable content of ores, etc.

REGULATORY ISSUES

The Oregon Legislature enacted House bill 2244, referred to as the chemical process mining or cyanide heap-leaching bill; it does not apply to those using flotation milling. The measure overhauled the State's mining regulations by proposing a number of administrative changes, including a lengthy permit process and backfilling in special cases. The bill specified that the Oregon Department of Geology and Mineral Industries (DOGAMI) would have the lead coordination role in rewriting the rules and that multiple permits from several State agencies will remain necessary. DOGAMI finished its rulemaking with provisions agreed to by a coalition of industry, environmental, and government representatives. However, draft rules proposed by the Department of Environmental Quality were considered too restrictive by industry, and debate continued.

An estimated 100,000 cubic yards of mildly radioactive lime waste was trucked about 250 miles from the Millersburg plant of Teledyne Wah Chang Albany Corp. (TWCA) to a specially built disposal cell at the Finley Buttes landfill near Boardman. The shipment marked the end of a 16-year debate over disposal of the sludge, tainted with radioactive elements originally present in the sand from which TWCA extracted zirconium and other metals. Formal approval for the disposal plan was given by the Environmental Protection Agency during the summer.

EXPLORATION ACTIVITIES

According to DOGAMI, the mood of exploration in 1991, especially for metals, could best be described as somber. Several companies reduced staff and closed offices; a number terminated projects completely. Terminated projects exceeded those initiated by a rate of about 2 to 1. A number of companies left Oregon altogether, some citing an uncertain regulatory future in the State, others, low gold prices. Of those exploration companies remaining, the commodity of choice continued to be gold.

Atlas Precious Metals Inc. continued development of its Grassy Mountain gold property. The proposed open pit site is about 25 miles south of Vale near the Owyhee Reservoir in Malheur County. Work progressed on permitting, and the company developed a water supply. The operating plan includes the construction of an underground mine with a flotation mill and two open pits using heap-leach cyanidation. Mine life was projected to be at least 8 years. Silver also will be recovered as part of the gold-extraction process.

Also in Malheur County, Atlas drilled the Katey claims and did assessment work at Harper Basin. Both Atlas and Echo Bay Exploration Inc. explored in the Tub Mountain area. Atlas held on to its properties, but Echo Bay's prospects reverted back to Malheur Mining Co., which also maintained its Kerby-East Ridge prospect near Farewell Bend.

Chevron Resources Co. terminated its U.S. metals exploration efforts. As a result, the Hope Butte gold project in northern Malheur County reverted back to Horizon Gold Shares Inc., and MK Gold, which held a 40% interest in the Jessie Page (Quartz Mountain) project, obtained the balance. Cyprus Minerals Co. acquired the rest of Chevron Resources' property interests in Oregon, including the Mahogany property, leased from Manville Corp., in the Mahogany Mountains.

In the Stockade area, Phelps Dodge Mining Co. drilled and sampled near Crowley, then terminated the project, and BHP-Utah International returned its property on Stockade Mountain to Carlin Gold Co. BHP-Utah initiated a drilling program at its Quartz Mountain Basin project in the Dry Creek Buttes area. ASARCO Incorporated and Manville did geophysical work in the areas of Dry Creek Buttes and the South Owyhee Ridge. Using geophysics and geochemistry, Western Epithermal identified drill targets at Shell Rock Butte. Near Malheur City, Ican Minerals Ltd. conducted an end-of-year drilling program on its Racey Gold property. Billiton Exploration Inc., which had earlier funded a drilling program, dropped out of the agreement.

Notable properties dropped in Malheur County included Cow Valley Butte by Cambior USA Inc., Atlas drilled then dropped Vale Butte, American Copper and Nickel dropped BCMX, and Phelps Dodge terminated its Mahogany Gap and Storm projects. Noranda Exploration Inc. and Sunshine Precious Metals Co. pulled out of the Burnt Mountain area; Sunshine had drilled two holes on its Lucky G claims. Echo Bay dropped Lucky Lady, discouraged by its proximity to the Owyhee Dam. Western Mining Corp. drilled then intended to drop its Freeze property.

In Baker County, Manville did geophysical work on its Record-Grouse Creek prospects southeast of Unity, Golconda Resources Inc. drilled and reopened some old tunnels at its Gold Hill and Gold Ridge Mines, Nerco Exploration Co. explored its property at Cave Creek, and Placer Dome Inc. drilled Pole Creek. Kennecott Exploration Co. explored two properties near the White Swan Mine, kept Gold Powder, but dropped the Virtue project. Also dropped in Baker County was the Bourne project in the Cracker Creek Mining District near Sumpter by Simplot Resources Inc. when it dissolved its precious-metals section.

In Grant County, Formation Capital Corp. mapped and sampled its Mammoth property. Mammoth, which includes the former Statler, Pioneer, Golden West, and Wray Mine properties, has both gold-copper and gold-silver targets. Cradle Mountain Resources and American Copper and Nickel dropped the Susanville prospect. The joint venture of Teck Resources Inc. and Carlin Gold did exploration drilling on Buck Mountain in Harney County. Also in Harney County, Noranda drilled its Flag property. In Jefferson County, Bond Gold Exploration Co. drilled then reclaimed its Red Jacket prospect.

In Lake County, Wavecrest Resources Inc., a subsidiary of Quartz Mountain Gold Corp., continued exploration and

drilling at its Quartz Mountain gold prospect, 33 miles west of Lakeview. The property contains the Crone Hill and Quartz Butte deposits and associated underground feeder veins. Work was done under the direction of Pegasus Gold Inc., which according to DOGAMI, committed to another year but noted anxiety about the low grade and refractory nature of the deposit. The heap-leach project would initially concentrate on an oxide ore zone, followed by possible development of a large disseminated sulfide resource.

In western Oregon, Plexus Resources Corp. completed a feasibility study and drilling program on its Bornite copper-gold-silver project. The company was seeking permission from the U.S. Forest Service to develop an underground mine about 50 miles east of Salem, in the North Santiam Mining District, Marion County. From its project office in Mill City, the company continued the permitting process, including the development of an environmental impact statement (EIS).

In Linn County, Placer Dome drilled the new Quartzville project, an epithermal gold property. Oregon Resources Corp. continued to define the extent of the resource and identify possible markets for onshore black sands in the Seven Devils area of western Coos County.

In Josephine County, Cominco American Resources Inc. continued to explore Savanna Resources Ltd.'s Turner Albright copper-zinc-gold property, near O'Brien. Cominco American can earn a 50% interest by completing an exploration and development program. At the Martha Mine in the Greenback district, Cambior drilled then returned the property to Dragon's Gold.

LEGISLATION AND GOVERNMENT PROGRAMS

Significant developments in several areas were achieved at the U.S. Bureau of Mines Albany Research Center (ALRC). As examples, honeycomb structures are used in highly stressed fabrications without adding a significant amount of weight. However, strength and fatigue at the joints and edges are a problem. A one-piece honeycomb casting of aluminum was produced that offers designers the opportunity of producing higher strength fabrications without the penalty of added weight. The casting was designed on a computer to address highly stressed areas requiring both optimum strength and fatigue resistance. The final design was recreated in a polystyrene pattern and cast with aluminum alloy 356.

ALRC, with metallurgists, ceramists, and chemists from private industry, worked to develop an improved ceramic refiner plate for the pulp and paper industry. The cooperative effort was the result of an "Oregon Metals Initiative" project. Refiner plates are used to mechanically shred wood fibers in the paper manufacturing process. Normally, a chromium-iron alloy is used that has a useful life of about 2 months. A ceramic plate was constructed by the group and tested. After 1 month of continuous service, the plate showed no signs of wear.

ALRC assisted in the replacement of the roof on Thomas Jefferson's Monticello monument. Acid rain had deteriorated the existing tin roof to the extent that it was no longer serviceable. Help was given to the Thomas Jefferson Memorial Foundation in its goal of replicating the tin roof with tin-plated stainless steel shingles, thus maintaining architectural authenticity. The 25,000 shingles have an estimated life of 80 years.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Estimated cement production in Oregon dropped in both tonnage and value from that of 1990. Ash Grove Cement West Inc., the State's sole cement producer, operated a cement plant and limestone quarry near Durkee, Baker County. The plant, the first dry-process cement plant in the Pacific Northwest equipped with a preheater kiln, is considered state of the art.

Almost all of the cement output was general use and moderate heat Types I and II gray portland cement; a small quantity of masonry cement also was produced. The bulk of the portland cement produced in the State was used by ready-mixed companies; other users included building materials dealers, concrete product manufacturers, government agencies, and highway and other contractors. The Durkee plant was fueled almost exclusively by natural gas. The cement rock (limestone) used in the manufacture of the cement was mined from a nearby pit. Virtually all of the production from the Durkee operation leaves the plant in bulk by truck or rail.

Clays.—Total clay production in Oregon decreased almost 5% in quantity and 22% in value from that of 1990. Two types of clay were produced in Oregon—bentonite and common clay.

Bentonite production decreased almost 23% in quantity and 26% in value from that of 1990. According to the U.S. Bureau of Mine's survey, three companies in two counties accounted for Oregon's bentonite production. Central Oregon Bentonite Co. and Evergreen Bentonite Inc. ranked first and second, respectively, in the State in quantity produced. They produced bentonite from adjoining properties on Camp Creek, 40 miles southeast of Prineville, Crook County. Teague Mineral Products Co., south of Adrian, Malheur County, was the State's third largest producer of bentonite clay. Teague's premium-grade sodium bentonite was mined in northern Malheur County. The material was sold for soil sealant at waste disposal sites, ditches, and ponds, for drilling mud, and as sealant for abandoned drill holes.

Common clay, used chiefly in bricks, cement, and ceramic tile, was mined by three companies in Baker, Jackson, Klamath, Lane, and Multnomah Counties. Ash Grove Cement was the State's leading producer.

Diatomite.—Diatomite production in Oregon rose more than 9% in quantity and almost 13% in value from that of 1990; the State again ranked fourth nationally for diatomite production value. Eagle-Picher Industries Inc. mined diatomite from Miocene lake sediments at a surface operation in the Juntura Basin, along the Malheur-Harney County line. The diatomite was trucked 70 miles to the company's Celatom diatomite processing facility west of Vale, Malheur County; production was used for filter aids in water and food processing and for pharmaceuticals.

An open pit and a processing facility were operated by Oil-Dri Production Co. in Christmas Valley, Lake County. The diatomite was used as an oil absorbent and was sold under several brand names as pet litter.

Emery.—Oregon Emery Co., of Halsey, produced emery from a deposit in eastern Linn County. At a plant south of Albany, the material was crushed and screened to specific particle shapes and size ranges and was primarily used in skid-resistant and hardened surfaces such as industrial floors, ramps, and traffic ways and on steel-bridge decking. Oregon was the only State to report emery production in 1991.

Gemstones.—The value of Oregon's gemstone production increased by almost two-thirds from that of 1990. Although not actually a rock, the thunderegg, Oregon's State rock, may be the State's most well-known gem material. Thundereggs were collected at many sites throughout the State. Some of the most popular collection sites were the Madras-Prineville area, which includes the counties of Crook, Jefferson, and Wheeler; near Burns, Harney County; near Lakeview, Lake County; and in the Succor Creek area in Malheur County. Gem-quality calcium plagioclase, commonly referred to as sunstone or heliolite, was the largest contributor to the State's gemstone production value.

Sunstone, a variety of feldspar, is Oregon's official gemstone. The production of sunstone occurred at three areas in Lake and Harney Counties. Opal also contributed significantly to Oregon's gemstone production. Other notable Oregon gemstones produced included various picture and scenic jaspers, agates, and petrified wood.

Lime.—Lime production increased more than 11% in quantity and more than 7% in value from that of 1990. Quicklime accounted for the bulk of Oregon's production, approximately 89% of the total lime produced in 1991. Ash Grove Cement was the State's largest producer. At Portland, Multnomah County, the company sold both quicklime and all of the State's hydrated lime. Hydrated lime was produced by Ash Grove at a kiln in Portland. High-calcium limestone was barged in from Ash Grove's quarry on Texada Island near Vancouver, British Columbia, and used as the plant's feedstock. Production was consumed by local steel, chemical, and paper industry markets.

Amalgamated Sugar Co. purchased high-purity crushed limestone from Ash Grove's Durkee pit, Baker County, for use as "sugar rock" feedstock at its plant in Nyssa, Malheur County. Amalgamated Sugar calcined the limestone to produce quicklime for use in the processing of beet sugar.

Perlite.—The quantity and value of expanded perlite produced in Oregon remained unchanged from that of 1990. Supreme Perlite Co. manufactured expanded perlite at its plant in Portland. Some of the raw perlite it processed came from the company's mine on Dooley Mountain, Baker County. Expanded perlite was used in the production of cryogenic, horticultural, masonry, and construction products.

Pumice.—Oregon pumice production again ranked first nationally for tonnage produced. Production decreased more than 4% in quantity, but the value remained essentially unchanged from that of 1990. In the Bend area, Deschutes County, Cascade Pumice Co. and Central Oregon Pumice Co. produced pumice from surface mines and operated crushing and screening plants. Cascade Pumice, the State's largest producer, mined pumice from two open pits and operated a quarry that produced red volcanic cinders. Central Oregon Pumice also produced pumice from two open pits and quarried red volcanic cinders from two additional sites. Both companies served markets in northern California, Oregon, Washington, and British Columbia by truck and railroad. The processed pumice was sold for a variety of uses, including lightweight concrete aggregate, building and decorative block, landscaping, road construction and maintenance, roofing, horticulture, and in the manufacture of stone-washed jeans.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Construction sand and gravel production estimated for Oregon remained essentially unchanged from that surveyed in 1990. Most Oregon counties had sand and gravel production, with Colombia, Lane, Marion, and Multnomah among the leading producers. Major uses included road base and coverings; concrete aggregates, including concrete sand; and concrete products, including blocks, brick, and pipe. Most of the construction sand and gravel was transported by truck.

Industrial.—Silica sand was produced by CooSand Corp. from dune sands mined on the north shore of Coos Bay, Coos County. The sand was shipped by rail to a plant in the Portland area where the bulk of it was processed to meet specifications for container glass manufactured by Owens-Illinois in Portland. The rest was used for sandblasting sand and railroad traction sand.

TABLE 2
OREGON: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	192	567	$2.95
Riprap and jetty stone	437	1,694	3.88
Filter stone	261	1,403	5.38
Other coarse aggregate	158	864	5.47
Coarse aggregate, graded:			
Concrete aggregate, coarse	160	690	4.31
Bituminous aggregate, coarse	924	5,353	5.79
Bituminous surface-treatment aggregate	201	987	4.91
Railroad ballast	688	2,853	4.15
Other graded coarse aggregate	31	220	7.10
Fine aggregate (-3/8 inch):			
Stone sand, concrete	41	184	4.49
Stone sand, bituminous mix or seal	347	2,010	5.79
Screening, undesignated	52	146	2.81
Other fine aggregate	308	2,464	8.00
Coarse and fine aggregate:			
Graded road base or subbase	7,779	31,995	4.11
Unpaved road surfacing	2,147	9,471	4.41
Terrazzo and exposed aggregate	23	110	4.78
Crusher run or fill or waste	905	5,511	6.09
Other construction materials[2]	1,037	3,660	3.53
Chemical and metallurgical: Cement manufacture	W	W	2.52
Unspecified:[3]			
Actual	2,167	8,334	3.85
Estimated	2,751	10,805	3.93
Total[4]	20,608	89,322	4.33

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes dolomite, granite, limestone, miscellaneous stone, quartzite, sandstone, traprock and volcanic cinder and scoria, excludes a minor amount of slate, withheld to avoid disclosing company proprietary data.
[2]Includes drain fields and roofing granules.
[3]Includes production reported without a breakdown by use and estimates for nonrespondents.
[4]Data may not add to totals shown because of independent rounding.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

The quantity of Oregon crushed stone production increased more than 14% from that estimated for 1990 and 12% from that reported in 1989. The value of production rose 3% from that estimated for 1990 and 10% from that reported in 1989. Reflecting the predominantly volcanic nature of the State's geology, the bulk of Oregon's crushed stone was traprock (basalt), followed by, in order of quantity produced, limestone, granite, sandstone, and volcanic cinder and scoria.

Crushed stone production was reported in 32 of the State's 36 counties. Klamath, Lane, Multnomah, Washington, and Yamhill Counties accounted for more than 42% of the total; Washington County was by far the State's leading producer. District 1, representing the northwestern part of the State, accounted for more than 55% of the production.

The State's six leading crushed stone producers accounted for one-third of the quantity and almost 37% of the total value of reported production in 1991. The top four uses for crushed stone in Oregon during the year were graded road base, unpaved road surfacing, bituminous aggregate, and crusher run or fill.

Talc (Soapstone).—Steatite of Southern Oregon Inc. produced high-grade variegated-colored soapstone from deposits on Elliott Creek Ridge in the Klamath Mountains at the southern edge of Jackson County. The principal product was asbestos-free sculpture stone in a variety of colors, which was marketed worldwide for art carving and other specialty uses.

Zeolite.—Teague Mineral mined clinoptilolite from deposits in the Succor Creek Formation in Malheur County. Although many Oregon zeolite deposits have been documented, Teague Mineral was the only company known to commercially mine a natural zeolite product in Oregon in 1991. Along with ore from deposits in southwest Idaho, the mine output was processed at the company's mill near Adrian and sold for ammonia absorbent in aquarium systems, animal feed supplement, anticaking agents, fungicide carriers, odor control, and wastewater treatment.

Metals

Aluminum.—Oregon's primary aluminum production decreased 16% in quantity and almost one-third in value from that of 1990, a result of the continuing drop in prices. Aluminum prices, which fell from $1.10 per pound in 1988 to $0.74 per pound in 1990, dropped to $0.59 per pound in 1991.

In December, Reynolds Metals Co. temporarily closed its smelter at Troutdale, reportedly because of economic conditions. The plant has a rated ingot capacity of 121,000 metric tons per year. Earlier in the year, the company had shut down three of its five potlines, citing depressed demand. Only

TABLE 3

OREGON:[1] CRUSHED STONE[2] SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2	
	Quantity	Value	Quantity	Value
Construction aggregates:				
Coarse aggregates (+1 1/2 inch)[3]	646	3,051	201	680
Coarse aggregates, graded[4]	1,231	6,826	W	W
Fine aggregates (-3/8 inch)[5]	546	3,816	6	56
Coarse and fine aggregates[6]	6,194	25,988	1,165	4,461
Other construction materials	183	838	36	159
Chemical and metallurgical[7]	—	—	—	—
Unspecified[8]				
Actual	1,137	4,409	381	1,836
Estimated	1,523	6,331	376	1,372
Total[9]	11,461	51,259	2,165	8,565

	District 3		District 4	
	Quantity	Value	Quality	Value
Construction aggregates:				
Coarse aggregates (+1 1/2 inch)[3]	107	344	4	12
Coarse aggregates, graded[4]	W	W	W	W
Fine aggregates (-3/8 inch)[5]	W	W	W	W
Coarse and fine aggregates[6]	806	2,949	859	4,778
Other construction materials	385	1,833	1,063	3,392
Chemical and metallurgical[7]	—	—	—	—
Unspecified[8]				
Actual	—	—	649	2,090
Estimated	798	2,840	54	262
Total[9]	2,096	7,966	2,628	10,534

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Excludes 2,258,800 short tons valued at $11,000,357 not reported by county.
[2]Excludes slate; withheld to avoid disclosing company proprietary data.
[3]Includes macadam, riprap and jetty stone, filter stone, and other coarse aggregate.
[4]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, railroad ballast, and graded coarse aggregate.
[5]Includes stone sand (concrete), stone sand (bituminous mix or seal), screening (undesignated), and other fine aggregate.
[6]Includes graded road base or subbase, unpaved road surfacing, crusher run (select material or fill), roofing granules, and drain fields.
[7]Includes cement manufacture, lime manufacture, flux stone, glass manufacture, and sulfur oxide removal.
[8]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[9]Data may not add to totals shown because of independent rounding.

the casthouse, that portion of the plant that turns metal cast into ingot, remained open. Reynolds Metals imported alumina from Australia and Jamaica to be processed at the Multnomah County facility.

Northwest Aluminum Co. maintained production at its tolling smelter near The Dalles in Wasco County. The company operated the 82,000-metric-ton-per-year plant under a lease-purchase agreement signed in 1986 with Martin Marietta Corp. The alumina used at the smelter was obtained from Australia.

Columbium, Hafnium, Tantalum, Titanium, and Zirconium.—TWCA, a major producer of columbium, produced high-quality columbium materials for use in columbium-bearing alloys for jet engines, aerospace applications, chemical processing equipment, and superconductor applications at its plant in Albany, Linn County. Products produced included columbium pentoxide, high-purity ferrocolumbium, nickel columbium, and columbium metal.

TWCA was one of only two domestic producers of zirconium metal sponge and ingot. Zirconium, a strong metal transparent to radiation, was used principally in nuclear reactors, in superalloys for the aerospace and defense industries, and in flash bulbs. A byproduct of zirconium production, TWCA produced hafnium metal as sponge and crystal bar. Major markets for hafnium metal included nuclear reactor control rods, ceramics, refractories, aerospace alloys, and optical fibers. Tantalum produced by TWCA continued to be used primarily for aerospace engine components.

Oregon Metallurgical Corp. (OREMET) was one of only three U.S.

TABLE 4
OREGON: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991[1]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	7	1,480	$5,490	$3.71	3	1,382	$6,418	$4.64
Dolomite	1	W	W	3.23	—	—	—	—
Granite	78	219	977	4.46	40	380	1,804	4.75
Traprock	191	15,242	65,222	4.28	209	16,594	71,632	4.32
Sandstone	75	786	5,499	7.00	52	344	1,589	4.62
Slate	—	—	—	—	—	—	—	—
Volcanic cinder and scoria	76	502	3,508	6.99	53	298	1,316	4.42
Miscellaneous stone	8	W	W	2.84	42	1,610	6,563	4.08
Total	XX	18,407	81,204	4.41	XX	20,608	89,322	4.33

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Excludes slate; withheld to avoid disclosing company proprietary data.

companies that produced titanium sponge. With 10 reduction furnaces, OREMETS's titanium plant at Albany, Linn County, had a rated capacity of 6,800 metric tons per year. An on-site magnesium plant was used to support titanium sponge output. Oregon Steel Mills Inc. formed a joint venture with OREMET to convert titanium slab to plate. OREMET previously employed several steel rolling mills in Pennsylvania for its plate conversion, but under terms of the joint venture, most of the work will be done at Oregon Steel's Portland plant. The agreement benefits OREMET by reducing transportation costs and cutting lead times.

Both OREMET and TWCA produced titanium ingot at their Oregon plants; TWCA's ingot was used in-house.

Copper.—Formosa Exploration, a subsidiary of Formosa Resources Corp. of British Columbia, began mining copper and zinc ore from its Silver Peak Mine. The gold-containing massive copper-zinc sulfide deposit, sited on a ridge about 10 miles south of Riddle in Douglas County, was mined underground. Several thousand tons of ore has been stockpiled. Concentrates produced at the company's 400-ton-per-day mill were trucked to Vancouver, WA, then shipped to Japan for further processing.

Gold.—Oregon's gold production came mainly from small placer mines in southwestern and northeastern parts of the State. There was no lode gold production reported to the U.S. Bureau of Mines in 1991. The Bonnanza Mine, a placer operation on Pine Creek near Halfway, Baker County, was the State's largest gold producer. The mine is operated on a seasonal basis, ideally April through November. Reclamation work was done along with production.

DOGAMI reported other placer production on Sucker Creek, Josephine Creek, and in the Galice area in Josephine County; on Deer Creek, Elk Creek, Pine Creek, and in the Rye Valley in Baker County; in the Morman Basin near the Baker County-Malheur County line; in the Greenhorn area in Baker and Grant Counties; and on Big Creek in Grant County.

Nickel.—The joint venture of Glenbrook Nickel Co., a wholly owned subsidiary of Cominco Resources International Ltd., and Cominco American Inc. operated the Nation's only nickel smelter near Riddle, Douglas County. Nickel production nearly doubled from that of 1990, a result of Glenbrook treating higher grade ore from the adjacent Nickel Mountain Mine. Previously, concentrate from a low-grade stockpile left by the former owners, the Hanna Nickel Co., provided the bulk of the smelter feed. Through a receiving area built by Glenbrook Nickel at a Coos Bay port facility, the company imported an 18,140-metric-ton shipment of nickel ore from New Caledonia. The company tested the feasibility of importing ore to process at its Riddle plant. Based on test results, regular shipments of New Caledonian ore through the port facilities at Coos Bay are planned to begin in 1992.

Glenbrook Nickel purchased Green Diamond Abrasive Co., which manufactures products from slag left over after the nickel is removed from the nickel ore. The abrasives plant, just north of Riddle, was owned by the Reed Minerals Co. The slag, an abrasive, sharp granule ranging in size from BB pellets to fine sand, is screened and sized and is used primarily in sandblasting; other uses include roofing granules and backing sand for shingles.

Silicon Metal and Ferrosilicon.—Silicon metal was produced by Dow Corning Corp. at its facility in Springfield, Lane County. The product was used exclusively for the company's silicon-base chemical operations in Michigan and Kentucky. Using a single 17.5-megawatt electric furnace, the Springfield plant is capable of producing about 9,000 metric tons of silicon metal annually. The plant's electric power was

supplied by Bonneville Power Authority, and all the raw materials reportedly are obtained domestically.

Steel.—Cascade Steel Rolling Mills Inc., operators of a minimill in McMinnville, Yamhill County, completed construction of a new melt shop. The plant, capable of producing more than 540,000 metric tons annually, was built by Danieli S.p.A., an Italian equipment manufacturer. The increased billet production was expected to correct a raw steel shortfall at the McMinnville plant. This allows the company outside billet sales and could lead to a new rolling mill capable of producing wire rod, which has not been produced in the West for about a decade. Cascade is owned by Schmitzer Steel Products, a private, family-controlled company.

Oregon Steel Mills Inc. produced steel slab and plate at a plant in Portland. The Portland-based steelplate and pipe producer used the plant's production to supply slab to its plate mill in Fontana, CA, and plate to its pipe mill in Napa, CA. Oregon Steel was awarded its largest single pipe contract. Reportedly, the company will supply more than 650 miles of 36-inch and 42-inch double-submerged arc-weld line pipe to be used on the Pacific Gas Transmission-Pacific Gas & Electric Pipeline expansion project.

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[1]State Mineral Officer, U.S. Bureau of Mines, Spokane, WA. He has 17 years of mineral-related experience in industry and government and has covered the mineral activities in Oregon since 1989. Assistance in preparation of the chapter was given by W. A. Lyons, editorial assistant.

OREGON

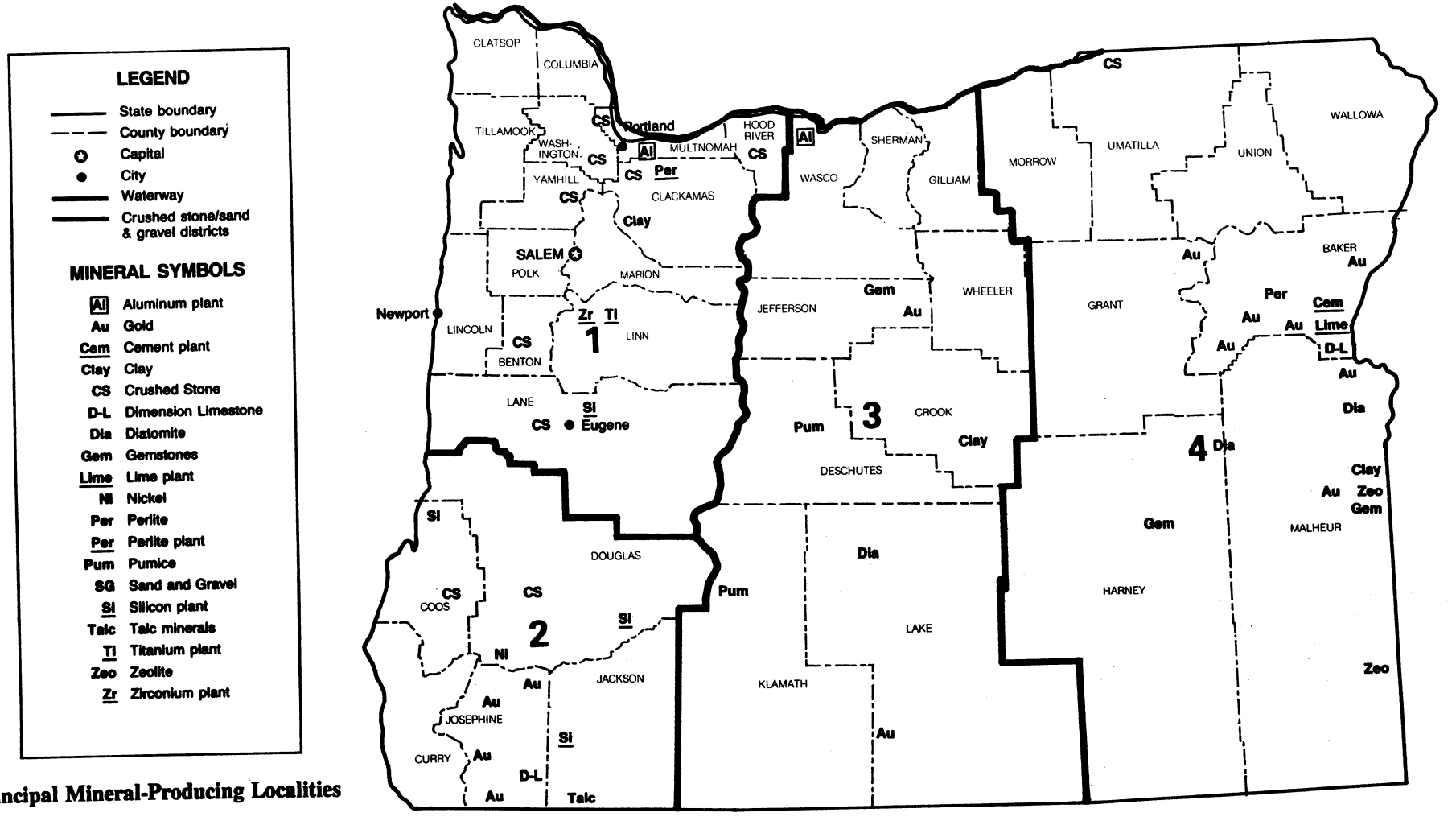
LEGEND
State boundary
County boundary
Capital
City
Waterway
Crushed stone/sand & gravel districts
MINERAL SYMBOLS
Al Aluminum plant
Au Gold
Cem Cement plant
Clay Clay
CS Crushed Stone
D-L Dimension Limestone
Dia Diatomite
Gem Gemstones
Lime Lime plant
Ni Nickel
Per Perlite
Per Perlite plant
Pum Pumice
SG Sand and Gravel
Si Silicon plant
Talc Talc minerals
Ti Titanium plant
Zeo Zeolite
Zr Zirconium plant
CLATSOP
COLUMBIA
TILLAMOOK
WASH-INGTON
YAMHILL
Portland
MULTNOMAH
HOOD RIVER
WASCO
SHERMAN
GILLIAM
MORROW
UMATILLA
UNION
WALLOWA
BAKER
CLACKAMAS
SALEM
POLK
MARION
JEFFERSON
WHEELER
GRANT
Newport
LINCOLN
LINN
BENTON
LANE
Eugene
CROOK
DESCHUTES
DOUGLAS
COOS
JOSEPHINE
CURRY
JACKSON
KLAMATH
LAKE
HARNEY
MALHEUR
1
2
3
4
Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Northwest Aluminum Co.	3313 West 2d St. The Dalles, OR 97058	Smelter	Wasco.
Reynolds Metals Co.	5100 NE Sundial Rd. Troutdale, OR 97060	do.	Multnomah.
Cement:			
Ash Grove Cement West Inc.	6720 SW Macadam Ave. Suite 300 Portland, OR 97219	Plants and quarries	Baker.
Diatomite.			
Eagle-Picher Industries Inc.	Graham Blvd. Vale, OR 97918	Surface mine and plant	Harney and Malheur.
Oil-Dri Production Co.	Box 191 Christmas Valley, OR 97638	do.	Lake.
Emery			
Oregon Emery Co.	3505 SW Pine St. Albany, OR 97321	do.	Linn.
Gold:			
Bonnanza Mining Inc.	Box 873 Halfway, OR 97834	Placer mine	Baker.
Lime:			
Amalgamated Sugar Co.	Box 1766 Nyssa, OR 97913	Plant	Malheur.
Ash Grove Cement West Inc.	6720 SW Macadam Ave. Suite 300 Portland OR 97219	do.	Multnomah.
Nickel			
Glenbrook Nickel Co.	Box 85 Riddle, OR 97469	Smelter	Douglas.
Perlite (expanded):			
Supreme Perlite Co.	4600 North Suttle Rd. Portland OR 97217	Plant	Multnomah.
Pumice:			
Cascade Pumice Co.	Box 1087 Bend, OR 97701	Pit	Deschutes.
Central Oregon Pumice Co.	5 NW Greenwood Ave. Bend OR 97701	Pit	Do.
Stone (crushed):			
Lone Star Northwest Aggregates	3510 SW Bond St. Portland, OR 97201	Quarry	Washington.
Morse Brothers Inc.	Box 7 Lebanon, OR 97355	Quarries	Linn and Washington.
Rogers Construction Co.	Box 730 Umatilla, OR 97882	do.	Multnomah and Washington.
U.S. Forest Services	333 SW First Ave. Portland, OR 97202	do.	Various.
Talc (soapstone):			
Steatite of Southern Oregon Inc.	2891 Elk Lane Grants Pass, OR 97527	Surface mine and mill	Jackson.
Titanium:			
Oregon Metallurgical Corp.	Box 580 Albany, OR 97321	Smelter	Linn.

See footnotes at end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Zeolite:			
Teague Mineral Products Co.[1]	Box 35-C, Route 2 Adrian, OR 97901	Surface mine and plant	Malheur.
Zirconium:			
Teledyne Wah Chang Albany Corp.[2]	1600 NE Old Salem Rd Albany, OR 97321	Plant	Linn.

[1]Also bentonite.
[2]Also columbian, hafnium, tantalum, titanium, and vanadium.

THE MINERAL INDUSTRY OF PENNSYLVANIA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Pennsylvania Bureau of Topographic and Geologic Survey, Department of Environmental Resources, for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.,[1] and Robert C. Smith[2]

The value of nonfuel mineral production in Pennsylvania in 1991 was about $844 million. Value dropped below $1 billion for the first time in 4 years. The decline in mineral production was indicative of the overall slowdown in the State's economy. Nationally, the State remained 1st in stone production and ranked 13th in value of nonfuel mineral production.

A significant decrease in production of crushed stone resulted in a loss of about $140 million in the State's nonfuel mineral value. Most of the other industrial minerals produced in the State also showed a drop in output as construction activity in Pennsylvania, as well as the Northeast, slowed during the year.

The downturn also affected the State's coal and steel industries. Coal production dropped by about 12 million short tons to about 62 million tons, according to the U.S. Energy Information Administration. Steel output fell below 10 million tons and was about 20% lower than that of 1990. Nationally, Pennsylvania remained the third leading State in steel production and ranked fourth in output of coal.

EMPLOYMENT

In 1991, Pennsylvania employed 26,000 workers in mining and 83,000 workers in primary metals, a decline of 2,000 workers in mining and about 6,000 in metals compared with totals of 1990.[3] Employment in the construction industry also decreased compared with that of 1990, by 4% to 220,000 workers.

LEGISLATION AND GOVERNMENT PROGRAMS

In November, the Pennsylvania General Assembly introduced House bill 2196, which proposed revisions to the State's Air Pollution Control Act (Act 787). The legislation, which remained in committee at yearend, provided measures for State compliance with amendments to

TABLE 1
NONFUEL MINERAL PRODUCTION IN PENNSYLVANIA[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Cement:							
Masonry	thousand short tons	349	$26,473	303	$22,594	e253	e$18,975
Portland	do.	5,757	301,980	5,621	286,185	e4,881	e248,931
Clays[2]	metric tons	1,049,973	4,936	840,646	2,900	701,399	2,890
Gemstones		NA	5	NA	5	NA	5
Lime	thousand short tons	1,660	92,139	1,626	92,557	1,695	95,328
Peat	do.	20	746	18	730	10	207
Sand and gravel (construction)	do.	e19,500	e94,600	20,883	97,348	e18,300	e87,800
Stone:							
Crushed[3]	do.	93,123	455,004	e95,800	e502,700	70,334	362,306
Dimension	short tons	44,267	10,032	e43,952	e9,898	38,493	10,077
Combined value of clays [fire (1990), kaolin], mica (scrap), sand and gravel (industrial), stone [crushed granite (1989-90), crushed limestone, dolomite, and quartzite (1991)], and tripoli		XX	14,754	XX	15,125	XX	17,482
Total		XX	1,000,669	XX	1,030,042	XX	844,001

eEstimated. NA Not available. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.
[3]Excludes certain stones; kind and value included with "Combined value" figure.

the Federal Clean Air Act of 1990. States failing to comply with the Federal legislation were expected to lose Federal highway funding as a penalty. Pennsylvania's share of that funding as passed into law under the 1991 Intermodal Surface Transportation and Infrastructure Act was estimated at about $900 million per year.

Legislation introduced in 1990 to create a $5 million fund for remining coal from previously abandoned mines was reintroduced in 1991, as were three bills relating to wetlands protection. All of these bills were in committee at yearend and were expected to once again be submitted in 1992.

The Pennsylvania Bureau of Topographic and Geologic Survey was the primary State agency involved in mineral resource and geologic studies. During the year, the Survey published a detailed report on the mineral resources and geology of Pike County.[4] The Survey also updated and revised a booklet on the rocks and minerals of the State.[5] This booklet included discussions of basic concepts of petrology and mineralogy in relation to the formations and rock types found in Pennsylvania.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Industrial minerals were produced in Pennsylvania at about 411 operations according to data reported to the U.S. Bureau of Mines and listed in table 1. Crushed stone was produced at 187 quarries, sand and gravel at 154 pits, common clay and shale at 26 pits, dimension stone at 13 quarries, lime and cement at 10 plants each, peat at 7 bogs, and industrial sand, kaolin, mica, and tripoli at 1 operation each. Production from these operations accounted for the State's mineral production value of $844 million in 1991.

In addition, the following mineral commodities were processed in Pennsylvania: synthetic graphite, iron oxide materials, expanded perlite, iron and steel slag, sulfur (recovered), and exfoliated vermiculite. The combined value of these commodities as reported to the U.S. Bureau of Mines was about $108 million.

Cement.—Output dropped for the fourth year in a row. Weak demand from the construction industry in 1991 and continued competition from overseas suppliers contributed to the downward trend in production. Ironically, foreign companies own about 60% of the U.S. cementmaking capacity indicative of the global marketplace that existed in the cement industry.

Cement producers in Pennsylvania continued attempts to lower energy costs by seeking permission to burn waste materials. Local residents and, in some areas, international environmental organizations were involved in protests opposing the burning of waste materials.

At yearend, LaFarge Corp. at its Whitehall plant completed an 11-day experiment in burning tires and awaited a State Department of Environmental Resources decision on continuing the procedure. The firm would burn about 120 tires per hour to maintain a 30% tire-70% coal fuel mixture.

Also during the year, Essroc Materials Inc. completed a $21 million modernization program at its Nazareth plant. Cement from the plant was marketed from Massachusetts to Virginia and, with the modernization, capacity was increased to about 1.3 million short tons per year.[6]

Lime.—In 1991, lime was the only commodity in Pennsylvania for which an increase in production was reported based on data received by the U.S. Bureau of Mines. During the past few years, demand for lime has increased for use in environmental applications. That market has offset some of the losses for lime used in steel manufacturing. Nationally, Pennsylvania ranked third in lime output, producing about 10% of the U.S. total.

During the year, one of the State's nine lime producers sought permission from Benner and Patton Township officials to develop an underground limestone mine near Filmore, Centre County. In 1990, the firm was denied permission for a surface mine in the same area. A decision on the new mine plan was pending at yearend.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Estimated production of construction sand and gravel of about 18.3 million short tons was the lowest reported since 1987.

TABLE 2
PENNSYLVANIA: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1990		1991	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Agriculture	12,425	$739	12,862	$867
Acid water neutralization	83,044	4,518	155,276	8,430
Paper and pulp	45,662	2,244	29,589	1,414
Steel, basic oxygen	350,718	19,878	460,658	21,821
Steel, electric	193,022	9,619	284,682	13,972
Sewage treatment	46,390	2,476	76,557	4,376
Water purification	38,829	2,394	47,866	2,893
Other[1]	855,489	50,689	627,205	41,555
Total	1,625,579	92,557	1,694,695	95,328

[1]Includes glass, industrial solid waste, ladle desulfurization, open-hearth steel, ore concentration, other chemical and industrial, other metallurgy, petroleum refining, refractory, road stabilization, sugar refining, sulfur removal, tanning, and wire drawing.

TABLE 3
PENNSYLVANIA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	163	808	$5
Riprap and jetty stone	1,262	7,503	5.95
Filter stone	645	3,565	5.53
Other coarse aggregate	W	W	3.00
Coarse aggregate, graded:			
Concrete aggregate, coarse	4,494	22,631	5.04
Bituminous aggregate, coarse	6,878	34,172	4.97
Bituminous surface-treatment aggregate	2,384	14,091	5.91
Railroad ballast	478	2,624	5.49
Fine aggregate (-3/8 inch):			
Stone sand, concrete	881	5,003	5.68
Stone sand, bituminous mix or seal	2,911	13,569	4.66
Screening, undesignated	1,156	5,303	4.59
Coarse and fine aggregate:			
Graded road base or subbase	9,041	39,834	4.41
Unpaved road surfacing	939	5,006	5.33
Crusher run or fill or waste	2,370	8,392	3.54
Other construction materials[2]	6,748	31,811	4.71
Agricultural:			
Agricultural limestone	929	8,398	9.04
Poultry grit and mineral food	25	252	10.08
Other agricultural uses	W	W	20.10
Chemical and metallurgical:			
Cement manufacture	6,402	31,024	4.85
Lime manufacture	634	4,079	6.43
Flux stone	W	W	7.08
Sulfur oxide removal	225	2,311	10.27
Special:			
Mine dusting or acid water treatment	W	W	20.00
Asphalt fillers or extenders	239	2,481	10.38
Whiting or whiting substitute	W	W	19.48
Other fillers or extenders	68	783	11.51
Other miscellaneous uses[3]	567	9,570	16.88
Unspecified:[4]			
Actual	16,518	88,302	5.35
Estimated	4,377	20,795	4.75
Total	70,334	[5]362,306	5.15

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes dolomite, limestone, granite, miscellaneous stone, sandstone, and traprock, excludes a minor amount of limestone and dolomite, and quartzite.
[2]Includes withheld amounts for coarse aggregate (+1 inch) and roofing granules.
[3]Includes withheld amounts for agricultural, chemical and metallurgical, special, and other specified uses not listed.
[4]Includes production reported without a breakdown by use and estimates for nonrespondents.
[5]Data do not add to total shown because of independent rounding.

Stone (Crushed).—Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Pennsylvania crushed stone statistics are compiled by geographical districts as depicted in the State map. Table 4 presents end-use statistics for Pennsylvania's four districts.

Although production of crushed stone declined in 1991, Pennsylvania remained the Nation's top producing State. Most of the drop in output occurred in District 4, the area of highest production. Demand declined in this area because of completed highway projects and reduced shipments to adjacent States. Since 1987, Pennsylvania has produced about 460 million short tons of crushed stone valued at $2.3 billion.

For the second time in 4 years, one of the State's top crushed stone producers was purchased. In 1988, Beazer PLC of the United Kingdom had purchased Koppers Co., which operated in the State as General Crushed Stone Co. In 1991, Hanson PLC, also of the United Kingdom, purchased Beazer. The transaction included 15 quarries in Pennsylvania.

Also during the year, Miller & Son Paving Inc. received permits from the State Department of Environmental Resources to open a quarry and concrete plant on a 150-acre site near Gardenville, Bucks County. The company must also receive approval from local government, which remained pending at yearend. The State permits included 23 pages of conditions for operation. Among them were restrictions on blasting noise and damage, air pollution, excavation, ground water, and erosion. Miller & Son had purchased the quarry site in 1988 for $2.8 million and planned to produce about 1 million tons of stone per year.

Metals

No metals were mined in Pennsylvania. Metals discussed in this section were processed from materials received from both foreign and domestic sources. Production and value data for these metals are not included in table 1.

TABLE 4

PENNSYLVANIA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Coarse aggregate (+1 1/2 inch)[2]	W	W	351	1,672	1,004	6,095	663	3,871
Coarse aggregate, graded[3]	608	2,275	1,030	5,081	3,945	21,495	8,650	44,666
Fine aggregate (-3/8 inch)[4]	780	2,441	539	2,460	1,048	5,082	2,580	13,892
Coarse and fine aggregate[5]	765	2,373	1,827	7,670	2,269	10,771	7,489	32,417
Other construction materials	138	525	674	3,290	350	1,681	5,639	26,553
Agricultural[6]	19	266	100	791	58	738	804	7,394
Chemical and metallurgical[7]	536	3,481	(8)	(8)	(8)	(8)	4,742	21,892
Special[9]	—	—	(8)	(8)	(8)	(8)	(8)	(8)
Other miscellaneous uses[10]	—	—	235	2,233	1,868	11,247	728	10,857
Unspecified:[11]								
Actual	854	4,782	531	2,722	4,348	22,618	10,786	58,179
Estimated	931	5,193	452	2,184	469	2,697	2,525	10,720
Total[12]	4,631	21,336	5,739	28,103	15,359	82,424	44,607	230,442

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Excludes limestone/dolomite and quartzite; withheld to avoid disclosing company proprietary data
[2]Includes filter stone, macadam, riprap and jetty stone, and other coarse aggregates.
[3]Includes concrete aggregate, coarse, bituminous aggregate, coarse, bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand, concrete, stone sand, bituminous mix or seal, and screening, undesignated.
[5]Includes graded road base or subbase, unpaved road surfacing, crusher run or fill or waste, and roofing granules.
[6]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[7]Includes cement manufacture, lime manufacture, flux stone, and sulfur oxide removal.
[8]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[9]Includes asphalt fillers or extenders, mine dusting or acid water treatment, whiting or whiting institute, and other fillers or extenders.
[10]Includes other specified uses not listed.
[11]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[12]Data may not add to totals shown due to independent rounding.

TABLE 5

PENNSYLVANIA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989[1]				1991[2]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	129	57,984	$289,594	$4.99	103	40,187	$210,571	$5.24
Dolomite	13	13,543	60,483	4.47	22	12,701	60,814	4.79
Marble	1	42	1,853	44.12	—	—	—	—
Granite	—	—	—	—	3	1,967	10,599	5.39
Traprock	11	8,037	39,311	4.89	10	4,108	22,609	5.50
Sandstone	34	7,515	34,017	4.53	34	5,136	28,033	5.46
Miscellaneous stone	12	6,001	29,745	4.96	15	6,234	29,680	4.76
Total[3]	XX	93,123	455,004	4.89	XX	70,334	362,306	5.15

XX Not applicable.
[1]Excludes granite; withheld to avoid disclosing company proprietary data.
[2]Excludes limestone/dolomite and quartzite; withheld to avoid disclosing company proprietary data.
[3]Data may not add to totals shown because of independent rounding.

During the past four decades, employment in Pennsylvania's primary metals sector has steadily declined. In the late 1950's, a new iron ore mine was opened in Berks County and zinc production commenced at the Friendensville Mine, Lehigh County. The iron ore mine closed in 1978 and the zinc mine in 1983, ending metal production in Pennsylvania. In 1958, Pennsylvania employed about 250,000 workers in its primary metals industries.

Employment dropped to about 200,000 by 1980 and continued to decline to about 83,000 workers in 1991. Imported steel

from the European Community and Japan; declining demand for U.S. automobiles, railroad cars, and trucks; substitution of aluminum and plastic for steel; and increasing worker productivity have caused the decline, according to the Pennsylvania Department of Labor and Industry.[7]

Iron and Steel.—Steel production declined from 12 million short tons in 1990 to about 9.4 million short tons in 1991, according to data published in the Pennsylvania Business Survey by The Pennsylvania State University. Output was the lowest since 1986 when a similar total was reported. USX Corp.'s U.S. Steel Group, the Nation's and one of Pennsylvania's leading steel producers, reported a decline in steel shipments nationwide to about 8.8 million tons.[8] During the year, U.S. Steel shut down iron- and steel-producing operations and a pipe mill at its Fairless Works near Philadelphia. In Western Pennsylvania near Pittsburgh, the firm continued construction of a new continuous slab caster at its Mon Valley Works. The facility was scheduled for startup in the third quarter of 1992 and was expected to have a capacity of 2.6 million tons per year.

Zinc.—Zinc Corp. of America (ZCA) operated 1 of 12 secondary zinc plants in the United States in 1991. ZCA's electrothermic smelter at Monaca had a capacity of about 146,000 metric tons per year and was the largest in the United States.

In Palmerton, Horsehead Resource Development Co., an affiliate of ZCA, processed electric arc furnace (EAF) dust. The plant had a capacity to process about 245,000 metric tons of EAF zinc calcine with recovery potential at about 75,000 metric tons of zinc.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related industry and government experience and has covered the mineral activities in Pennsylvania for 9 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]Economic geologist, Pennsylvania Bureau of Topographic and Geologic Survey, Department of Environmental Resources, Harrisburg, PA.

[3]Pennsylvania Business Survey. College of Business Administration, The Pennsylvania State University, University Park, PA, Feb. 1991, p. 4.

[4]Sevon, W. D., T. M. Berg, L. D. Schultz, and G. H. Crowl. Geology and Mineral Resources of Pike County, PA Geol. Surv., 4th Series, County Report 52, 1991, 141 pp.

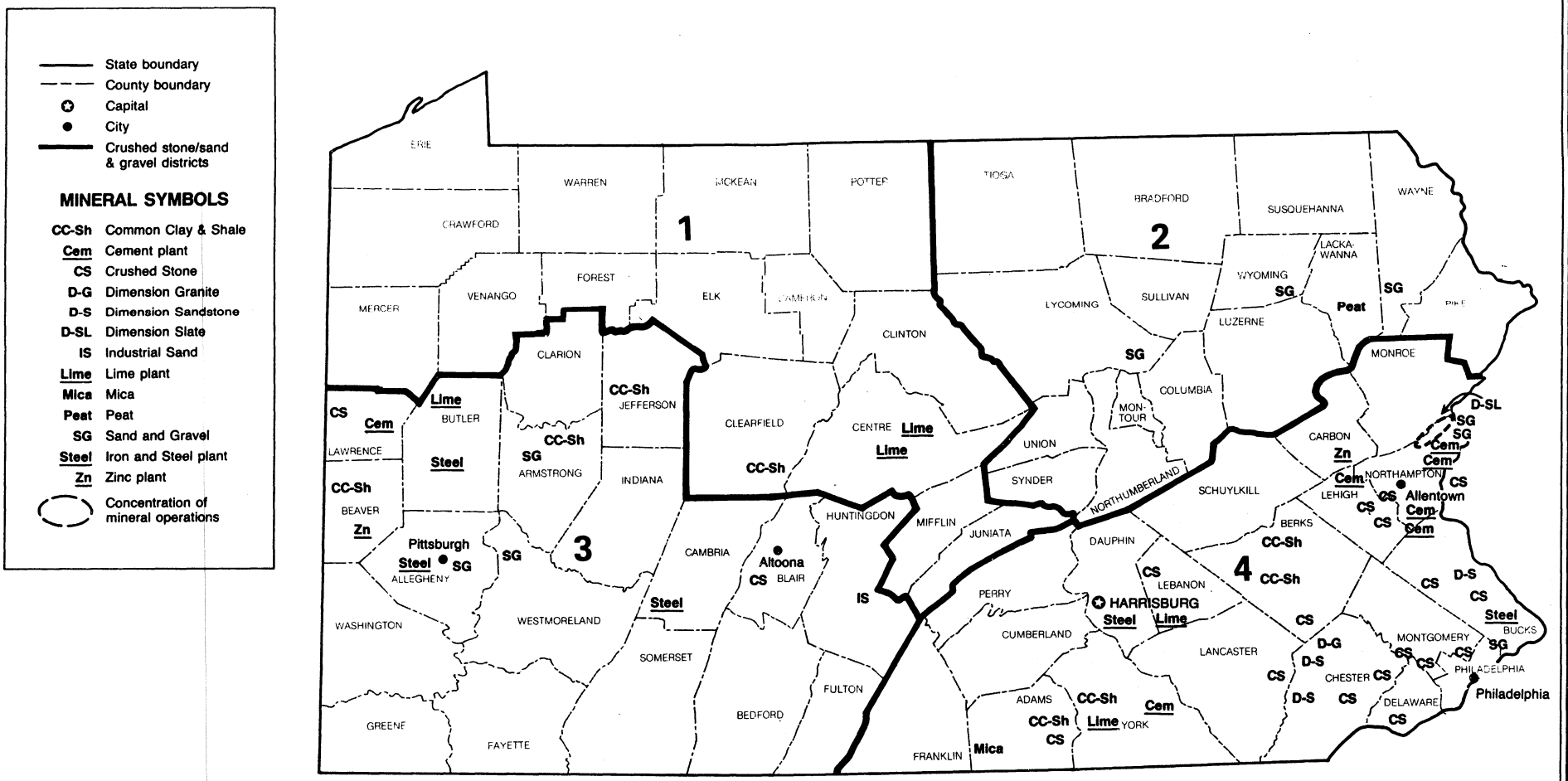
[5]Barnes, J. H. Rocks and Minerals of Pennsylvania. PA Geol. Sur., 4th Series, 3d ed., June 1991, 30 pp.

[6]The Morning Call (Allentown, PA). Tack in Technology Goes for Long Term. July 29, 1991, Sec. B, p. 1.

[7]Labor Market Information. Trends in Pennsylvania's Primary Metals Industry, Pennsylvania Department of Labor and Industry, Bureau of Research and Statistics, Mar. 1992, p. 11.

[8]USX Corp. 1991 Annual Report, p. 3.

PENNSYLVANIA



Principal Mineral-Producing Localities

TABLE 6
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Allentown Portland Cement Co. Inc.	Box 199 Blandon, PA 19510	Plant and quarry	Berks.
Essoroc Materials Inc.	Drawer 32 Nazareth, PA 18064	Plant and quarries	Lehigh and Northampton.
LaFarge Corp.	5160 Main St. Whitehall, PA 18052	Plant	Lehigh.
Hercules Cement Co.	Center St. Stockertown, PA 18083	Plant and quarry	Northampton.
Lone Star Industries Inc.	Box 818 Nazareth, PA 18064	Plant	Do.
Clays and shale:			
Common:			
Glen-Gery Corp.	Box 1542 Reading, PA 19603	Pits and plants	Adams, Berks, Jefferson, York.
Harmar Brick Inc.	Rich Hill Rd. Cheswick, PA 15024	Pit	Allegheny.
McAvoy Vitrified Brick Co.	Rural Delivery 2, Box 309 Phoenixville, PA 19460	Pit	Chester.
Watsontown Brick Co.	Box 68 Watsontown, PA 17777	Pit	Northumberland.
Kaolin:			
Narvon Products Corp.	900 East 8th Ave., Suite 200 King of Prussia, PA 19406	Pit and plant	Lancaster.
Lime:			
J. E. Baker Co.	320 North Baker Rd. York, PA 17404	Plant and quarry	York.
Bellefonte Lime Co. Inc.	Box 448, North Thomas St. Bellefonte, PA 16823	Plant and quarries	Centre.
Wimpey Minerals PA Inc.[1]	Box 468 Hanover, PA 17331	do.	Adams and Lebanon.
Centre Lime & Stone Co. Inc.	Box 130 Pleasant Gap, PA 16823	Plant and quarry	Centre.
Mercer Lime & Stone Co.	525 William Penn Place Pittsburgh, PA 15219	Plant	Butler.
Peat:			
Lake Benton Soil Products Inc.	Rural Delivery 1 Dalton, PA 18414	Bog	Lackawanna.
Sand and gravel:			
Construction:			
A. Barletta & Sons	Box 40 Hazelton, PA 18201	Pits and plant	Luzerne.
Davison Sand & Gravel Co.	400 Industrial Blvd. New Kensington, PA 15068	Dredge and pits	Armstrong and Westmoreland.
Dravo Basic Materials Co.	4800 Grand Ave. Pittsburgh, PA 15225	Dredge, pit, plant	Allegheny and Beaver.
Glacial Sand & Gravel Co. Inc.	Box 1022 Kittanning, PA 16201	Dredge and plant	Armstrong.
Hasbrouck Sand & Gravel Inc.	Rural Delivery 4 Titusville, PA 16354	Pit and plant	Crawford.

See footnotes at end of table.

TABLE 6—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued:			
Construction—Continued:			
Warner Co.	699 Bristol Pike Morrisville, PA 19067	Pit and plant	Bucks.
Wyoming Sand & Stone Co.	Rural Delivery 2, Box 26 Tunkhannock, PA 18657	Pits and plant	Bradford and Wyoming.
Industrial:			
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	Quarries and plant	Huntingdon.
Stone:			
Crushed:			
Commercial Stone Corp.	2200 Springfield Pike Connellsville, PA 15425	Quarries and plant	Fayette and Westmoreland.
Eastern Industries Inc.[2]	4401 Camp Meeting Rd. Center Valley, PA 18034	do.	Berks, Carbon, Dauphin, Lancaster, Lehigh, Mifflin, Northampton, Northumberland, Susquehanna, Tioga, Union.
Eureka Stone Quarry Inc.	Box 249 Chalfont, PA 18914	do.	Bucks, Lackawanna, Monroe, Pike, Wayane.
Glasgow Inc.	Box 1089 Glenside, PA 19038	do.	Chester and Montgomery.
Hanson PLC[2]	Box 231 Eastern, PA 18044	do.	Centre, Chester, Clinton, Columbia, Delaware, Lycoming, Monroe, Montour, Tioga, Wayane, York.
Medusa Cement Co.	2001 Portland Park Wampum, PA 16157	do.	Butler, Lawrence, York.
New Enterprise Stone & Lime Co. Inc.	Rural Delivery 3 New Enterprise, PA 16664	do.	Adams, Bedford, Blair, Clearfield, Cumberland, Franklin, Huntingdon, Lancaster, Somerset.
Penns Supply Inc.	Box 3331 Harrisburgh, PA 17105	do.	Cumberland, Dauphin, Perry.
Dimension:			
A. Dally & Sons Inc.	Box 27, Railroad Ave. Pen Argyl, PA 18072	Quarries and mills	Northampton.
Delaware Quarries	Route 22 Lumberville, PA 18933	Quarry and plant	Bucks.
Pennsylvania Granite Corp.	Box 510 St. Peters, PA 19470	Quarries and mill	Chester.
Welsh Mountain Building Stone Inc.	227 Isabella St. Norristown, PA 19401	Quarry	Do.
Mark C. Wise Inc.	Box 208 Bowmansville, PA 17507	do.	Do.

[1]Also stone.
[2]Also sand and gravel.

THE MINERAL INDUSTRY OF PUERTO RICO, NORTHERN MARIANAS, ISLAND POSSESSIONS, AND TRUST TERRITORY

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Department of Natural Resources, Commonwealth of Puerto Rico, for collecting information on all nonfuel minerals.

By Steve W. Sikich[1] and Ramon M. Alonso[2]

THE COMMONWEALTH OF PUERTO RICO

Statistics released by the U.S. Bureau of Mines, Department of the Interior, indicate that the value of nonfuel mineral commodities produced in Puerto Rico was $166 million. In 1990, production valued at $126.3 million was reported; however, the values of clays and crushed stone were not included. In 1991, the Commonwealth recorded the second highest mineral value in its history, just 0.6% less than the record high of $167.0 million achieved in 1988.

Puerto Rico ranked ahead of 12 States in the value of its mineral production. The leading commodity was cement, which accounted for more than two-thirds of the total. Crushed stone, valued at $49.8 million, ranked second and accounted for more than 30%. Clays and lime, the two other minerals for which production was reported, were responsible for less than 3% of the value.

Trends and Developments

The increase in Puerto Rico's mineral production in 1991 was indicative that the recession that had impacted mainland United States beginning in 1989 did not have as great an impact on the Commonwealth. Part of the reason that Puerto Rico was spared a serious recession resulted from the $1.5 billion that was pumped into the island's economy for reconstruction after Hurricane Hugo devastated eastern Puerto Rico in 1989.[3]

A bill to authorize a Puerto Rican plebiscite on its political status died in a U.S. Senate committee in February. Regardless, the Commonwealth held a referendum in December that defeated by a 53% to 45% margin an antistatehood bill strongly supported by Governor

TABLE 1

NONFUEL MINERAL PRODUCTION[1] IN THE COMMONWEALTH OF PUERTO RICO AND ISLANDS ADMINISTERED BY THE UNITED STATES

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
PUERTO RICO							
Cement (portland)	thousand short tons	1,374	$112,318	1,486	$122,027	e1,382	e$110,560
Clays	metric tons	136,873	311	W	W	145,483	355
Lime	thousand short tons	26	3,800	29	3,483	30	4,440
Sand and gravel (industrial)	do.	30	600	55	825	55	825
Stone (crushed)	do.	8,389	46,648	NA	NA	8,828	49,839
Total		XX	163,677	XX	[2]126,335	XX	166,019
ADMINISTERED ISLANDS							
American Samoa: Stone (crushed)	thousand short tons	48	$476	—	—	69	$756
Guam: Stone (crushed)	do.	1,063	11,133	—	—	2,201	18,038
Virgin Islands: Stone (crushed)	do.	312	3,159	—	—	W	W
Total		XX	14,768	XX	—	XX	18,794

eEstimated. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Total does not include value of item withheld.

Rafael Hernandez Colon.[4] Supporters of the bill favored remaining a Commonwealth with increased autonomy. Statehood advocates hoped the results of the referendum would convince Congress to authorize a plebiscite in 1992.

Bayamon Steel Producers completed two construction projects: a $30 million steel galvanizing line at its Bayamon plant and a $5 million expansion at its second manufacturing facility in Bayamon.

Employment

Preliminary data reported[5] by the Mine Safety and Health Administration (MSHA) showed an average of 1,708 people directly employed by Puerto Rico's mining industry in 1991. This represents a 16.4% decrease from the 2,044 reported for 1990. Of the total number, 1,081 were employed in surface mines and 627 were employed in mills and preparation facilities. One fatality, at a crushed stone quarry, occurred in Puerto Rico's mining industry in 1991.

Regulatory Issues

The Commonwealth Environmental Quality Board (EQB) formally denied the Puerto Rico Highway Authority permission to initiate reconstruction of the El Yunque Highway (Route 191) through the Caribbean National Forest without first filing an environmental impact statement. EQB ruled that even though the authority had complied with Federal regulations, it was not exempt from provisions of the Commonwealth Environmental Protection Law of 1970. The central part of the highway has been impassable since 1989, when it was extensively damaged by Hurricane Hugo.

In September, the U.S. Environmental Protection Agency (EPA) promulgated new rules regarding the location, design, operation, and postclosure care of nonhazardous solid waste landfills. The regulations gave landfill operators 2 years to bring facilities into conformance with the new rules. The Puerto Rico Solid Waste Management Authority developed a master plan to close 18 of the island's existing 62 landfills and to upgrade 42 of those remaining to meet the new regulations.

Safety-Kleen Envirosystems began a $14 million expansion to more than double the current solvent recycling and organic fuel production capacity at its Manati facility. Construction, which began after midyear, was expected to be completed by the end of 1992. In December, Commercial Incineration Corp. submitted construction permit applications to the Puerto Rico Regulations and Permits Administration for a $3 million expansion of its Carolina hazardous waste incineration facilities. Improvements would include the installation of a biochemical waste incinerator and a plastic recycling facility that would produce plastic wood. In 1990, the last year for which data were published, Safety-Kleen recycled more than 7.7 million gallons of solvents from over 1,000 companies in Puerto Rico. More than 3 million gallons was returned to businesses on the island for reuse. The remaining 4.7 million plus gallons was used to produce organic fuel, which was purchased by San Juan Cement Co. under exclusive contract and used as an energy source for its cement kilns.

Exploration Activities

The U.S. Geological Survey, along with the Puerto Rico Department of Natural Resources (DNR) and the University of Puerto Rico at Mayaguez, neared completion of a reassessment of the mineral resources of Puerto Rico. A public meeting to detail results of the new assessment was tentatively scheduled for mid-1992.

The only private company known to be actively exploring for metallic minerals was Cominco American Resources Inc., which continued a low-level exploration program. Several other companies were reported to have an interest in exploring for metals on the island, but none applied for exploration or exploitation permits.

Legislation and Government Programs

The Caribbean Basin Financing Authority (Carifa) was created in 1990 to finance economic development projects in countries eligible to participate in the Federal Caribbean Initiative (CBI) program. Carifa was the result of a U.S. Congressional mandate issued in 1990. The mandate required the Commonwealth government to channel a minimum of $100 million per year in loans to finance development projects in CBI countries for Puerto Rico to maintain its tax benefits granted by section 936 of the U.S. Internal Revenue Code. Carifa employs section 936 funds to provide financing for development projects in the Caribbean and Central America through the issue of tax-exempt industrial revenue bonds in Puerto Rico.[6] Alcan Aluminum Ltd. of Canada became the first company to take advantage of Carifa when it announced a $200 million modernization program at its two alumina plants in Jamaica. Carifa bonds will finance $60 million of the program. The remaining $140 million will be provided by Alcan.

Fuels

Arochem Corp. closed its 80,000-barrel-per-day refinery at Penuelas late in 1991 after Federal Bureau of Investigations and Internal Revenue Service officials began investigating allegations that top company executives illegally channeled large amounts of money from the firm.[7] Arochem's shutdown put on hold plans by the company to build, in conjunction with Texaco Inc. and General Electric Co., a multimillion dollar, 240-megawatt cogeneration plant capable of producing both electricity and steam. The electricity was to have been sold to the Puerto Rico Power Authority, and the steam would have been used in Arochem's refining operations.

Review by Nonfuel Mineral Commodities

Industrial Minerals.—Industrial minerals accounted for all of Puerto Rico's mineral production. The Commonwealth ranked ahead of 16 States in the value of industrial minerals produced in 1991.

Cement.—Portland cement, once again, was the most valuable mineral commodity produced in 1991, accounting for 66.9% of the total mineral value. Production was an estimated 1.4 million short tons, 7% less than was produced in 1990. The record-high production in 1990 was bolstered by reconstruction of structures damaged by Hurricane Hugo in late 1989.

Portland cement was produced by two companies in Puerto Rico; neither manufactured masonry cement. Puerto Rican Cement Co., the island's largest supplier of construction materials, operated a dry-process plant with a rated capacity of 1 million short tons per year at Ponce. San Juan Cement, the third largest construction materials supplier, also operated a dry-process plant with a capacity of 850,000 short tons per year.

Plycern Manufacturing Corp., a new venture involving local and Swiss investors, announced plans to construct a $12 million plant to manufacture cement and fiberboards for use in building construction. The boards are to be made from portland cement, calcium carbonate, and mineralized cellulose fiber using a proprietary manufacturing process.

Clays.—Clay production decreased slightly in volume to 145,483 metric tons and significantly in value to $355 million from 1990 to 1991. Production in 1991 was 6.3% more than the 136,873 metric tons mined in 1989, the last year for which clay data were published. The value in 1991 was 14.1% greater than the value in 1989. All of the clay production in Puerto Rico was common clay used in the manufacture of portland cement.

Lime.—Puerto Rico produced 30,000 short tons of lime valued at more than $4.4 million and ranked ahead of 5 of the 32 States that produced lime in 1991. Production decreased 3.4% from that of 1990, but the value of lime increased 27.5%. Puerto Rican Cement Co., the island's only lime producer, manufactured hydrated lime and a minor amount, less than 0.1%, of quicklime. Principal markets were in water purification and construction applications.

Sand and Gravel.—Construction.—Due to very poor response to its canvass forms, the Bureau no longer compiles production data for construction sand and gravel mined in Puerto Rico.

MSHA inspected 42 construction sand and gravel operations that were working full-time in Puerto Rico in 1991, 3 more than in 1990. Seven additional operations were listed as permanently closed, and eight more were worked on an intermittent basis.

Industrial.—Industrial sand and gravel production remained at the same level as that of 1990, 55,000 short tons valued at $825,000. Owens-Illinois of Puerto Rico (O-I) was the Commonwealth's only industrial sand producer. O-I manufactured a variety of glass containers using locally mined silica sand and recycled bottles, jars, and domestic glass.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

TABLE 2
PUERTO RICO: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch): Riprap and jetty stone[2]	70	407	$5.81
Coarse aggregate, graded:			
Concrete aggregate, coarse	1,256	7,422	5.91
Bituminous aggregate, coarse	27	133	4.93
Bituminous surface treatment aggregate	W	W	4.17
Fine aggregate (-3/8 inch):			
Stone sand, concrete	1,416	8,443	5.96
Concrete aggregate, coarse	372	1,756	4.72
Screening, undesignated	W	W	13.25
Other fine aggregate	W	W	4.79
Coarse and fine aggregate:			
Graded road base or subbase	65	181	2.78
Unpaved road surfacing	W	W	4.10
Terrazzo and exposed aggregate	29	270	9.31
Crusher run or fill or waste	35	137	3.91
Other construction materials[3]	218	1,556	7.14
Agricultural: Poultry grit and mineral food[4]	18	175	9.72
Chemical and metallurgical: Cement manufacture	1,391	5,561	4.00
Special: Other fillers or extenders	W	W	4.38
Other miscellaneous uses[5]	157	741	4.72
Unspecified:[6]			
Actual	249	1,368	5.49
Estimated	3,524	21,687	6.15
Total[7]	8,828	49,839	5.65

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes granite, limestone, marble, miscellaneous stone, sandstone, sandstone/quartzite and traprock.
[2]Includes macadam, and filter stone.
[3]Includes withheld amounts for coarse aggregate, graded, fine aggregate (-3/8 inch), and coarse and fine aggregates.
[4]Includes other agricultural uses.
[5]Includes withheld amounts for special and other specified uses not listed.
[6]Includes production reported without a breakdown by use and estimates for nonrespondents.
[7]Data may not add to totals shown because of independent rounding.

TABLE 3
PUERTO RICO: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	37	5,084	$27,187	$5.35	30	7,235	$40,191	$5.56
Marble	4	362	2,787	7.70	4	565	3,426	6.06
Granite	1	W	W	6.73	1	W	W	6.72
Sandstone	1	1	5	5.00	4	287	1,572	5.48
Sandstone and quartzite	—	—	—	—	1	W	W	4.56
Traprock	2	W	W	5.26	—	—	—	—
Miscellaneous stone	3	1,835	9,988	5.44	2	W	W	9.22
Total	XX	8,389	46,648	5.56	XX	8,828	49,839	5.65

W Withheld to avoid disclosing company proprietary data, included in "Total." XX Not applicable.
[1]Data do not add to total shown because of independent rounding.

Crushed.—Crushed stone was Puerto Rico's second most valuable mineral commodity, accounting for 30.2% of the total value of minerals produced in 1991. total of 8.8 million short tons valued at $49.8 million was quarried. This was a 5.2% increase, 439,000 tons more than was produced in 1989. The value was $3.2 million greater in 1991, a 6.8% increase. Contributing to the increase was a $400 million construction program at the Luis Muñoz Marin International airport in San Juan. Projects requiring crushed stone included construction of a ramp for the new international terminal, construction of a new parking garage, and new roads in front of the airport. The modernization is not expected to be completed until 1995, although the international terminal ramp was nearly completed at yearend.

Crushed stone production was reported by 40 companies from 43 quarries. The five largest producers, in descending order of production, were Productora de Agregados Inc, Arecibo; Puerto Rican Cement Co., Ponce; Empresas Ortiz Brunet, San Juan; Empresas Terrassa, Mayaguez and San Juan; and Cantera Carraizo Inc., San Juan.

Major end uses of crushed stone are summarized in table 2. Types of rock used as crushed stone included granite, limestone, marble, sandstone, and traprock. Data on the quantity and value of each type are included in table 3.

Kivo Group, a Brazilian industrial and trading group with interests in mining, announced plans to construct a $10 million plant on the south coast of Puerto Rico to process crushed stone for export to construction markets in Canada, Europe, and the United States. Granite used in the operation would be imported from Brazil.

Dimension.—One company, Marmoles Vassco Inc., reported dimension stone production to the Bureau in 1991. Production data were withheld and not included in table 1 to protect proprietary company data. Production consisted of sawed marble blocks from a quarry in Aquadilla County. MSHA reported two other dimension stone quarries operating full-time in 1991: a marble quarry operated by Empresas Tito Castro Inc. and a quarry with the rock type not specified operated by Canteras Del Sur Inc. Both quarries are in Ponce County.

Other Industrial Minerals.—Two additional industrial minerals were recovered in Puerto Rico. Salt, evaporated from seawater, was produced by two companies in southwestern Mayaguez. Salt was also imported through the Port of San Juan. Elemental sulfur was recovered as a byproduct of oil refining by the Sun Oil Co. Inc. at Yabucoa.

Peat moss imports through the Port of San Juan decreased from 497 short tons valued at $109,000 in 1990 to 291 tons valued at $119,000 in 1990. The record-high peat imports in 1990 was attributed to the use of horticultural material to landscape houses rebuilt as a result of Hurricane Hugo.

Metals.—Metals have not been mined in Puerto Rico since the Juncos iron mine closed in 1953, and prospects for resuming metal mining in the foreseeable future are unlikely. However, metal occurrences are common on the island, and the possibility of future development of an economic metal deposit should not be completely discounted. Work by the U.S. Geological Survey has identified more than 150 metallic mineral occurrences. Types of metal deposits identified included porphyry copper; copper skarn; iron skarn; porphyry copper-gold; polymetallic veins; volcanogenic manganese; epithermal quartz-alunite gold; lateritic nickel; placer gold-platinum-group alloys; shoreline placer titanium; copper manto; and metallic occurrences of copper, iron, gold, and molybdenum.

Among Puerto Rico's major exports are metal products manufactured from material imported from the United States and foreign countries and from recycled scrap. Aluminum was extruded to manufacture contours in the form of tubes, channels, and angles by Alruss Extrusion and Finishing Corp. and Aluminum Extrusion Corp. (Alumex).

Alumex produced 50% of its own ingots from a recycling plant in Canovanas.

Although no steel is manufactured in Puerto Rico, more than 20 companies sell or install steel imported mainly from the United States. Bayamon Steel Producers constructed a $30 million steel galvanizing line that will allow the company to produce galvanized steel from imported cold-rolled and hot-rolled steel using a hot-dip zinc galvanizing process. The hot-dip galvanizing line, the first of its kind in Puerto Rico and the Caribbean, will have the capacity to produce 120,000 tons of galvanized steel per year. Products manufactured from the galvanized steel will be sold in Puerto Rico and shipped to markets on the U.S. mainland. The $5 million expansion project doubled the size of Bayamon's 80,000-square-foot-facility in the Lucchetti Industrial Park.

THE COMMONWEALTH OF THE NORTHERN MARIANAS

Sixteen islands with a total area of 164 square miles comprise the Commonwealth of the Northern Marianas. A 17th island, Guam, is the southernmost island of the Mariana island chain but is not part of the Commonwealth. Although the Northern Marianas theoretically has equal status with the Nation's only other Commonwealth, Puerto Rico, the U.S. Department of the Interior plays a much larger role in its administration. The only mineral production on the islands was crushed stone for the local construction industry.

CARIBBEAN ISLAND POSSESSIONS

The Caribbean Island Possessions consist of the U.S. Virgin Islands, which includes 3 major islands, more than 50 smaller islands, and 7 islands lying off the Central American coast. The major islands are St. Croix, St. John, and St. Thomas. Mineral production was reported from St. Croix and St. Thomas in 1991.

Review by Nonfuel Mineral Commodities

The only mineral commodity mined in the Virgin Islands in 1991 was crushed stone. One other industrial mineral, elemental sulfur, was recovered as a byproduct of oil refining; a metal, alumina, was refined from imported bauxite.

Industrial Minerals.—Stone.—Crushed stone production data were withheld because only two companies, Devcon International Corp. on St. Croix and St. Thomas and St. Croix Stone and Sand Co. on St. Croix, reported production to the Bureau in 1991. MSHA records indicate that a third company, No. 1 Contracting Corp., operated a traprock quarry at Sara Hill in St. Thomas. MSHA also inspected two stone crushing operations on the islands. V. I. Cement and Building Products Inc. operated the Springfield crusher on St. Thomas, and Inter Island Inc. of Puerto Rico operated a mobile crusher at an unspecified location.

Devcon, based in Deerfield Beach, FL, operated the Brookman Quarry about 7 miles west of Charlotte Amalie on St. Thomas. Production capacity from the quarry is listed at 150,000 short tons per year. Devcon also imports cement from Columbia and fine sand from Barbuda, a small island about 200 miles east of St. Thomas. The sand supplements manufactured sand produced from the crushed stone and is used in the manufacture of concrete blocks.

Caribbean Material Supply Co. Inc., a wholly owned Devcon subsidiary, operated the Springfield Quarry near Groveplace on St. Croix. Plant capacity was 150 tons per hour, about the same as that of the St. Thomas plant. St. Croix Stone and Sand Co. operated the Robes Hill Quarry near Frederiksted. Plant capacity was about 125 tons per hour. No. 1 Contracting Corp. operated the Sara Hill Quarry on St. Thomas.

Other Minerals.—The Virgin Islands Aluminum Corp., a subsidiary of the Swiss-based aluminum trading company Clarendon Ltd., operated a 700,000-short-ton-per-year alumina refinery on St. Croix. The refinery, built by Martin Marietta, had been idle since 1985. Bauxite, the basic raw material used in manufacturing the alumina, was imported from the recently opened bauxite deposits on the Berbice River in Guyana.

PACIFIC ISLAND POSSESSIONS

The Pacific Island Possessions consist of 12 islands or island chains that were acquired by the United States between 1839 and 1967. The major islands are American Samoa, Guam, and Johnston. The only mineral production on the islands that was reported to the Bureau was crushed stone for local construction. American Samoa reported the production of 69,000 short tons valued at $756,000. This represented a 44% increase in quantity and a 59% increase in value from data reported in 1989. The unit price of the stone increased from $9.92 per ton in 1989 to $10.56 per ton in 1991. Crushed stone production on Guam was 2.2 million short tons valued at slightly over $18 million. This represented a 107% increase in quantity, but only a 62% increase in value from data reported in 1989. The average cost of crushed stone decreased 22% from $10.47 per ton in 1989 to $8.20 per ton in 1991.

Regulatory Issues

A temporary permit, allowing the U.S. Army to destroy chemical weapons, was extended for an additional 180 days. The permit, which originally expired in December 1990, covered the destruction of weapons containing nerve gas and mustard gas. The U.S. Army was also waiting for a decision from EPA on its request to make permanent modifications to the Johnston Atoll Chemical Agent Disposal System facility that would incorporate design and operational improvements.

Legislation and Government Programs

Australia, New Zealand, and the United States entered into an agreement to continue marine geoscientific research and studies of the mineral resource potential of the South Pacific region. Studies conducted by the South Pacific Offshores Areas organization will include evaluation of the mineral and hydrocarbon potential of areas in the South Pacific.

TRUST TERRITORY OF THE PACIFIC ISLANDS

The Trust Territory of the Pacific Islands was created in 1947 when the United Nations created 11 trusteeships for territories captured from Japan and other Axis powers. The only territory remaining in the Trust, the Republic of Palau, applied for "free association" status with the United States in 1983, but a compact has not yet been ratified. Under terms of free association, the United States would provide economic aid and be responsible for Palau's defense in return for being allowed to maintain military bases on the island. The major obstacle in ratifying the compact has been a nuclear free clause in Palau's constitution, which the United States deems incompatible with its defense and security interests.

Mineral production was not reported from Palau. Micronesian Mineral Resources, a subsidiary of an exploration company based in Denver, CO, completed the evaluation of a gold prospect discovered in 1989 near the southern tip of Babelthuap, the largest island in the Palau group. The prospect proved to be noncommercial.

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[1]State Mineral Officer, U.S. Bureau of Mines, Tuscaloosa, AL. He has 33 years of industry and government experience and has covered the mineral activities in Puerto Rico since 1989. Assistance in the preparation of the chapter was given by Maylene E. Hubbard, editorial assistant.

[2]Director, Puerto Rico Geological Survey.

[3]Caribbean Business (San Juan, Puerto Rico). Editorial: The Worst Is Behind Us. Mar. 14, 1991, p. 38.

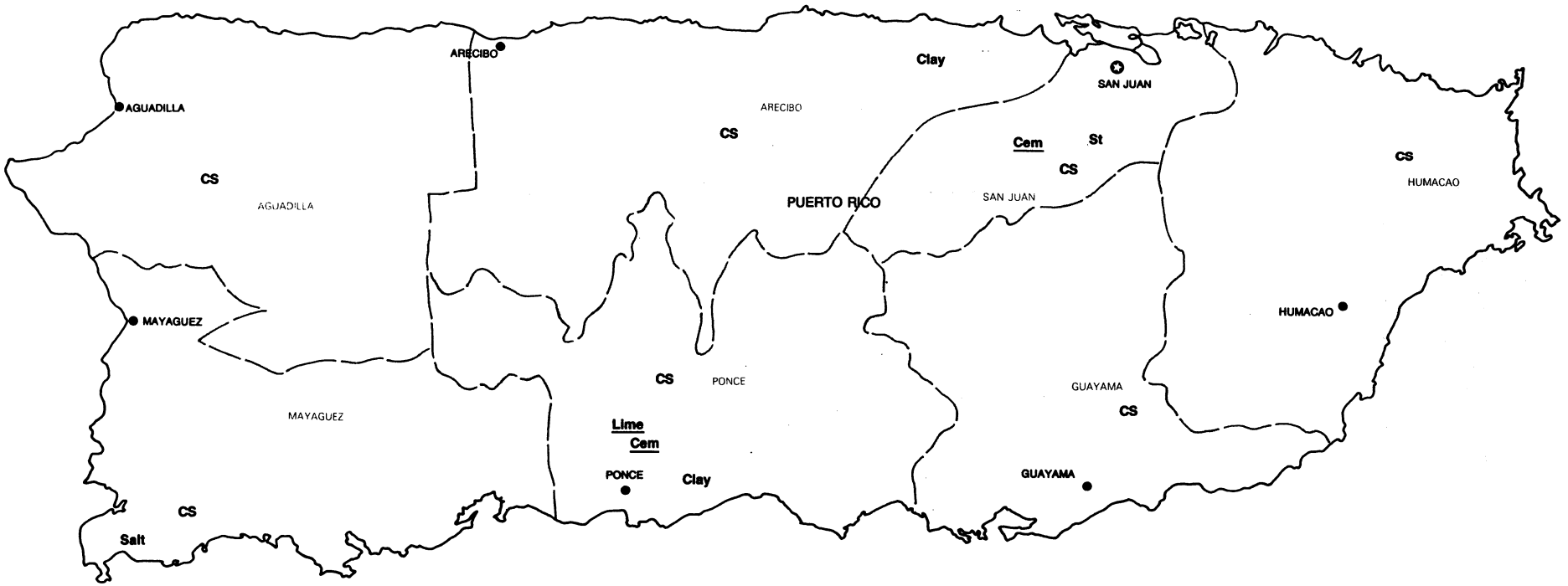
[4]Birmingham (AL) Post-Herald. Victory Sweet for Puerto Ricans Who Favor Closer Bonds With U.S. Dec. 10, 1991, p. B6.

[5]U.S. Department of Labor. Mine Injuries and Work Time, Quarterly. Jan.-Dec. 1991, p. 14.

[6]Caribbean Business (San Juan, Puerto Rico). Alcan Aluminum To Upgrade Jamaica Plants. V. 19, No. 8, Feb. 28, 1991, p. 33.

[7]———. Hopes Grow That Arochem Will Reopen Here. V. 20, No. 10, Mar. 12, 1992, p. 11.

PUERTO RICO



LEGEND

MINERAL SYMBOLS

———	State boundary	**Cem**	Cement plant
– – –	District boundary	**Clay**	Clay
✪	Capital	**CS**	Crushed Stone
●	City	**Lime**	Lime plant
		Salt	Salt
		St	Stone

Principal Mineral-Producing Localities

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
	PUERTO RICO		
Cement:			
Puerto Rican Cement Co.[1]	Box 1349 Ponce, PR 00733	Plant	Ponce.
San Juan Cement Co.[2]	GPO 2888 San Juan, PR 00936	do.	San Juan.
Sand (industrial):			
Owens-Illinois Inc.	Box 387 Vega Alta, PR 00762	Pit and plant	Arecibo.
Stone (crushed):			
Productora De Agregados Inc.	Box 1052 Sabana Seca, PR 00749	Quarry	Do.
Empresas Ortiz Brunet	Box 1839 Guaynabo, PR 00657	do.	San Juan.
Terressa Aggregates Inc.	24 Building 35 #17-Sta Rosa Bayamon, PR 00620	do.	Mayaguez and San Juan.
Cantera Carrizo Inc.	Box 2588 San Juan, PR 00936	do.	San Juan.
Stone (dimension):			
Marmoles Vassco Inc.	Box 8238 Ponce, PR 00732	do.	Aquadilla.
Empresas Tito Castro Inc.[3]	Box 589 Ponce, PR 00731	do.	Ponce.
Sulfur:			
Puerto Rico Sun Oil Co.	Box 476 Yabucoa, PR 00767	Plant	Humacao.
	VIRGIN ISLANDS		
Alumina:			
Virgin Islands Alumina Inc.	Box 1525 Kingshill St. Croix, VI 00851	Plant	St. Croix.
Stone (crushed):			
Devcon International Corp.	Box 7368 St. Thomas, VI 00801	Quarry	St. Thomas.
St. Croix Stone & Sand Inc.	Box 732 Frederiksted St. Croix, VI 00840	do.	St. Croix.
	GUAM		
Sulfur:			
Amerada Hess Corp.	1 Hess Plaza Woodbridge, NJ 07095	Plant	St. Croix.
Stone (crushed):			
Guam Government Public Works Dept.	Agana, GU 96910	Quarry	Guam.
Hawaiian Rock Products	Box H Agana, GU 96910	do.	Do.
Perez Brothers Inc.	Box F Agana, GU 96910	do.	Do.

[1]Also lime, clay, and crushed stone.
[2]Also clay and crushed stone.
[3]Also crushed stone and construction sand and gravel.

THE MINERAL INDUSTRY OF RHODE ISLAND

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Rhode Island Department of Environmental Management, for collecting information on all nonfuel minerals.

By Donald K. Harrison[1]

The value of nonfuel mineral production in 1991 was $13.3 million, a $4.6 million decrease from the 1990 value. The primary reason for the decrease was the drop in sales of crushed stone and construction sand and gravel, the State's two primary mineral commodities. A small amount of industrial sand was also mined. Mineral-related industrial activity in the State included glass and wire manufacturing, refinishing of precious and specialty metals, and metalworking and fabrication. The State was also the headquarters for at least three national jewelers' associations.

TRENDS AND DEVELOPMENTS

Overall, construction activity continued to remain depressed in Rhode Island in 1991. The total value of construction during 1991 was down almost 26%, from $510 million in 1990 to $380 million in 1991. Decreases were reported for all categories of construction. The largest decline in construction contract values was in new residential nonhousekeeping, which declined by 96%. Other decreases were reported for new nonresidential buildings (down 49%); new residential housekeeping (down 26%); and additions, alterations, and conversions, which fell 10%.[2] Because the State's two primary minerals produced are crushed stone and construction sand and gravel and both of these industries rely heavily on construction, the State's mineral industry continued to be affected by the ongoing recession. Both quantity and value of these commodities declined in 1991. Output and value of crushed stone declined 25% and 17%, respectively, from 1990 levels. Similarly, both output and value of construction sand and gravel declined 34% from those of the previous year.

EMPLOYMENT

In 1991, the average number of workers[3] employed in the mineral extractive industries in Rhode Island was 122, a total of 34 less than that of 1990. Of this total, 84 workers were employed at sand and gravel operations, 15 at stone operations, and 23 employees worked at mineral-related mills and preparation plants in the State.[4] In the mineral-dependent construction industry, 14,700 workers were employed in 1991. The number of workers was down 3,400 or almost 19% from that of 1990.

REGULATORY ISSUES

The U.S. Environmental Protection Agency (EPA) adopted a recommendation in April to let nature clean up contaminated ground water at the abandoned Western Sand & Gravel Superfund site in Burrillville. Between 1953 and 1975, an active sand and gravel pit was operated at the location. From 1975 to 1979, approximately 12 acres at the northern end of the site was used for disposal of liquid chemical and septic wastes. Over time, these wastes penetrated the soil and reached the ground water.

Although EPA has been involved in cleaning up the site since 1980, its decision in April would allow the ground water to clean itself naturally in a

TABLE 1
NONFUEL MINERAL PRODUCTION IN RHODE ISLAND[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gemstones		NA	$2	NA	$2	NA	$1
Sand and gravel (construction)	thousand short tons	e1,100	e3,900	1,969	9,042	e1,300	e6,000
Stone (crushed)	do.	[2]1,208	7,170	[2] e1,600	e8,800	1,187	7,262
Total[3]		XX	11,072	XX	17,844	XX	13,263

eEstimated. NA Not available. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes crushed traprock.
[3]Partial total, excludes values that must be concealed to avoid disclosing company proprietary data.

chemical and biological process that was estimated to take 24 to 28 years. The agency will continue to monitor the levels of contaminants in the ground water during that time. If levels do not drop as predicted, EPA will pump out the ground water, scrub it free of contaminants, and return it to a nearby reservoir.

LEGISLATION AND GOVERNMENT PROGRAMS

Public Law 152, "Soil Erosion and Sediment Control," was signed into law in June. The law provides a model ordinance for a city or town that chooses to adopt an erosion and sediment control ordinance. It states that "it is unlawful for any person to disturb any vegetation, grades, and contours of land in a manner that may increase the potential for soil erosion, without first applying for a determination of applicability from a building official or his/her designee." Public Law 152 applies to sand and gravel extraction operations, but exempts rock quarrying from provisions of the law.

A number of bills concerning environmental issues were introduced in the 1991 legislative session. Topics of the bills included waste recycling, solid waste disposal, hazardous waste, and radon testing in schools. Most of these bills remained in committee and were expected to be carried over to the 1992 legislative session. One bill concerning hazardous waste was passed in 1991. House bill H-5265 was signed into law as Public Law 215. The law provides for notice of violation of hazardous waste disposal to be sent to the mayor or town manager and president of city or town council of the city or town where the real property subject to violation is located.

The Rhode Island State Geologist, together with the other New England State Geologists, investigated the future demand for construction aggregates—sand and gravel and crushed stone—in the New England region. The aggregates demand study was initiated by the New England Governors Council with funds provided by the U.S. Department of the Interior, Minerals Management Service. The study was the first of a two-part investigation to determine the potential difficulties that may exist in establishing the availability of construction aggregates in New England. The first part of the investigation, which focused on aggregate demand and the problems faced by aggregate producers in opening new production facilities, was published in January 1992.[5] The second part of the investigation, which will focus on the location and quantities of sand and gravel deposits that are available for eventual development, will be initiated in 1992.

A cooperative agreement for funding the Office of the State Geologist in fiscal year 1992 was drafted by the Rhode Island Division of Planning. The major project will be to advance work on a surficial geologic map at a scale of 1:100,000. This multiyear project should be of great value to planners, ground water aquifer managers, solid waste managers, sand and gravel operators, and others concerned with land planning and the environment throughout the State.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Gypsum.—Highland America of Rhode Island Inc. operated a gypsum fiberboard plant for part of 1991. The gypsum fiberboard, trade named Gypsonite, is a relatively new type of drywall construction board that is made from natural gypsum and cellulose fiber. It was first introduced in Germany in 1984. Unlike conventional wallboard, Gypsonite is a solid material and looks like plaster. Gypsum for the plant was mined in Nova Scotia and brought in by ship and truck. The source of the cellulose was recycled newspapers.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Construction sand and gravel was the second leading mineral commodity produced and accounted for 45% of the State's total mineral value. In 1991, the estimated production and value of construction sand and gravel each declined by 34% from 1990 levels. Average unit value remained essentially the same as that of 1990 at about $4.06 per short ton f.o.b. A total of 11 companies mined construction sand and gravel at 18 pits in 3 counties. Leading counties, in order of output, were Providence, Kent, and Washington. The material was used mainly for concrete aggregate, road base and covering, and fill.

In August, the Coventry Town Council approved an amendment to the town's 1990 soil erosion and sediment control ordinance, which required sand and gravel companies in Coventry to submit plans to the town for controlling erosion and sediment within a given time period. The amendment enables the town to fine each company $250 per day for every day plans are not submitted. Under terms of the erosion ordinance, if the town determines that the possibility of significant environmental damage exists, soil erosion and sediment control plans must be submitted within 60 days of notification. Although some operators have shown a willingness to work with the town, the town was planning to bring at least two companies to court near yearend.

Industrial.—Holliston Sand Co. Inc., Providence County, was the only producer of industrial sand in the State. Most of the sand was used for filtration, blasting, golf course sand, and molding and core.

Stone (Crushed).—Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

TABLE 2

RHODE ISLAND: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Riprap and jetty stone	21	125	$5.95
Filter stone	66	427	6.47
Coarse aggregate, graded:			
Concrete aggregate, coarse	W	W	5.73
Bituminous aggregate, coarse	120	795	6.63
Bituminous surface-treatment aggregate	168	899	5.35
Railroad ballast	W	W	10.71
Fine aggregate (-3/8 inch): Stone sand, concrete[2]	163	911	5.59
Coarse and fine aggregates: Terrazzo and exposed aggregate[3]	125	678	5.42
Other construction materials[4]	97	548	5.65
Agricultural:			
Agricultural limestone	15	137	9.13
Unspecified:[5]			
Actual	415	2,741	6.60
Total[6]	1,187	7,262	6.12

W Withheld to avoid disclosing company proprietary data: included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes granite, limestone, and traprock.
[2]Includes screening, undesignated.
[3]Includes graded roadbase or subbase, unpaved road surfacing, and crusher run or fill or waste.
[4]Includes withheld amounts for coarse aggregate, graded.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.
[6]Data may not add to totals shown because of independent rounding.

Crushed stone was the State's leading mineral commodity, accounting for almost 55% of the State's total value. In 1991, production and value decrease 25% and 17%, respectively, compared to those of 1990. Six companies operated six quarries in three of the State's five counties. Limestone accounted for the majority of stone produced, followed by granite and traprock. The average unit value was $6.12 per short ton f.o.b. Most of the stone was used for bituminous aggregate, road base, and concrete aggregate.

The Cumberland Town Council was continuing to study a noise ordinance that would limit the hours of the day some outdoor businesses could operate. Earlier in the year, the town council had asked its ordinance subcommittee to study the proposed noise ordinance after complaints about blasting at the J. H. Lynch & Sons crushed stone quarry. Residents near the quarry contended that blasting at the quarry devalued their homes and represented a health and safety hazard. Near yearend, the town council was researching the legality and wording of such a proposed ordinance.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related experience and has covered the mineral activities in Rhode Island for the past 7 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]Rhode Island Department of Economic Development, Research Division. Rhode Island Economic Trends—Dec. 1991. Jan. 30, 1992.

[3]"Average number of workers" is a summary of the average number of workers at individual mining establishments during periods (not necessarily continuous) of active operations."

[4]U.S. Department of Labor, Mine Safety and Health Administration. Mine Injuries and Worktime Quarterly, Jan.-Dec. 1991, 33 pp.

[5]Construction Aggregates Demand in the New England States. The New England Governors' Conference Inc. in cooperation with Minerals Management Service, U.S. Department of the Interior, Boston, MA: The Conference (1992), 219 pp.

TABLE 3
RHODE ISLAND: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989[1]				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	3	676	$4,259	$6.30	2	437	$2,931	$6.71
Granite	1	532	2,845	5.35	2	584	3,234	5.54
Traprock	1	W	67	W	2	166	1,097	6.61
Total	XX	1,208	[2]7,170	5.94	XX	1,187	7,262	6.12

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Excludes traprock, quantity only; withheld to avoid disclosing company proprietary data.
[2]Data do not add to total shown because of independent rounding.

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Construction (1990):			
Acme Sand & Gravel Inc.	100 Armento St. Johnston, RI 02919	Pit	Providence.
A. Cardi Construction Co. Inc.	451 Arnold Rd. Coventry, RI 02816	Pit	Kent.
Material Sand & Stone Corp.	RFD 1, Greenville Rd. Woonsocket, RI 02895	Pits	Providence.
Richmond Sand & Gravel Inc.	Box 389 Wyoming, RI 02898	Pit	Washington.
River Sand & Gravel Co. Inc.	101 Ferris St. Pawtucket, RI 02861	Pits	Kent.
South County Sand & Gravel Co.	Box 3725 Peace Dale, RI 02883	do.	Washington.
Industrial:			
Holliston Sand Co. Inc.	Box 97, 303 Lowland St. Holliston, MA 01746	Pit	Providence.
Stone:			
Cherenzia Excavation Inc.	41 Ledward Ave. Westerly, RI 02891	Quarry	Washington.
The Conklin Limestone Co. Inc.	RFD 1 Lincoln, RI 02865	do.	Providence.
J. H. Lynch & Sons Inc.[1]	825 Mendon Rd. Cumberland, RI 02864	do.	Do.
Peckham Brothers Co. Inc.	Box 193 Newport, RI 02840	do.	Newport.
Tilcon Inc.	875 Phoenix Ave. Cranston, RI 02920	do.	Providence.
Todesca Forte Inc.	14 Whipple St. Berkley, RI 02864	do.	Do.

[1]Also sand and gravel.

RHODE ISLAND

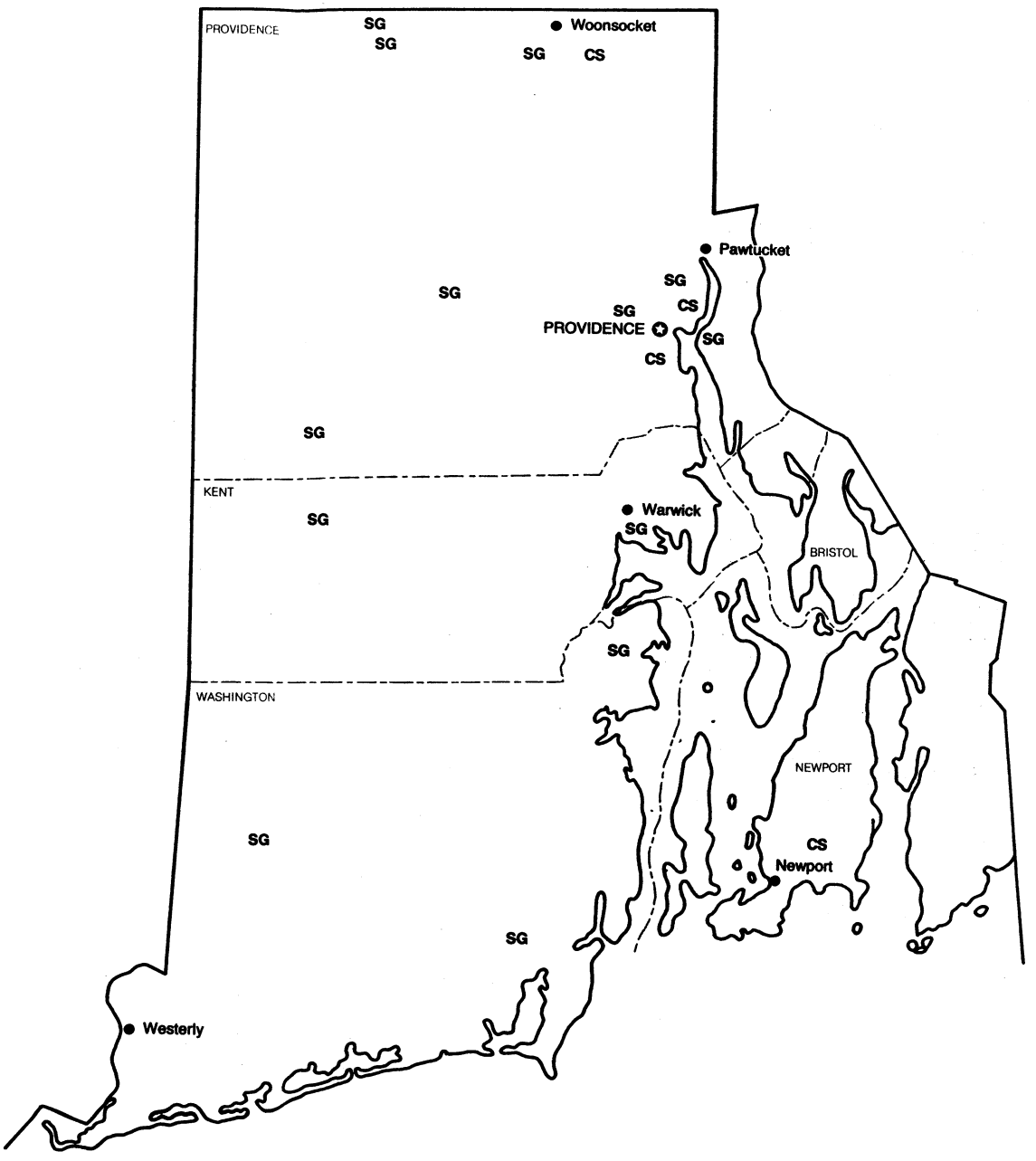
LEGEND

- State boundary
- County boundary
- Capital
- City

MINERAL SYMBOLS

- CS Crushed Stone
- SG Sand and Gravel

Principal Mineral-Producing Localities



THE MINERAL INDUSTRY OF SOUTH CAROLINA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the South Carolina Geological Survey for collecting information on all nonfuel minerals.

By Steve W. Sikich[1]

The value of nonfuel mineral commodities produced in South Carolina in 1991 was $338 million, a 24.9% decrease from the previous year's value of $450 million. A decline in the value of the State's three leading minerals, cement, crushed stone, and gold, accounted for 81% of the decrease. Of the 13 major mineral commodities produced in South Carolina, only industrial sand and gravel, with a modest 2.4% increase, showed a higher value in 1991 than in 1992.

As a result of the lower mineral revenue, South Carolina dropped from 24th in 1990 to 32d in 1991. It also ranked 22d in the value of industrial minerals and 18th in the value of metals. The State led the Nation in vermiculite production, ranked second in kaolin output, and remained the only gold-producing State in the Eastern United States.

TRENDS AND DEVELOPMENTS

South Carolina's economy declined in 1991 after reaching record highs in each of the 8 previous years. Although the national economy began to recede in July 1991 after 92 consecutive months of growth,[2] South Carolina's economy continued to grow for an additional 6 months. This resulted largely as the aftermath of rebuilding following Hurricane Hugo's devastation of coastal South Carolina in late 1989. After this rebuilding was completed, the State's economy weakened and its mineral production followed suit. The decline was led by lessened demand for the State's major mineral commodities. Crushed stone, the leading commodity in 1990, decreased 37.7% from $135.4 million to $84.3 million. Cement became the leading mineral produced in 1991, although its value decreased 9.0% from $109.6 million in 1990 to $99.7 million. Gold values also decreased partly as a result of the weaker economy and partly as a result of mining operations being suspended at two of South Carolina's four mines for much of the year. Mining at the Brewer Mine in Lancaster County resumed in June after being discontinued in late 1990 because of a tailings dam failure. The State's oldest gold mine, Piedmont Mining Corp.'s Haile Gold

TABLE 1
NONFUEL MINERAL PRODUCTION IN SOUTH CAROLINA[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	2,188	$99,083	2,464	$109,644	e2,215	e$99,675
Clays	metric tons	1,596,153	39,075	2,062,824	44,486	1,709,205	25,662
Gemstones		NA	10	NA	10	NA	10
Sand and gravel:							
Construction	thousand short tons	e7,500	e23,300	8,627	24,941	e6,600	e18,900
Industrial	do.	842	16,635	844	15,972	822	16,348
Stone:							
Crushed[2]	do.	24,429	111,656	e26,200	e135,400	18,216	84,260
Dimension	short tons	W	W	W	W	8,829	854
Combined value of cement (masonry), gold, manganiferous ore, mica (scrap), peat, silver, stone [crushed shell (1989-90), crushed dolomite (1991)], vermiculite, and values indicated by symbol W		XX	135,538	XX	119,400	XX	92,436
Total		XX	425,297	XX	449,853	XX	338,145

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain stones; kind and value included with "Combined value" figure.

Mine, terminated mining operations early in the year because of a lack of easily minable reserves. Clay, the State's fourth leading mineral commodity, showed the most dramatic decrease, dropping more than 42% in value from 1990's record high.

Running counter to the State's recessionary trend, the Port of Charleston experienced a record year, exceeding 6 million short tons of containerized cargo handled for the first time. Volume of the port's general cargoes totaled more than 7 million tons. Clay and clay products ranked second both in the amount of containerized cargo handled and in the volume exported. Another significant mineral commodity exported through the port was sheet aluminum. A majority of the aluminum was manufactured by Alumax Inc. at Goose Creek, Berkeley County, and by Alcoa from plants in North Carolina and Tennessee.

South Carolina's fourth gold mine began operations at Barite Hill in McCormick County. In late December, Kennecott Ridgeway Mining Co. announced that it planned to purchase Galactic Resources Ltd.'s interest in the Ridgeway Gold Mine in Fairfield County. In January, Beazer PLC completed the sale of its cement plant at Harleyville to Blue Circle America. Later in the year, Beazer sold its remaining operations in South Carolina to Hansen PLC.

EMPLOYMENT

Preliminary data reported[3] by the Mine Safety and Health Administration (MSHA) showed an average of 2,068 people directly employed by South Carolina's mining industry in 1991. This represents a 9.2% decrease from the 2,277 reported for 1990. Of the total number, 937 were employed in surface mines and 1,131 were employed in mills and preparation facilities.

REGULATORY ISSUES

Regulatory issues did not disrupt the mineral industry in South Carolina appreciably in 1991. Environmental groups periodically decried the use of cyanide to process gold and the landscape disruption caused by the mining operations. The Tuscaloosa Research Center of the U.S. Bureau of Mines worked with several of the gold mining companies in South Carolina. One of the projects that was completed in 1991 related to the control of mine drainage and liquid waste at the Haile Gold Mine. For this study samples of soil and ground water adjacent to an abandoned gold mine and processing site were collected and analyzed to determine the areal extent of cyanide migration. A parallel phase of the investigation to determine an environmentally safe method of closing heap-leach stacks and to develop methods for properly closing these sites once mining has ceased was in progress at yearend. A similar study at the Brewer gold mine in Jefferson County was suspended as a result of the company's temporary shutdown of operations because of a holding pond dam failure.

Concern was expressed by local residents over the development of sinkholes near mining operations in the Loris, Horry County, and Johnstown, Berkeley County, areas. This led to more than 40 Berkeley County residents filing a class-action lawsuit against Southern Aggregates Co. A group of Fairfield County residents organized in an attempt to force county officials to adopt a countywide zone ordinance. The main purpose of the group was to prevent further development of mining and other industries that it does not consider environmentally compatible.[4]

An attempt to ban shipments of hazardous waste from North Carolina was ruled in violation of interstate commerce laws by a Federal judge. South Carolina attempted to impose the ban when North Carolina failed to meet deadlines for construction of a hazardous waste disposal facility that it had agreed to build as part of a five-State compact to which both States belonged.

The U.S. Department of Energy announced in mid-December that it had restarted a nuclear reactor, which had been idled for several years, at the Savannah River Site. The reactor had been rebuilt and modernized at a cost of $3 billion dollars.[5] It is the Nation's only source of tritium, a radioactive gas that increases the explosive force of nuclear weapons.

EXPLORATION ACTIVITIES

Mineral exploration in South Carolina concentrated on the gold segment of the industry; however, activity decreased markedly during the final 6 months of 1991 because of the low price of gold and the general economic recession that adversely affected exploration budgets. Existing producers conducted programs to increase reserves and develop new ore bodies in the vicinity of their existing operations. Amax Gold Inc. began an extensive drilling program as part of its reevaluation of reserves at the Haile Gold Mine. Evaluation of data obtained from the drilling phase of the program, which exceeded 41,000 feet and was largely completed by yearend, was not expected before May 1992. Exploration by Brewer Gold Co. resulted in the discovery of two deposits in Lancaster County about 10 miles from the Jefferson Gold Mine. Nevada Goldfields Corp. initiated an exploration program to supplement reserves at the Barite Hill Gold Mine. Efforts are to be concentrated within a 30-mile radius surrounding the mine.

Corona Corp. and Piedmont Mining Co. terminated their agreement to explore for heavy-mineral sands in the Carolinas. Exploration for heavy minerals by other companies also decreased from the high levels of activity characterizing the previous 2 years.

LEGISLATION AND GOVERNMENT PROGRAMS

The South Carolina mineral industry was indirectly affected by legislation enacted in 1991. The major legislation peripherally affecting the industry was the South Carolina Waste Management Act of 1991. This bill established service fees assessed at the time items are purchased to offset disposal costs and to encourage recycling. Fees assessed on items such

as tires, automotive lubricants, batteries, and large appliances will be used to provide grants for research, construction, or operation of waste treatment or recycling facilities.

The South Carolina Mining Council promulgated regulations to the South Carolina Mining Act that modified the procedures for applications for mining permits, approval of applications for mining permits and reclamation plans, public notice requirements, terms and conditions of mining permits, inspections of mines, public hearing procedures, appeal of mining permit decisions, minimum standards for environmental protection and land reclamation, and mining permit application fees. The promulgated regulations were submitted to the General Assembly for adoption during the 1992 session.

The Mining and Reclamation Program of the South Carolina Land Resources and Conservation Commission reported that 260 mining companies held 486 mining permits covering 67,639 acres as of December 31, 1991. This represents a decrease of 36 permits and 2,145 acres from those of 1 year previously. Of the acres permitted, only 19,429 was actually affected by mining, a decrease of 400 acres from that of the previous year. To ensure the completion of reclamation after mining, the commission had a total of $11,737,857 on file at yearend. A total of 603 acres was reclaimed and released by the commission during the year. Mined lands were reclaimed as grassland, pasture land, ponds and lakes, woodlands, wildlife habitat, recreational areas, and commercial development.

The South Carolina Mining Council ruled in May that appeals to the issuance of a mining permit must be made within 30 days of the date on which the Mining Council announced that a permit would be issued, rather than the date that the permit was actually issued. The decision was made in response to an appeal by citizens of Jamestown protesting the issuance of a mining permit to Southern Aggregates Co. The Mining Council made the decision to issue the permit in late January, and interested parties were notified by the South Carolina Land Resources Conservation Commission on February 8, 1991.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Ten industrial minerals were mined in South Carolina in 1991. Four additional industrial mineral commodities (cement, synthetic graphite, iodine, and exfoliated vermiculite) were produced from raw materials mined within the State, shipped from other States, or imported. The 10 mined minerals and cement accounted for more than 80% of the value of minerals produced in 1990.

Cement.—Portland cement regained its number one position as the most valuable mineral produced after being supplanted by crushed stone for 2 years. Cement production decreased 10.1% from 2,464,000 short tons in 1990 to an estimated 2,215,000 tons in 1991. Its value showed a corresponding 9.0% drop from $109.6 million to $99.7 million. Portland cement represented 29% of the value of South Carolina's total mineral production and more than 36% of its industrial mineral production. Nationally, South Carolina ranked 12th in both the quantity and value among the 38 States producing portland cement. In the production of masonry cement, it ranked second in quantity and fourth in value.

Portland cement was manufactured by Giant Cement Co. and Blue Circle Inc., both in Harleyville, Dorchester County, and by Holnam Inc. in Holly Hill, Orangeburg County. Giant and Holnam also manufactured masonry cement.

Raw materials used in the manufacture of cement in South Carolina included 36,500 tons of limestone, 3.2 million tons of marl, 333,000 tons of clay, 119,000 tons of sand, 46,000 tons of iron ore, 279,000 tons of fly ash, and 147,000 tons of gypsum.

Clays.—Clay production fell drastically after reaching record-high values in 1990. The value of clay produced fell 42.3% from $44.5 million in 1990 to $25.7 million in 1991 primarily as the result of decreases in the quantity and unit value of kaolin produced. Only two types of clay, common clay (used primarily in the manufacture of brick) and kaolin, were produced in 1991.

Common Clay and/or Shale.—Surprisingly, both the quantity and value of common clay produced increased in 1991 although the unit value decreased by 23%. The quantity produced grew 39% from 0.83 million metric tons in 1990 to 1.15 million metric tons in 1991. The increase resulted in a large increase in the reported tonnage of clay used in cement manufacture and a smaller increase in the amount of clay used to manufacture face brick. The value of common clay increased only 7.1% from less than $2.1 million in 1990 to more than $2.2 million in 1991 as the unit value fell from $2.50 per ton to $1.95 per ton.

Common clay production was reported by 14 companies with 25 pits in 14 of South Carolina's 45 counties. This represents an increase of one company, three pits, and one county over common clay operations reported in 1990. Common clay was used in (listed in order of decreasing volume) cement manufacture, common brick, face brick, and miscellaneous floor and wall tile.

Major producers in 1991 were Blue Circle Cement Co. Inc., Dorchester County; Dundee Cement Co., Orangeburg County; Palmetto Brick Co., Marlboro and Kershaw Counties; Richtex Corp., Richland County; and Southern Brick Co., Greenwood and Saluda Counties.

Kaolin.—South Carolina continued to rank second nationally in the value of kaolin produced, although it dropped to third in the quantity produced because of a 55% decrease from that of 1990. Much of this reduced production was related to the one-time use of a large quantity of low-value unprocessed kaolin as fill material for a proprietary project in 1990.

Another factor in the decline was a 29% reduction in the quantity of air-floated kaolin produced. This decrease

TABLE 2
SOUTH CAROLINA: KAOLIN SOLD OR USED BY PRODUCERS, BY KIND

(Thousand metric tons and thousand dollars)

Kind	1990		1991	
	Quantity	Value	Quantity	Value
Air-float	497	37,372	353	21,765
Unprocessed	734	5,036	203	1,672
Total	1,231	42,409	555	23,437

TABLE 3
SOUTH CAROLINA: KAOLIN SOLD OR USED BY PRODUCERS, BY KIND AND USE

(Thousand metric tons)

Kind and use	1990	1991
Air-float:		
Adhesives	12	W
Animal feed and pet waste absorbent	3	3
Ceramics[1]	6	W
Fertilizers, pesticides, and related products	19	W
Fiberglass	135	W
Paper coating and filling	17	W
Rubber	148	167
Refractories[2]	7	W
Other uses[3]	88	W
Exports[4]	60	29
Total	497	353
Unprocessed: Face brick and other uses	r730	197
Grand total[5]	r1,227	550

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Other" and/or "Total."
[1]Includes crockery and earthenware; electrical porcelain; fine china and dinnerware; floor and wall tile; pottery; and roofing granules.
[2]Includes refractory calcines and grogs; firebrick, blocks and shapes; refractory mortar and cement; and high-alumina refractories.
[3]Includes animal oils; catalysts (oil refining); chemical manufacturing; ink; medical; sewer pipe; and unknown uses.
[4]Includes ceramics; adhesives; paper filling; pesticides and related products; and rubber.
[5]Data may not add to totals shown because of independent rounding.

resulted largely from the shift by paper manufacturers that had been using air-floated kaolin as a filler in their manufacturing process to precipitated calcium carbonate. This led kaolin producers to attempt to replace the lost sales of high unit value paper-grade kaolin with sales to the lower unit value fiberglass and rubber markets. Air-floated kaolin producers in neighboring Georgia responded in a similar manner, thereby increasing the competition faced by South Carolina producers. The resulting oversupply of air-floated kaolin for fiberglass further depressed the unit value of the kaolin and resulted in a 42% drop in the value of air-floated kaolin sold. Table 2 compares quantity and value of the different types of kaolin produced for the years 1990 and 1991.

Processed kaolin was produced by five companies from seven pits in Aiken County. Producing companies were Dixie Clay Co., a subsidiary of R. T. Vanderbilt Co.; J. M. Huber Corp.; Kentucky-Tennessee Clay Co., a subsidiary of Hecla Mining Co.; National Kaolin Co., a subsidiary of W. R. Grace and Co.; and Southeastern Clay Co. Almost 87% of the quantity and more than 95% of the value of kaolin produced in Aiken County was air floated. Major end uses for air-floated kaolin were in rubber, which increased 12.6% over 1990's production, and fiberglass, which decreased 40.7%. Data on kaolin used as a catalyst for oil refineries and as paper filler, the next most common uses, was withheld. Other uses of kaolin are included in table 3.

Unprocessed kaolin, used primarily in the production of bricks, was reported by Carolina Ceramics Inc., Richland County; Dixie and National, Aiken County; Guignard Brick Works, Calhoun County; Palmetto Brick Co., Kershaw County; and Richtex Corp., Lexington and Richland Counties. Tables 2 and 3 summarize kaolin used in South Carolina by kind and end use, respectively, for the years 1990 and 1991.

Mica.—South Carolina continued to rank fourth nationally in the value of crude mica produced, although production for 1991 was less than that of 1990. Piedmont Mining Co. continued to mine "mineralite" mica, a weathered, fine-grained, white micaceous mineral assemblage that mineralogically would be more correctly classified as a sericite. The ore is dry processed and used mainly as a filler in paint, with additional applications in joint compounds, electronic plastics, rubber, and foundry facings. Plant capacity is rated at 25,000 to 30,000 short tons per year. Piedmont operated the property, located adjacent to the Haile Gold Mine near Kershaw, Lancaster County, through its wholly owned subsidiary, Mineral Mining Co. Inc.

Spartan Minerals Corp., a subsidiary of FMC, Lithium Div., was one of the Nation's six largest producers of ground mica in 1991. The company processed mica and a feldspar-silicate concentrate obtained from FMC's lithium operations near Bessemer City, NC, for use by glass and whiteware manufacturers.

Peat.—American Peat and Organics Co. remained South Carolina's only peat producer. The peat is mined for potting soil and soil-conditioning additives from Snuggedy Swamp near the Edisto River

TABLE 4

SOUTH CAROLINA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch): Riprap and jetty stone[2]	577	3,378	$5.85
Coarse aggregate, graded:			
Concrete aggregate, coarse	2,494	15,144	6.07
Bituminous aggregate, coarse	1,172	7,671	6.55
Bituminous surface-treatment aggregate	307	2,165	7.05
Railroad ballast	W	W	5.48
Fine aggregate (-3/8 inch):			
Stone sand, concrete	W	W	5.32
Stone sand, bituminous mix or seal	564	2,638	4.68
Screening, undesignated	913	2,349	2.57
Coarse and fine aggregates:			
Graded road base or subbase	1,842	8,024	4.36
Crusher run or fill or waste	775	3,182	4.11
Other construction materials[3]	1,077	5,603	5.20
Chemical and metallurgical: Cement manufacture	W	W	1.77
Special: Asphalt fillers or extenders	W	W	5.00
Other miscellaneous uses[4]	1,769	3,721	2.10
Unspecified:[5]			
Actual	6,440	28,801	4.47
Estimated	286	1,584	5.54
Total[6]	18,216	84,260	4.63

W Withheld to avoid disclosing company proprietary data: included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes granite, limestone, marl, and shell; excludes a minor amount of dolomite withheld to avoid disclosing company proprietary data.
[2]Includes macadam and filter stone.
[3]Includes withheld amounts for coarse aggregate, graded, and fine aggregate (-3/8 inch).
[4]Includes withheld amounts for chemical and metallurgical, and special.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.

in Colleton County. Of 19 producing States, South Carolina ranked 17th in the value of peat mined in 1991.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Construction sand and gravel production was estimated at 6.6 million short tons valued at $18.9 million. This represented a 24% decrease in both quantity and value from those reported in 1990 (8.6 million tons and $24.9 million, respectively).

MSHA[6] inspected 57 active construction sand and gravel pits operated by 49 companies in 26 counties. Eight of the operations were listed as operating on an intermittent basis during 1991.

A conditional-use permit that would have allowed sand and gravel mining in the James River was revoked by the Charleston County Council in February. A proposed purchaser of the property had applied to have provisions related to mining the property made less stringent. An application for a sand and gravel permit near Red Bank in Lexington County was pending at yearend.

Industrial.—South Carolina continued to rank 10th in the value and improved from 12th to 11th in the quantity of industrial sand produced in 1991. Industrial sand was produced in 37 States. The value increased 2.4% to $16.3 million, although the volume mined decreased by 2.6% to 822,000 short tons. At $19.88 per ton, the unit value of industrial sand processed in South Carolina was the highest in the Nation, averaging almost 30% more than the national average of $15.25.

Five companies, two of which consented to releasing production data, produced industrial sand and gravel in 1991. Whibco Inc., with one operation near Leesburg, Kershaw County, produced almost 150,000 short tons valued at $1.5 million. U.S. Silica Co. from three pits in Lexington County produced slightly more than 500,000 short tons valued at $11.3 million. Other producers included Unimin Corp. in Kershaw County and Columbia Silica Sand Co. and Foster Dixiana Corp., both in Lexington County. Each company had one industrial sand and gravel operation.

W. R. Bonsal and Co. permanently terminated operations at its site near Beech Island, Aiken County. The operation, designed to produce both construction and industrial sand and gravel, began in 1990 and closed without reaching projected capacity.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

South Carolina crushed stone statistics are compiled by geographic districts as depicted on the State map. These data are summarized by major use category in table 4, by use and district in table 5, and by kind in table 6.

Crushed.—Crushed stone dropped to second in the value of minerals produced after leading for 2 years. Production declined to 18.2 million short tons, a 30.5% decrease from estimated production in 1990 and 25.4% less than that reported in 1989, the last year the industry was surveyed.

Crushed stone was produced by 13 companies with 32 operations in 18 of the State's 46 counties. The largest

TABLE 5
SOUTH CAROLINA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[2]	W	W	W	W	—	—
Coarse aggregates, graded[3]	2,421	14,264	W	W	W	W
Fine aggregates (-3/8 inch)[4]	976	4,153	W	W	W	W
Coarse and fine aggregates[5]	1,266	5,777	W	W	W	W
Other construction materials	1,353	6,880	2,513	13,482	2,962	9,318
Chemical and metallurgical[6]	—	—	—	—	W	W
Special[7]	W	W	—	—	—	—
Unspecified:[8]						
Actual	944	4,976	3,709	15,371	1,787	8,455
Estimated	234	1,526	—	—	52	57
Total	7,194	37,576	6,222	28,853	4,801	17,830

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Excludes dolomite; withheld to avoid disclosing company proprietary data.
[2]Includes macadam, riprap and jetty stone, and filter stone.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[5]Includes graded road base or subbase, crusher run (select material or fill), and other construction and maintenance uses.
[6]Includes cement manufacture.
[7]Includes asphalt fillers or extenders.
[8]Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 6
SOUTH CAROLINA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991[1]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	8	4,474	$19,339	$4.32	5	2,487	$10,935	$4.40
Dolomite	—	—	—	—	—	—	—	—
Calcareous marl	4	W	W	1.97	4	3,296	6,812	2.07
Shell	2	W	W	1.19	1	135	554	4.10
Granite	20	16,822	86,140	5.12	21	12,298	65,959	5.36
Total	XX	24,429	[2]111,656	4.57	XX	18,216	73,325	4.03

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Excludes dolomite; withheld to avoid disclosing company proprietary data.
[2]Data do not add to total shown because of independent rounding.

producers, in order of quantity produced, were Martin Marietta Aggregates (7 operations), Vulcan Materials Co. (6 operations), Tarmac Mid-Atlantic Inc. (4 operations), Holnam Inc. (1 operation), CSR American Inc., Southern Aggregates Div. (3 operations), and Hansen, USA (2 operations). The six operations accounted for 80% of the crushed stone produced in South Carolina in 1991, with each producing more than 1 million short tons. Major uses of crushed stone are summarized in table 4.

Hansen PLC, a United Kingdom-based industrial management conglomerate, purchased Beazer PLC, another British conglomerate with extensive holdings in the construction and industrial mineral industries in the United States. Included in the purchase were granite aggregate quarries in Anderson and Greenville Counties.

Dimension.—The value of dimension stone quarried in South Carolina decreased 6.7% from that of 1990, although the quantity produced remained essentially unchanged. In 1991, 8,800 short tons valued at $854,000 was quarried. Granite, the only rock type quarried, was produced by three companies: Matthews International Corp. with quarries in Kershaw and Lancaster Counties, and North Carolina Granite Co.

and Georgia Granite Co. Inc., each with a quarry in Kershaw County. The granite was sold as rough blocks, rough monumental stone, cut veneer stone, and sawed stone blocks.

Vermiculite.—South Carolina, one of three States in which vermiculite was mined, continued to lead the nation in both the quantity and value produced. Vermiculite was mined by three companies in Laurens County: W. R. Grace & Co., Patterson Vermiculite Co., and Virginia Vermiculite Ltd. A mine operated by Enoree Minerals Corp. in Spartanburg County was inactive during the year.

W. R. Grace began mining operations on a 4-acre tract in the Laurens County Park. When the land is restored after mining is completed in 1992, royalties from the mining operation will be used to build two new ballfields at the park.

South Carolina continued to rank second in the quantity and improved from third to second nationally in the value of exfoliated vermiculite produced. Both the quantity and value increased approximately 13% from those of the previous year. Exfoliated vermiculite was produced by W. R. Grace and Patterson Vermiculite Co. primarily for use in agriculture, insulation, and aggregate applications.

Other Industrial Minerals.—The value of gemstones produced in South Carolina remained at $10,000. The State tied with neighboring Georgia in ranking 32d nationally. All 50 States reported gemstone production. A minor amount of manganiferous schist was mined by two brick manufacturing companies for use as a brick colorant. The value of manganese ore mined decreased by more than 90% from that of 1990 because brick manufacturers switched to using imported manganese oxide as a colorant. Sericite schist was mined for use in manufacturing brick by Industrial Minerals Inc. in Cherokee County and by Boral Brick Co., Boren Brick Co., and Carolina Ceramics in Kershaw County.

Several other industrial minerals were produced or used in South Carolina from materials shipped in from out-of-State. Industrial Minerals Inc. also ground calcium borate minerals imported from Turkey for sale to fiberglass manufacturers. Synthetic graphite was used to make low-modulus cloth and fiber and high-modulus fibers by Amoco Performance Products Inc. in Greenville. High-modulus fibers were also manufactured by BASF Corp., Structural Materials Div., in Rock Hill, York County.

Showa Denco Carbon Inc., a subsidiary of Tokyo-based Showa Denco K.K., manufactured graphite carbon electrodes used in high-temperature electric arc furnaces in Ridgeville, Dorchester County.

Westvaco Corp. manufactured organic iodine compounds at the North Charleston, Charleston County, plant. Kaolin from Florida and ball clay from Tennessee and Kentucky were used by the Kohler Manufacturing Co. to produce sanitaryware at its Spartanburg plant. Heckett Div., Harsco Corp., processed steel slag for aggregate from Georgetown Steel Corp.'s minimill in Georgetown. Slag from MacAlloy Corp.'s ferroalloy plant in Charleston was used for aggregate, refractory material, and roofing shingle applications.

Metals

The only metals of commercial value mined in South Carolina were gold and byproduct silver, which was recovered during the gold refining process. Gold was mined at four operations, all of which used cyanide leaching to separate the gold from the ore. Although not mined in South Carolina, several other metals were shipped into the State for processing into higher value products. Included in these were aluminum, copper, nickel and titanium alloys, and steel.

Gold.—The U.S. Bureau of Mines withholds production data for gold in South Carolina; however, published data[7] estimated the State's production at 179,000 troy ounces. Based on these data, South Carolina retained its ranking as the seventh leading State in gold production. Gold production decreased in 1991 partly because of the temporary closing of the Jefferson Mine and suspension of mining at the Haile Mine. These decreases were not offset by increased production from the Barite Hill Mine, which completed its first year of production in 1991.

Kennecott Ridgeway Mining Co., a subsidiary of the United Kingdom's RTZ Corp. PLC (RTZ), acquired 100% control of the Ridgeway Mine in Fairfield County when it purchased Galactic Resources Ltd.'s 48% share of the mine late in December. Galactic had earlier announced[8] its intention to sell its interest in the mine to Placer Dome Inc. of Vancouver, British Columbia. RTZ then exercised its right of first refusal to purchase Galactic's share under the terms offered by Placer Dome.

Nevada Goldfields Corp. (NGC) purchased the assets of Gwalia (U.S.A.), a wholly owned subsidiary of Australia's Gwalia International Ltd. Included in the purchase was Gwalia's Barite Hill Gold Mine in McCormick County. Gwalia International then acquired a 60% controlling interest in NGC.

In mid-February, Piedmont Mining Co. Inc. announced that it reached a joint-venture agreement with Amax Gold Inc. Under terms of the agreement Amax would conduct an exploration program at Piedmont's Haile Gold Mine in Lancaster County. If warranted by results of the exploration, Amax could then purchase a 62.5% interest in the Haile Mine under terms previously agreed upon. Evaluation of the property was expected to be completed by May 1992, at which time Amax was to announce its decision. Piedmont announced[9] in mid-November that preliminary results of the exploration program indicated that three areas could contain 640,000 ounces of gold with an average grade of 0.061 ounce per ton. Piedmont discontinued mining operations at the site in January, but continued its heap-leaching operations throughout the year.

Brewer Mining Co. resumed mining operations at the Jefferson Gold Mine in western Chesterfield County in July. Operations had been suspended since late

October 1990 because of the failure of a tailings pond dam. Brewer applied for mining permits to develop two pits in Lancaster County northwest of the Jefferson Mine. Ore from the pits will be trucked approximately 10 miles to the Jefferson Mine for processing.

Blythe and McCarter, a local company, applied for zoning and State mining permits to develop a gold mine in western York County southeast of Hickory Grove. The company proposed a placer operation in which the gold would be hydraulically concentrated at the site and shipped to Nevada for processing.

Silver.—Recovery of silver was reported by three of the four companies mining gold. Two companies consented to releasing data on their production. Piedmont Mining Co. Inc. reported 5,321 troy ounces valued at $21,497 from 235,461 short tons of treated material. NGC reported the recovery of 4,100 ounces valued at $16,564 from 173,803 tons of treated material.

Other Metals.—Although gold and silver are the only metals with commercial value mined in South Carolina, significant amounts of copper (1.5% locally) have been reported to occur in the gold ore at the Brewer Mine. Recovery of the copper has not been economically feasible.

Primary aluminum was produced by Alumax Inc., a wholly owned subsidiary of Amax Inc., at its Mount Holly, Berkeley County, plant. Blasius Group Inc., operating under chapter 11 bankruptcy protection, suspended secondary aluminum ingot production at its Spartanburg plant in March. The company resumed operations in May, processing recyclable aluminum for scrap dealers. The scrap was processed in a 30-foot by 90-foot rotary kiln. Company officials indicated[10] they would consider resuming secondary aluminum ingot production if market conditions improved dramatically. Other companies processing aluminum in South Carolina included Alcoa Fujikura Ltd. and Kaiser Aluminum and Chemical Corp. Aluminum used in the manufacture of automotive components and electrical products is processed by Alcoa Fujikura Ltd. at Spartanburg. The Stolle Corp., another Alcoa subsidiary, processed aluminum into building products at Gaffney, Cherokee County. Kaiser, a Maxxam Inc. subsidiary, produced aluminum forgings in Greenwood, Greenwood County.

Gaston Copper Recycling Corp., a subsidiary of Southwire Co. of Carrollton, GA, exported copper and precious metals from its plant in Gaston, SC, to Venezuela.

In December, the Environmental Protection Agency denied a request by Ethyl Corp. for a waiver to permit the sale of methylcyclopentadienyl manganese tricarbonyl (MMT) as an additive to boost octane in unleaded gasoline. Had the request been granted, Ethyl would have manufactured the additive at its plant in Orangeburg. MMT manganese additives have been used as gasoline additives in Canada for more than 10 years.

Teledyne Allvac began production at its new continuous bar rolling mill in Richburg, Chester County, and announced[11] plans to begin construction on a adjacent $10 million finishing facility. Construction of the rolling mill started in September 1989 and was originally scheduled to be completed by December 1990. Both titanium and high-temperature nickel alloy, in straight-length bars and rod coils weighing up to 3,000 pounds, were produced. The titanium and nickel superalloys were used in the aerospace industry, for biomedical implants, and in the automotive industry.

Steel rods were produced by Georgetown Steel Co. at its minimill in Georgetown. Florida Steel Corp. integrated its wholly owned subsidiary, Stafford Rail Products Inc., into an operating division of the parent company. Stafford, located at Lancaster, produced rail track spikes that are sold throughout the United States.

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[1]State Mineral Officer, U.S. Bureau of Mines, Tuscaloosa, AL. He has 33 years of industry and government experience and has covered the mineral activities in South Carolina since 1989. Assistance in the preparation of the chapter was given by Maylene E. Hubbard, editorial assistant.

[2]South Carolina Board of Economic Advisors. 1991 Economic Report. Dec. 1991, p. 18.

[3]U.S. Department of Labor Mine Injuries and Worktime, Quarterly. Jan.-Dec. 1990, p. 15.

[4]The Herald Independent (Winnsboro, SC). Land Use Plan Is Goal of Citizen Group. Mar. 21, 1991, p. 1.

[5]Tuscaloosa (AL) News. Nuclear Arms Plant Being Restarted. Dec. 14, 1991, p. 3A.

[6]U.S. Department of Labor. Quarterly Mine Report—Mine Inspection Data Analysis System. Jan. 22, 1991, pp. 979-992.

[7]Mining Engineering. Growth in U.S. Primary Gold Production Slowed in 1991. V. 44, No. 2, Feb. 1992, p. 130.

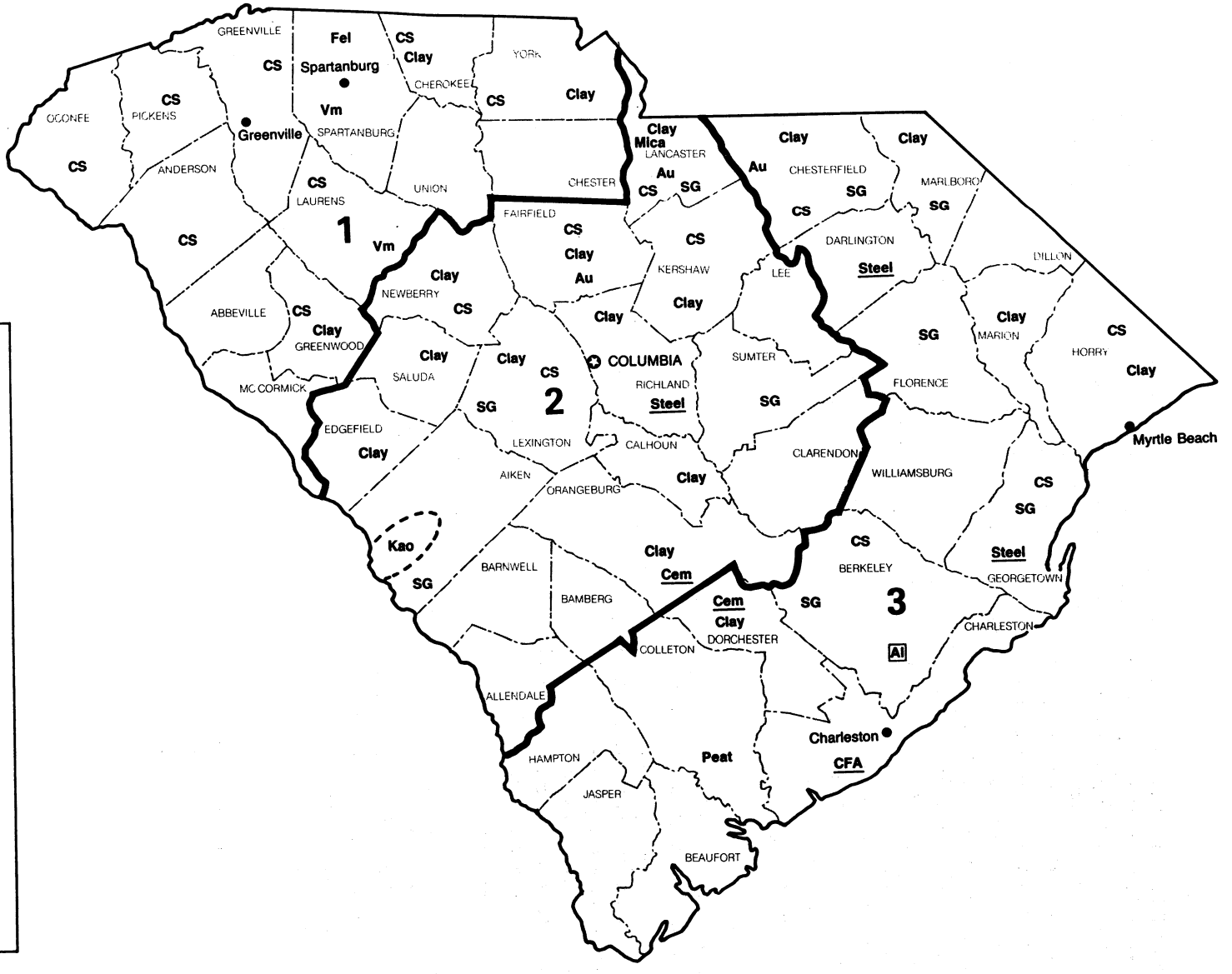
[8]American Metal Market (New York, NY). Galactic, Placer Dome in Ridgeway Mine Deal. V. 99, No. 228, Nov. 26, 1991, p. 2.

[9]The State (Columbia, SC). Piedmont Mining Co. Nov. 15, 1991.

[10]American Metal Market (New York, NY). Blasius Processing Recyclable Aluminum. V. 99, No. 97, May 21, 1991, p. 16.

[11]———. Allvac Will Build New $10 Million Finishing Facility. V. 100, No. 25, Feb. 6, 1992.

SOUTH CAROLINA



LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Al	Aluminum plant
Au	Gold
Cem	Cement plant
CFA	Chrome Ferroalloy plant
Clay	Clay
CS	Crushed Stone
Fel	Feldspar
Ful	Fuller's earth
Kao	Kaolin
Mica	Mica
Peat	Peat
SG	Sand and Gravel
Steel	Iron and Steel plant
Vm	Vermiculite

Concentration of mineral operations

Principal Mineral-Producing Localities

TABLE 7
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum (smelters):			
Alumax Inc.	Box 1000 Goose Creek, SC 29445	Plant	Berkeley.
Kaiser Aluminum & Chemical Corp.	1508 Hwy. 246 S. Greenwood, SC 29646	do.	Greenwood.
Cement:			
Blue Circle Industries, PLC[1]	Box 326 Harleyville, SC 29448	do.	Dorchester.
Giant Cement Co.[1]	Box 218 Harleyville, SC 29448	do.	Do.
Holnam Inc.[1]	Box 698 Holly Hill, SC 29059	do.	Orangeburg.
Clays:			
Common clay and shale:			
Palmetto Brick Co.	Box 430 Cheraw, SC 29520	Pits and plant	Kershaw and Marlboro.
Richtex Corp.[2]	Box 3307 Columbia, SC 29230	do.	Lexington and Richland.
Southern Brick Co.	Box 208 Ninety Six, SC 29666	do.	Greenwood and Saluda.
Kaolin:			
J.M. Huber Corp.	Box 306 Langley, SC 29834	do.	Aiken.
Kentucky-Tennessee Clay Co.	Route 7, Box 965 Aiken, SC 29801	do.	Do.
National Kaolin Products Co., a subsidiary of W.R. Grace & Co.	Box 2768 Aiken, SC 29802	do.	Do.
Southeastern Clay Co.	Box 1055 Aiken, SC 29801	do.	Do
Feldspar:			
Spartan Minerals Corp., a subsidiary of FMC, Lithium Div.	Box 520 Pacolet, SC 29372	do.	Spartanburg.
Gold:			
Brewer Gold Co., a subsidiary of Westmont Mining Co.	Route 2, Box 57 Jefferson, SC 29718	Mine and plant	Chesterfield
Kennecott Ridgeway Mining Co.	Route 2, Box 106 Ridgeway, SC 29130	do.	Fairfield
Nevada Goldfields Inc.	Box 1530 McCormick, SC 29835	do.	McCormick
Piedmont Mining Corp.	Box 505 Kershaw, SC 29067	do.	Lancaster
Mica (sericite):			
Mineral Mining Co., a subsidiary of Piedmont Mining Co.	Box 458 Kershaw, SC 29067	do.	Do.
Sand and gravel:			
Augusta Sand & Gravel Co.	Box 472 Clearwater, SC 29822	Pits and plants	Aiken.

See footnotes at end of table.

TABLE 7—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued:			
Brewer Sand Co. Inc.	Box 267, Route 2 Lancaster, SC 29720	Pits and plants	Chesterfield and Lancaster.
Foster-Dixiana Sand Co.	Box 5447 Columbia, SC 29250	do.	Lexington.
Stone:			
Crushed:			
Martin Marietta Aggregates	Box 30013 Raleigh, NC 27612	Quarries and plant	Berkeley, Georgetown, Horry, Lexington, Richland, York.
Southern Aggregates Co.	Box 191 Jamestown, SC 29453	do.	Berkeley, Horry, Orangeburg.
Tarmac America Inc.	Box 5185 Columbia, SC 29250	do.	Fairfield, Greenwood, Richland.
Vulcan Materials Co.	Box 8834 Greenville, SC 29605	do.	Cherokee, Greenville, Laurens, Pickens, Spartanburg.
Dimension:			
Georgia Stone Industries, Div. of Florida Crushed Stone Co.	Box 898 Elberton, GA 30635	do.	Kershaw.
Matthews International Corp.	Box 606 Kershaw, SC 29067	do.	Kershaw and Lancaster.
North Carolina Granite Co.	Box 151 Raleigh, NC 27612	do.	Kershaw.
Vermiculite:			
Carolina Vermiculite Div. of Virginia Vermiculite Ltd.	Box 98 Woodruff, SC 29388	Mines and plant	Do.
W.R. Grace & Co.	Route 1 Enoree, SC 29335	do.	Laurens.
Patterson Vermiculite Co.	Route 1 Enoree, SC 29335	do.	Do.

[1]Also common clay and crushed stone.
[2]Also kaolin.

THE MINERAL INDUSTRY OF SOUTH DAKOTA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the South Dakota Geological Survey for collecting information on all nonfuel minerals.

By Eileen K. Peterson[1] and Richard H. Hammond[2]

In 1991, the value of nonfuel mineral production in South Dakota was about $290 million, a 6% decrease from the record-high 1990 level of $310 million. Decreases in the values of gold, silver, and sand and gravel production accounted for most of the decline in value. The value of gemstone production jumped significantly from the estimated $110 thousand in 1990 with the opening of a rose quartz mine. Modest increases in value were observed for cement, feldspar, lime, and crushed and dimension stone.

Nonfuel mineral production came from 63 of the State's 67 counties. Lawrence County was again the leading county in terms of value for nonfuel mineral production, contributing almost two-thirds to the State's total.

The State ranked 34th nationwide in the total value of nonfuel mineral production, accounting for about 1% of the Nation's total. South Dakota ranked fourth in gold production, behind Nevada, California, and Utah, fourth in gemstone production, and in the top five nationally in the production of mica.

Gold, the principal commodity produced in the metallic sector, accounted for approximately $6 out of every $10 of the State's total nonfuel mineral value. In terms of value, leading nonmetallic commodities were cement, gemstones, sand and gravel, and stone. Construction commodities contributed about 30% of the State's total nonfuel mineral production value.

TRENDS AND DEVELOPMENTS

Most of South Dakota's industrial minerals production is used in construction. According to U.S. Department of Commerce figures for South Dakota, 2,507 new residential units valued at $146 million were permitted for construction in 1991. Permitted nonresidential construction was valued at $102 million.

State mineral extraction taxes for 1991 generated $5.2 million for the State treasury. That figure represented a 35% drop in 2 years. Gold and silver severance taxes in South Dakota, the highest in the country, are based on a twofold system: companies are taxed on gross production and on profits. Lower gold prices and production resulted in the decreased severance tax payments.

The South Dakota Supreme Court overturned a South Dakota Board of Minerals and Environment 1989 decision not to transfer a mine permit from Homestake Mining Co. to Minerva

TABLE 1
NONFUEL MINERAL PRODUCTION IN SOUTH DAKOTA[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Gemstones		NA	$150	NA	$110	NA	W
Gold[2]	kilograms	16,123	198,318	r17,870	r221,157	16,371	$191,217
Lead[2]	metric tons	4	3	—	—	—	—
Sand and gravel (construction)	thousand short tons	e6,400	e20,800	9,689	23,689	e8,700	e20,800
Silver[2]	metric tons	4	705	r10	r1,566	7	944
Stone:							
Crushed	thousand short tons	3,833	14,303	e4,800	e16,800	4,824	19,657
Dimension	short tons	54,623	17,738	e50,688	e12,871	W	W
Combined value of cement, clays (common), feldspar, gypsum (crude), iron ore (usable), lime, mica (scrap), and values indicated by symbol W		XX	32,341	XX	34,310	XX	57,304
Total		XX	284,358	XX	r310,503	XX	289,922

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Recoverable content of ores, etc.

Explorations Inc. for the Ragged Top area near Spearfish Canyon. The Department of Environment and Natural Resources (DENR) had recommended that the Board transfer the permit; however, the Board voted against the transfer. Minerva has not announced whether it will mine and treat the ore on-site or ship the ore elsewhere for treatment.

Homestake Mining continued work on expansions of the company's Open Cut Mine and the historic Homestake underground mine, both in Lead. Permitting for the $30 million expansion of the Open Cut was in process with the State. The expansion will require relocation of about 460 meters (1,500 feet) of highway through Lead, relocation of approximately 175 homes and businesses, and construction of a highway overpass to transport waste rock to a dump. Underground, work on the 4.8-kilometer-long (3-mile) exploration drift to the North Homestake Project neared the halfway point this year. The 5-year, $23 million project is being driven off the 2,070-meter level (6,800-foot) of the underground mine. In September, Homestake began an unprecedented minewide shutdown of the underground operation. Because of unacceptable safety problems and four fatalities during the year, mine sections were shut down sequentially to correct safety and equipment problems. The inspection was expected to last into 1992.

Brohm Mining Corp. decided to place on hold plans for a large sulfide expansion project at the company's Gilt Edge Mine east of Lead. Continued low gold prices were cited as the major reason for the decision.

EMPLOYMENT

Despite some monthly variations in mining employment, South Dakota Department of Labor figures indicated the 1991 employment figure of 2,520 was down slightly from the 1990 average of 2,600 employees. Construction employment increased slightly in 1991 to 11,878, up from 11,676 in 1990. Oil and gas extraction employment figures remained unchanged from those of 1990.

The mining industry in South Dakota had the highest average annual earnings of any industry group in the State in 1991. Average mining earnings were $32,810, up 4.3% from $31,453 in 1990 and a 5-year increase (1987-91) of 17.8%. Metal mining had the highest average at $35,916, oil and gas earnings averaged $26,144, and other mining averaged $25,915. U.S. Department of Labor statistics indicated the 1991 average annual wage in the State was $16,450, about 50% of the average for the mining sector.

Four fatalities from four separate accidents were reported in 1991 in South Dakota's underground mining operations. No fatalities were reported from associated mills and/or operation plants or surface mines. During the almost 4.6 million employee-hours worked at mines and mining facilities, a reported 125 injuries occurred to workers resulting in lost workdays and an additional 148 injuries occurred with no workdays lost.

REGULATORY ISSUES

Because of a 2-year moratorium on new mining operations, the South Dakota Board of Minerals and Environment (SDBME) issued no life-of-mine permits for large-scale mines in 1991.

SDBME made its first preliminary designation of a "special or unique area" under House bill 1289 (passed by the 1989 State legislature). Spearfish Canyon and its entire 38,850-hectare (96,000-acre) watershed area, about 20% of the land area in Lawrence County, was designated as an "exceptional, special, critical, or unique" land area. The designation does not preempt mining in the area but does add a more stringent set of rules and questions to be answered before permits will be granted.

The Whitewood Creek U.S. Environmental Protection Agency (EPA) Superfund site and about 27 kilometers (17 miles) of Whitewood Creek were nominated for designation but were determined not eligible by the SDBME. Whitewood Development Corp. (a wholly owned subsidiary of Homestake) and Goldstake Explorations formed a joint venture, Whitewood Creek Joint Venture, to examine the possibility of recovering gold from relict mine tailings along the creek using a sodium cyanide heap-leach pad system. The 27-kilometer-long (17-mile) area has more than 9.4 million metric tons (10.4 million short tons) of tailings containing more than 15,550 kilograms (500,000 troy ounces) of recoverable gold. At yearend, the project was on hold because of low gold prices.

During 1991, two Notices of Violation were issued by DENR for environmental problems. Brohm Mining was issued both notices and was assessed a penalty of $99,800 for a release of cyanide solution to surface and ground water. The cyanide solution apparently leaked through a heap-leach pad berm when the pad was being used to store excess storm water from spring rains. Brohm reached an agreement with the State and Homestake to transport excess storm water to Homestake's Grizzly Gulch tailings dam. At another mine, elevated levels of nitrate were detected in drainage from waste rock depositories. The nitrate levels did not exceed permitted levels, however, and no fines were assessed. Research was undertaken to identify possible sources of the elevated nitrate levels. All other large-scale gold mining in the Black Hills proceeded within required environmental controls.

Cleanup at the abandoned Spokane Mine site southeast of Keystone was undertaken when the mine was found to contain chemical and physical hazards. Abandoned shafts, adits, mill tailings, and a waste pit were covered or sealed at a cost of $420,000. The Spokane Mine produced lead, silver, and zinc from about 1898 until 1940.

Waste disposal and landfills continued to make news in South Dakota in 1991. RSW Inc., a Torrington, CT, company, proposed a 2,050-hectare (5,067-acre) solid waste landfill on the Rosebud Sioux Indian Reservation, Todd County. The landfill would be used to dispose of ash from waste incineration. Concerns about lead and cadmium in the ash have been voiced by reservation residents and

environmental groups. The decision whether to approve the landfill will be made by the tribe and the U.S. Bureau of Indian Affairs.

Late in 1991, two former investors in the bankrupt CMC (Consolidated Waste Management Corp.) filed a preliminary application with the South Dakota DENR to reopen the defunct sewage-ash landfill near Edgemont in Fall River County. A new company, Fall River Properties, was formed to manage the project that would dispose of about 136,000 metric tons (150,000 short tons) of ash per year at the old Igloo munitions depot 8 kilometers (5 miles) south of Edgemont. CMC had planned to extract gold and other precious metals from the ash. DENR will review the application and make a recommendation to the SDBME, which has the authority to approve or deny the permit.

The South Dakota Supreme Court was reviewing several lawsuits related to the proposed Lonetree Landfill, also near Edgemont. SDBME authorized the South Dakota Disposal Systems Inc. landfill in 1989; however, because of ongoing opposition, the landfill has not been constructed. In the November 1990 election, voters approved a law requiring legislative approval of large-scale landfills. The 1991 legislature approved the landfill but opponents gathered enough signatures to put the issue on the November 1992 ballot. Late in 1991, the operating company filed two lawsuits against the State seeking financial damages resulting from delayed opening of the landfill and to stop the Statewide vote on the landfill scheduled for November 1992. The company wants a judge to rule on whether the landfill can begin operation. At yearend, no decision had been reached.

EXPLORATION ACTIVITIES

The South Dakota DENR issued 11 exploration permits in 1991, down from the 15 issued in 1990. Eight of the 11 permits were for gold exploration in Lawrence and Pennington Counties. A 16% increase from 1990 permits was noted in the number of exploration drill holes permitted. Some companies have slowed exploration activities in South Dakota because of uncertainties about the future of mining in the State pending State action on the recommendations of the Cumulative Environmental Evaluation (CEE), completed in December 1990.

Kalahari Resources of Vancouver, Canada, conducted a geophysical program in the Keystone area of Pennington County. Based on estimates in a 1940 U.S. Bureau of Mines Bulletin,[3] the company estimated that two long inactive mines in the Keystone area contain estimated reserves of 1.3 million metric tons with 10.6 grams of gold per metric ton (1.4 million short tons of 0.31 ounce of gold per short ton). Gold mineralization is hosted in a Precambrian iron-formation similar to that at the Homestake Mine at Lead. Kalahari holds a land position 8.8 kilometers long (5.5 miles) and up to 0.8 kilometer wide (0.5 mile). Upon completion of the geophysical work, 12 anomalies were identified with lengths from 305 to 914 meters (1,000 to 3,000 feet).

LEGISLATION AND GOVERNMENT PROGRAMS

During the 1991 session, the South Dakota Legislature defeated a proposal to extend the moratorium on large-scale gold and silver mining in the Black Hills. The current 2-year moratorium is scheduled to expire January 1, 1992.

The CEE of mining in the Black Hills was completed in December 1990, and six recommendations were presented to SDBME in 1991. The major impacts on mining would be a proposed 2,430-hectare (6,000-acre) limit on large-scale gold and silver surface mines in the Black Hills and a requirement that 202 hectares (500 acres) of land affected by the mines be reclaimed by September 1997. All six of the recommendations will be part of the Second Century Environmental Protection Act to be considered by the 1992 South Dakota Legislature.

DENR completed a study funded by the Western Governors' Association regarding cyanide testing of treated spent ore.

The U.S. Forest Service began studying reclamation plans for an abandoned uranium strip mine at Riley Pass near Ludlow, Harding County. Uranium was produced from the area in the 1960's by strip mining uranium-bearing lignite coal beds up to 24 meters (80 feet) below the ground surface. Full-scale restoration of the 81-hectare (200-acre) site could cost as much as $8 million.

The South Dakota Geological Survey continued to assess the potential for economic deposits of manganese in eastern South Dakota and completed reports on sand and gravel resources in Lincoln and Codington Counties.

An allotment grant of $148,000 from the U.S. Bureau of Mines was received by the Mining and Mineral Resources Research Institute at the South Dakota School of Mines and Technology in Rapid City. The grant was given under provisions of Public Laws 98-409 and 100-483. The purpose of the institute is to coordinate and administer training and research in mining, mineral resources, minerals development, and mineral processing. In State fiscal year 1991, Bureau-sponsored research included the use of insulation in critical areas of hot mines, leaching behavior of metal alloys, fine particle separation by centrifugation, and efficient removal of toxic ionics using liquid fluidized beds. Additional research was done on characterization of metal zoning in sediment-hosted parts of tertiary epithermal-mesothermal systems in the northern Black Hills. Twelve graduate fellowships benefited by the allotment grant.

South Dakota received $592,000 in Federal royalties for minerals produced on Federal lands within the State borders. The money represents the State's share of bonuses, rents, and royalties collected by the U.S. Department of the Interior's Minerals Management Service. The State also received about $1.3 million in Payments in Lieu of Taxes through the U.S. Bureau of Land Management to offset the loss of revenues caused by tax-

exempt Federal land located within the jurisdiction of local governments.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Gold and Silver.—The quantity and value of gold produced in the State decreased slightly from the 20-year high reported in 1990 of 17,870 kilograms (574,537 troy ounces). Production of silver, obtained as a coproduct with gold at four of the five major gold mines, also fell from the revised 1990 production figure of 10 metric tons (324,815 troy ounces).

Collectively, in 1991 the major gold mining operations processed in excess of 8.7 million metric tons (9.6 million short tons) of ore from which 16,371 kilograms (526,261 troy ounces) of gold and 7 metric tons (233,590 troy ounces) of silver were recovered. The average unit prices in 1991 were $363.29 per troy ounce for gold and $4.04 per troy ounce for silver, down from 1990 when gold was $384.93 per troy ounce and silver was $4.82 per troy ounce.

All the major gold operations were within an 11.3-kilometer (7-mile) radius of Lead, in Lawrence County. Four of the five major gold producers recovered gold by heap leaching with cyanide; the other producer used vat leaching with cyanide.

Homestake, despite having an almost 18% drop in gold production, continued to be the State's largest gold producer, accounting for nearly two-thirds of the total output. The decrease in gold production resulted from lower ore grades and an interruption in underground production. The underground mine underwent a 5-month cleanup and safety evaluation following four unrelated deaths in the mine in 7 months.

Homestake's 1991 annual report reported gold production levels of 7,014 kilograms (225,515 troy ounces) from the underground mine and 2,910 kilograms (93,565 troy ounces) from the Open Cut. To maintain full milling rates, production of lower grade Open Cut ore was increased to offset loss of production from the underground mine. As a result, the average grade of processed ore dropped 15% while tonnage milled increased 5%. A total of 2.3 million metric tons (2.5 million short tons) of ore was milled with an average gold grade of 4.8 grams per metric ton (0.140 troy ounce per short ton) and a recovery of 92.7%. Average cash costs were $377 per troy ounce of gold recovered. Cumulative production from the Homestake mines surpassed 1.13 million kilograms (36.5 million troy ounces) during 1991. Company annual reports listed yearend proven and probable reserves at 26.6 million metric tons with 6.9 grams of gold per metric ton (29.3 million short tons with 0.202 troy ounce of gold per ton). During 1991, Homestake spent $10.6 million on a mill optimization project.

Bond Gold Richmond Hill Inc. (wholly owned subsidiary of LAC Minerals Ltd.) conducted exploration drilling near the Richmond Hill Mine, 8 kilometers (5 miles) northwest of Lead, to define more ore reserves. Current mine reserves will be mined out in 1992 if no additional mining areas are defined and permitted. According to the LAC Minerals annual report for 1991, Richmond Hill Mine produced 1,300 kilograms (41,815 troy ounces) of gold and 1,552 kilograms (49,884 troy ounces) of silver from 1.34 million metric tons of ore (1.48 million short tons). Average gold grade was 0.96 gram per metric ton (0.028 troy ounce per short ton). Cash costs associated with production were $277 per troy ounce of gold produced. Proven and probable gold reserves at yearend were 772,900 metric tons with 1.7 grams gold per metric ton (852,000 short tons with 0.05 troy ounce of gold per short ton).

Operators of the Golden Reward Mine (MinVen Gold Corp. and United Coin Mines), 4.8 kilometers (3 miles) southwest of Lead, encountered problems with pond leakage, slow detoxification of spent ore, and equipment. The mine was basically shut down for most of February and March. Ice buildup on the leach cells precluded use of the reclaimer, and off-loading was done using front-end loaders. Stress fractures in the leach pad were repaired as the cells were off-loaded.

MinVen Gold's annual report for 1991 showed production at the Golden Reward Mine included 1,262 kilograms (40,590 troy ounces) of gold and 2,677 kilograms (86,080 troy ounces) of silver from 1.18 million metric tons (1.3 million short tons) of ore. Cash cost was $269 per troy ounce of gold recovered. At yearend, proven and probable gold reserves within the permitted mine area were identified as more than 9 million metric tons (10 million short tons) with an average gold grade of 1.44 grams per metric ton (0.042 troy ounce per ton). Outside the permitted mine area, the company has more than 3.6 million metric tons of reserves with 1.3 grams of gold per metric ton (4 million short tons with 0.038 troy ounce of gold per short ton).

Late in 1991, MinVen Gold announced plans to acquire the Golden Reward stock held by United Coin Mines (66.7%). MinVen currently holds 33.3% of the Golden Reward stock in addition to 100% of the Gilt Edge Mine, southeast of Lead. The acquisition is subject to regulatory and stockholder approvals.

Operations at the Brohm Mining (subsidiary of MinVen Gold) Gilt Edge Mine encountered problems during the first half of 1991 with heavy rainfall that subsequently led to a cyanide leak and temporarily halted cyanide additions to a heap-leach pad. MinVen Gold's annual reports for 1991 showed production in 1991 included 992 kilograms of gold (29,872 troy ounces) and 1,179 kilograms of silver (37,898 troy ounces) from 1.18 million metric tons (1.3 million short tons) of ore processed. The average gold grade was 1.4 grams per metric ton (0.041 troy ounce per short ton) and recovery was about 61%. Average cash costs were $389 per troy ounce of gold recovered. Both ore processed and gold recovered were down slightly from those of 1990.

The company's annual report for 1991 showed that at yearend, the Gilt Edge Mine had proven and probable reserves

of 745,000 metric tons with 1.2 grams of gold per metric ton (821,000 short tons with 0.035 troy ounce of gold per short ton). Outside the currently permitted mine area, the company reported more than 4.5 million metric tons of ore with 0.89 gram of gold per metric ton (5 million short tons with 0.026 troy ounce of gold per short ton).

Brohm completed feasibility studies for milling operations to recover gold from 40.8 million metric tons (45 million short tons) of sulfide reserves at the Gilt Edge Mine. Because of high cash and capital costs and the low market price for gold, plans for milling the sulfide reserves are on hold. Metallurgical tests indicated some of the sulfide reserves are amenable to heap leaching, and the company is studying this alternate processing plan.

At the Annie Creek/Foley Ridge Mine 6.4 kilometers (4 miles) west of Lead, Wharf Resources Inc. produced a record 2,910 kilograms of gold (93,569 troy ounces) from 3 million metric tons (3.3 million short tons) of ore at a cash cost of $209 per troy ounce of gold recovered. The Annie Creek pit is nearly mined out, except for some small extensions, and backfilling of the pit is expected to begin in 1992. Drilling on mine properties resulted in expanding the proven and probable reserve figure to 22.3 million metric tons with 1.3 grams of gold per metric ton (24.6 million short tons with 0.039 troy ounce of gold per short ton) and drilling outside the permit area defined additional gold ore. At yearend, Wharf had not applied for permits to expand the mine outside the currently permitted area.

Dakota Placers Inc. requested permission from the State to increase processing capacity at the Red-Ex Mine from 382,280 cubic meters (500,000 cubic yards) to 611,650 cubic meters (800,000 cubic yards) per year. The placer operation processes alluvial deposits along Whitewood Creek near Deadwood.

Iron Ore.—Pete Lien & Sons Inc. produced iron ore from a pit near Nemo in Pennington County. The ore was used by the South Dakota Cement Plant in Rapid City as an ingredient in cement manufacturing. Production was estimated by the U.S. Bureau of Mines to have increased significantly from that of 1990.

Industrial Minerals

The State's industrial minerals sector manufactured or produced 10 different industrial minerals. The top three, which accounted for more than 20% of the total nonfuel mineral value, were sand and gravel, stone, and lime.

Cement.—All cement manufactured in South Dakota came from the State-owned plant in Rapid City. Production at the plant increased for the third straight year. The output consisted of portland and masonry cement. Mineral resources used in the manufacturing of cement at this plant included clay, gypsum, iron ore, and limestone. The South Dakota Cement Plant Commission had been looking into burning hazardous wastes in its cement kilns but did not apply to EPA for interim status that would have allowed burning of the wastes.

Clays.—The South Dakota Cement Commission mined common clay in Pennington County for use in cement manufacturing. Production increased slightly in both quantity and value. The State Geological Survey reported that minor amounts of shale were mined for use in production of cement blocks and a small amount was manufactured for expanded shale (lightweight aggregate).

Feldspar.—Feldspar production continued to decrease, both in quantity and value. Production decreased almost 50% from the 1989 level. Pacer Corp. of Custer was the sole processor of the hand-cobbed feldspar from pegmatite deposits in Custer County.

Gemstones.—During 1991, International Rose Quartz began mining rose quartz from pegmatites near Custer, Custer County. The company's production moved South Dakota from the 25th to the 4th largest gem material producer in the country.

Gypsum.—Crude gypsum was produced in Meade County by the South Dakota Cement Commission for use in cement manufacturing. Both quantity and value of production decreased by more than 50% from 1990 figures.

Lime.—Pete Lien & Sons in Rapid City was the sole producer of lime in the State. Although concealed, both production and value of quicklime and hydrated lime increased slightly over 1990 figures.

Mica.—Mica production and value both decreased slightly in 1991. Pacer Corp. of Custer accounted for the entire State output. Scrap mica was produced from pegmatites in Custer County.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1990 and estimates for 1989 and 1991.

Based on company estimates, construction sand and gravel output decreased about 10% from that of the previous year. Leading counties in terms of production were Pennington and Minnehaha.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only: data for even-numbered years are based on annual company estimates. This report contains estimates for 1990 and actual data for 1989 and 1991.

Crushed.—Crushed stone was produced from 11 quarries in 5 counties by 10 operators. Granite, limestone, sandstone, and quartzite were produced in 1991. Production and value in 1991 increased slightly, compared with estimates for 1990. Counties leading in crushed stone production were

TABLE 2

SOUTH DAKOTA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Riprap and jetty stone	20	103	$5.15
Filter stone	87	396	4.55
Coarse aggregate, graded:			
Concrete aggregate, coarse	269	1,240	4.61
Bituminous aggregate, coarse	W	W	4.38
Bituminous surface-treatment aggregate	109	561	5.15
Railroad ballast	63	303	4.81
Fine aggregate (-3/8 inch): Stone sand, bituminous mix or seal[2]	154	455	2.95
Coarse and fine aggregate: Graded road base or subbase	W	W	3.57
Other construction materials[3]	254	998	3.93
Chemical and metallurgical:			
Cement manufacture	W	W	1.30
Lime manufacture	W	W	5.52
Other miscellaneous uses[4]	1,109	2,035	1.83
Unspecified:[5]			
Actual	1,931	10,666	5.52
Estimated	827	2,900	3.51
Total	[6]4,824	19,657	4.07

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes granite, limestone, miscellaneous stone, quartzite, and sandstone.
[2]Includes stone sand, concrete, and screening, undesignated.
[3]Includes withheld amounts for coarse aggregate, graded, and coarse and fine aggregate.
[4]Includes withheld amounts for chemical and metallurgical.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.
[6]Data do not add to total shown because of independent rounding.

Minnehaha, Pennington, and Hanson. Major uses of the crushed stone were concrete aggregate, cement manufacturing, lime manufacturing, and graded road base. Unit values for all crushed stone ranged from $5.15 per short ton for exposed aggregate to $1.30 per short ton for cement manufacturing. Average unit value for all crushed stone uses was $4.08 per short ton.

Dimension.—South Dakota ranked sixth of 34 States in dimension stone production. Milbank Granite, a dark to medium red granite found in the northeastern part of the State, has been quarried continuously since 1907 and is the major source of dimension stone in the State. Three companies, Cold Springs Granite Co., Dakota Granite Co., and Georgia Stone Industries Inc., produced dimension stone from eight quarries in Grant County. Most of the production was used as monument stone, building stone veneer, steps, and floor tile. The average unit value for all uses was about $285 per short ton. A small amount of slate was produced in the Black Hills for use as dimension stone.

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[1]Mining engineer, U.S. Bureau of Mines, Denver, CO. She has 16 years of mineral-related work with the Government. Assistance in the preparation of the chapter was given by Pat LaTour, editorial assistant.

[2]Geologist, South Dakota Geological Survey, Vermillion, SD.

[3]Allsman, P. T. Reconnaissance of Gold-Mining Districts in the Black Hills, SD. U.S. Bureau of Mines Bulletin 727, 1940, 146 pp.

TABLE 3

SOUTH DAKOTA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity
Construction aggregates:								
Coarse aggregates (+1 1/2 inch)[1]	W	W	—	—	W	W	8	31
Coarse aggregates, graded[2]	W	W	—	—	W	W	134	658
Fine aggregates (-3/8 inch)[3]	W	W	—	—	W	W	41	76
Coarse and fine aggregates[4]	W	W	—	—	—	—	—	—
Other construction materials	1,670	4,308	—	—	212	1,018	—	—
Agricultural	—	—	—	—	—	—	—	—
Chemical and metallurgical[5]	W	W	—	—	—	—	—	—
Special	—	—	—	—	—	—	—	—
Other miscellaneous uses	—	—	—	—	—	—	—	—
Unspecified:[6]								
Actual	30	136	—	—	101	364	1,800	10,166
Estimated	820	2,868	—	—	—	—	7	32
Total	2,520	7,312	—	—	313	1,382	1,990	10,963

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes riprap and jetty stone, and filter stone.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).
[4]Includes graded road base or subbase.
[5]Includes cement manufacture and lime manufacture.
[6]Includes production reported without a breakdown by end use and estimates for nonrespondents.

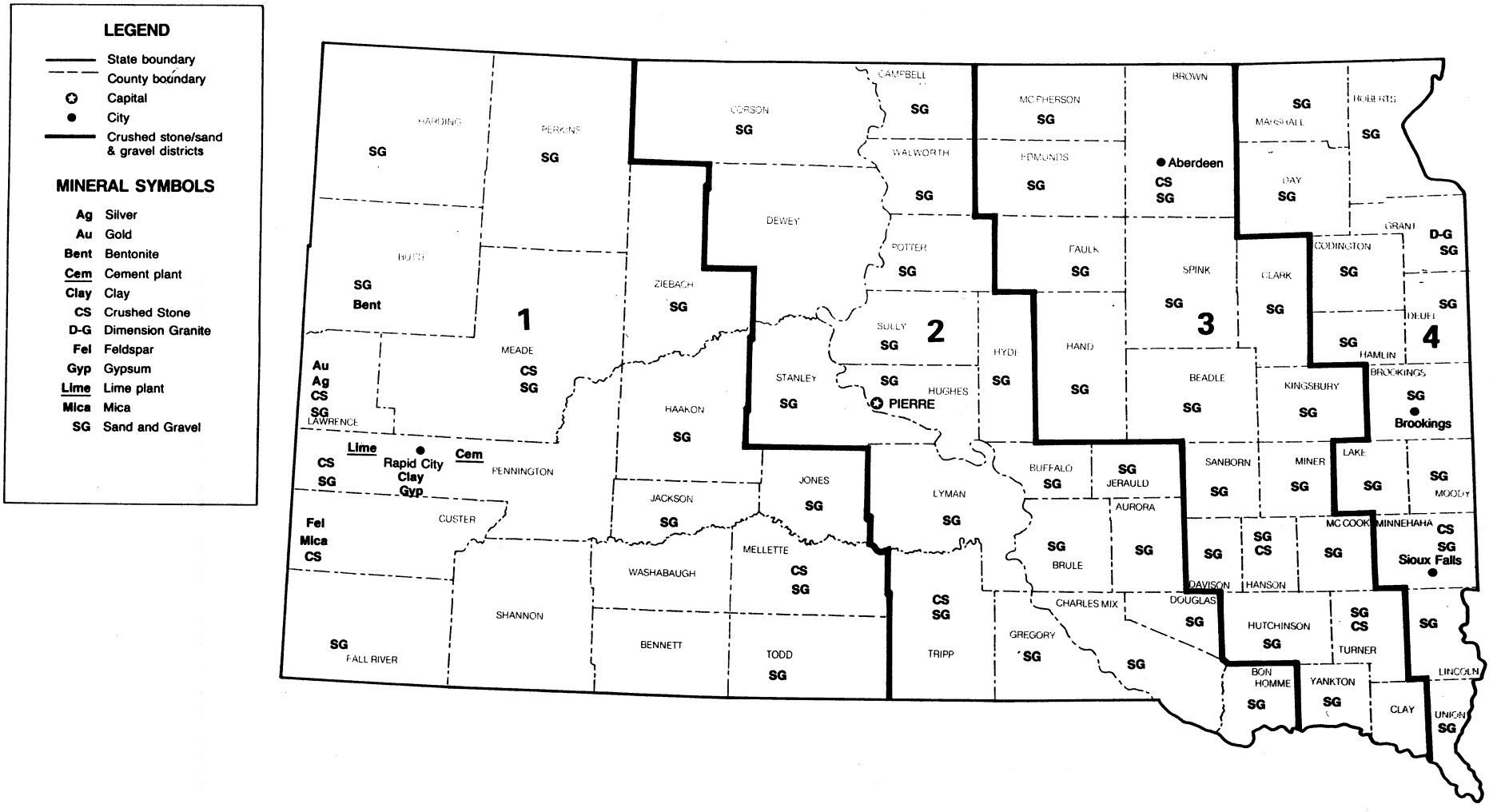
TABLE 4

SOUTH DAKOTA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	8	2,332	$6,697	$2.87	5	2,619	$7,667	$2.93
Granite	—	—	—	—	1	W	W	4.57
Sandstone and quartzite	4	W	W	5.09	4	2,195	11,949	5.44
Miscellaneous stone	1	W	W	4.09	1	W	W	4.50
Total[1]	XX	3,833	14,303	3.73	XX	4,824	19,657	4.07

W Withheld to avoid disclosing company proprietary data, included in "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

SOUTH DAKOTA



Principal Mineral-Producing Localities

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
South Dakota Cement Commission	Box 360 Rapid City, SD 57709	Plant	Pennington.
Clays:			
South Dakota Cement Commission	do.	Open pit mine	Do.
Feldspar:			
Pacer Corp.	Box 912 Custer, SD 57730	Open pit mines and dry-grinding plant	Custer.
Gold:			
Bond Gold-Richmond Hill Inc., a subsidiary of LAC Minerals Ltd.[1]	Box 892 Lead, SD 57754	Open pit and leach pads	Lawrence.
Brohm Mining Corp., a division of MinVen Gold Corp.[1]	Box 485 Deadwood, SD 57732	do.	Do.
Golden Reward Mining Co., a joint venture of United Coin Mines Ltd. and MinVen Gold Corp.[1]	Box 888 Lead, SD 57754	do.	Do.
Homestake Mining Co.[1]	Box 875 Lead, SD 57754	Underground mine and open pit, cyanidation mill, gravity separation, refinery	Do.
Wharf Resources (U.S.A.) Inc.[1]	Box 897 Lead, SD 57754	Open pit and leach pads	Do.
Gypsum:			
South Dakota Cement Commission	Box 360 Rapid City, SD 57709	Open pit mine	Meade.
Iron ore:			
Pete Lien & Sons Inc.	Box 440 Rapid City, SD 57709	do.	Lawrence.
Lime:			
Pete Lien & Sons Inc.	do.	Plant	Pennington.
Mica:			
Pacer Corp.	Box 912 Custer, SD 57730	Mine and dry-grinding plant	Custer.
Sand and gravel (construction):			
Birdsall Sand & Gravel Co., a division of Pete Lien & Sons Inc.	Box 767 Rapid City, SD 57709-0767	Pits and plants	Fall River, Pennington, Sully.
Brownlee Construction Co.	717 South Broadway Watertown, SD 57201	do.	Codington.
Fisher Sand & Gravel Co.	Box 1034 Dickinson, ND 58602	do.	Beadle, Clark, Davison, Hanson, Pennington, Sanborn, Union, Walworth.
Myrl & Roy's Paving Inc.	1300 North Bahnson Sioux Falls, SD 57103	do.	Lincoln and Minnehaha.
Sweetman Construction Inc.	Box 84140 Sioux Falls, SD 57118	do.	Minnehaha and Roberts.
Stone:			
Crushed:			
Limestone:			
Pete Lien & Sons Inc.	Box 440 Rapid City, SD 57709	Quarry and plant	Pennington.

See footnote at the end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone—Continued:			
Crushed—Continued:			
Limestone—Continued:			
Northwestern Engineering Co. (Hills Materials Co.)	Box 2320 Rapid City, SD 57709	Quarries and plants	Pennington.
South Dakota Cement Commission	Box 360 Rapid City, SD 57709	Quarry and plant	Do.
Sandstone-quartzite:			
L. G. Everist Inc.	Box 829 Sioux Falls, SD 57117	do.	Minnehaha.
Spencer Quarries Inc.	Box 198 Spencer, SD 57374	do.	Hanson.
Sweetman Construction Co.	Box 84140 Sioux Falls, SD 57118	do.	Minnehaha.
Dimension, granite:			
Cold Spring Granite Co.	202 South 3d Ave. Cold Spring, MN 56320	Quarries and plant	Grant.
Dakota Granite Co.	Box 1351 Milbank, SD 57252	do.	Do.

[1]Also silver.

THE MINERAL INDUSTRY OF TENNESSEE

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Tennessee Division of Geology for collecting information on all nonfuel minerals.

By Steve W. Sikich,[1] Robert E. Fulweiler,[2] and Ray C. Gilbert[3]

The value of nonfuel mineral commodities produced in Tennessee declined 17.3% to $547.8 million in 1991. This was the first time that the State's mineral output fell since 1985. As a result of the decrease, Tennessee's national ranking dropped from 17th in 1990 to 19th. In order of value, the most important nonfuel mineral commodities produced in Tennessee in 1991 were crushed stone, zinc, cement, clays, and gemstones. The State led the Nation in the value of gemstones and ranked second in the production of zinc.

Significant declines in the value of 9 of the 12 nonfuel mineral commodities mined or produced in Tennessee were responsible for the decrease. Mineral commodities that decreased in value included crushed stone (16.8% to $223.6 million) and construction sand and gravel (10.1% to $21.1 million). The following major commodities, for which data were withheld to protect proprietary company data, also decreased both in quantity produced and in total value: cement, phosphate rock, and zinc. The only mineral commodities that increased in value were clays, gemstones, and industrial sand and gravel.

TRENDS AND DEVELOPMENTS

Nonfuel mineral production in Tennessee was valued at $114.8 million less in 1991 than that in 1990. The decrease in mineral production was a response to a decline in the State's overall economy, which was impacted by the national recession. The increase in published clay value resulted primarily because fuller's earth was included in 1991 but not in 1990. Total clay production increased 16.7%, largely as the result of an increase in fuller's earth production.

An era in the history of the Tennessee minerals industry ended in 1991 when the State's two remaining phosphate rock producers, Occidental Chemical Corp. and Rhône-Poulenc Basic Chemicals Co. Inc., terminated mining and refining operations. This marked the end of 98 years of continuous mining that produced more than 113 million short tons of phosphate rock valued at more than $830 million since the U.S. Bureau of Mines began collecting data in 1910.

Pasco Zinc Products, a Memphis zinc oxide producer, closed its secondary smelter at Millington when it filed for chapter 7 bankruptcy in July. Under chapter 7 regulations, the company's assets will have to be sold; the company cannot reorganize its debts while continuing to operate as it could have had it filed under chapter 11 bankruptcy regulations.

Boliden Intertrade AG of Sweden reorganized the Tennessee Chemical Co.

TABLE 1
NONFUEL MINERAL PRODUCTION IN TENNESSEE[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Clays[2]	metric tons	1,137,152	$26,292	1,060,662	$25,776	828,635	$44,572
Sand and gravel (construction)	thousand short tons	e6,100	e21,900	7,619	23,474	e6,700	e21,100
Stone:							
Crushed	do.	52,917	252,785	e54,600	e268,600	44,088	223,561
Dimension	short tons	4,888	437	e10,108	e2,051	3,460	260
Combined value of barite (1989), cement, clays [common (1989, 1991), fuller's earth (1989-90), kaolin (1991)], copper, gemstones, lead, lime, phosphate rock (1989-90), sand and gravel (industrial), silver, and zinc		XX	336,993	XX	r344,627	XX	258,294
Total		XX	638,407	XX	r664,528	XX	547,787

eEstimated. rRevised. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.

(TCC), which it acquired in 1990, into its BIT Manufacturing Co. subsidiary. BIT began construction of a new sulfur burner that was expected to go on-line in early 1992. The company also planned to spend about $4 million on environmental projects in 1991-92.

United Clays Inc., a major ball clay and kaolin producer headquartered in Gleason, Weakley County, purchased the Yellow Banks Clay Products Co. of Huntingburg, IN, and erected a ball clay processing facility at Sledge, MS. K-T Clay, also headquartered in Gleason, installed a new control room and testing facility at its ball clay operation.

The Rogers Group Inc., Nashville, bought the assets of Crushed Stone Inc., Cowan, Franklin County, and of Lynchburg Stone Inc., Lynchburg, Moore County. The acquisitions gave Rogers, the third largest crushed stone producer in Tennessee, a total of 16 operations. The assets of the State's fourth largest crushed stone producer, Beazer PLC, were acquired by another British firm, Hanson PLC. Hanson gained four limestone quarries in central Tennessee as a result of the purchase.

Franklin Limestone Co., a longtime producer of crushed stone headquartered in Nashville, changed its name to Franklin Industrial Minerals Co. The name change reflects Franklin's growth into the production of specialty mineral fillers and chemical-grade raw materials.

EMPLOYMENT

The U.S. Department of Labor estimated that an average of 5,600 workers were employed in Tennessee's mining industry, including coal, in 1991.[4] This represented a 9.7% decrease from the 6,200 mineral workers employed at the beginning of the year. The U.S. Mine Safety and Health Administration (MSHA) reported 3,689 workers employed in the nonfuel mining sector in 1991.[5] This represents a 9% reduction from the 4,052 workers reported in 1990.

MSHA also reported three fatal accidents in Tennessee's mining industry in 1991. Two occurred in surface crushed stone operations and one occurred in a sand and gravel pit.

Union Zinc Inc. and the United Steelworkers Union agreed to a new 3-year contract at the company's Jefferson City Zinc Mine on December 30, 1 day before the existing contract was scheduled to expire.

REGULATORY ISSUES

Regulatory issues directly related to the minerals industry were restricted primarily to local objections to proposed quarrying and mining operations. To a lesser extent, there were complaints about disturbances caused by existing operations. Most of the issues involved quarrying operations in suburban areas.

The General Assembly enacted a solid waste management program that set a goal of reducing solid waste deposited in municipal landfills by 25% by December 1995. An assessment of facilities, services, and needs for solid waste management must be submitted to the State by September 30, 1992, by each county or by multicounty regions if adjoining counties decide to combine their programs.

The geohydrological survey well being drilled by E. I. du Pont de Nemours & Co. in Humphreys County was completed at a depth of more than 5,827 feet in the Lower Cambrian Copper Ridge Dolomite member of the Knox Group. The well, which was cored from the surface to its total depth, was planned to bottom in the Precambrian crystalline basement at a depth of more than 8,000 feet. The well was begun in 1988 by Du Pont as part of an agreement with the U.S. Environmental Protection Agency (EPA). The company had applied to EPA for permits to drill hazardous waste disposal wells under Underground Injection Control regulations. Reviews by EPA considered some of the data submitted by Du Pont to be inconclusive with respect to underground sources of drinking water. Du Pont agreed to drill the well to obtain precise data that would resolve the issue. Although the well was drilled for environmental reasons, the information it provides should benefit mineral exploration by providing a more complete understanding of regional geology and stratigraphy. Du Pont has offered to donate land, buildings, and other appurtenances at the site of the test well to the Tennessee Division of Geology (TDG).

EXPLORATION ACTIVITIES

Exploration activity in 1991 slowed largely as the result of the State's depressed mineral economy. ASARCO Incorporated continued its underground exploration program in the east Tennessee zinc district. Other companies reported to be conducting active zinc exploration projects included Independence Mining Co., Elko, NV; and Noranda Inc., headquartered in Toronto, Canada.

LEGISLATION AND GOVERNMENT PROGRAMS

Legislation directly affecting the minerals industry was not enacted by the General Assembly in 1991. A bill that changed the name of the Tennessee Department of Conservation to the Department of Environment and Conservation (TDEC) was signed into law in May. For the present, the Division of Geology's functions within the department will remain the same, with emphasis on geologic and mineral resource investigations, publication of geologic maps and other geologic information, and serving as staff to the Oil and Gas Board. Shortfalls in the State's budget mandated cuts in TDG staff positions from 31 to 19 by July 1992.[6]

The Surface Mining Section (SMS) of the Division of Water Pollution Control of TDEC regulates the permitting of noncoal mining operations. Exempted from permitting requirements are limestone and sand and gravel operations. In 1991, 16 new mining permits were issued. The total acreage permitted as of yearend 1991 was 4,540. Of these, 4,086 acres had been disturbed and an additional 1,186 acres had been reclaimed. Seven new coal permits,

which are administered by the U.S. Office of Surface Mining (OSM), were issued in 1991. This brought the total acreage permitted for coal mining to 9,268, of which 5,600 acres had been disturbed. Total coal acreage that has been reclaimed was 3,513.5. The cost to reclaim land disturbed by coal mining varied from $1,860 to $3,280; costs for reclaiming land disturbed by noncoal mining were not available.

A significant number of mine closings in recent years reduced the number of mine inspections.[7] However, the mine inspectors have been assigned the additional responsibilities of inspection and permitting of National Pollutant Discharge Elimination System (NPDES) sites for all surface and underground mining operations in the State.

In 1991, SMS completed four abandoned coal mine reclamation projects under the federally funded Abandoned Mined Land (AML) program. The four tracts comprised 31 acres that was reclaimed at a total cost of $104,964 or $3,385.94 per acre. Plans for the AML in 1992 called for the reclaiming of five additional sites totaling 50 acres at an estimated cost of $192,400.

The U.S. Geological Survey coordinated a seismic study that began in October of potential earthquake hazards along the New Madrid Fault. The study, conducted jointly with the University of Tennessee, Memphis State University, Lamont-Doherty Geological Observatory, and the University of Wyoming, used controlled explosions along the fault to give the participants a better understanding of the structure of the upper 30 miles of the Earth's crust.

FUELS

Coal production in Tennessee decreased by 31.4%, from 6,193,000 short tons to 4,251,000 short tons. End uses of the coal were distributed as follows: utilities, 68%; industrial plants, 28.1%; residential and commercial, 2.4%; and unknown, 1.5%.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Eight industrial minerals were mined in Tennessee in 1991. Their value accounted for more than 75% of the total mineral value produced in 1991.

Barite.—Tennessee's only barite producer, A. J. Smith, Jr., operated a mine and jigging plant on a 1,400-acre tract in the Head of Creek area in McMinn County under contract to New Riverside Ochre Co. (NRO) of Cartersville, GA. The property along the McMinn-Monroe Counties line was acquired by NRO from Baroid Corp. in 1989.

Cement.—Cement was produced by Dixie Cement Co., a subsidiary of Southdown Inc., at Knoxville and by Signal Mountain Cement Co., a subsidiary of IFI International, at Chattanooga. Dixie operated a two-kiln, 550,000-short-ton-per-year dry-process plant. Signal Mountain operated a two-kiln, wet-process facility with a 450,000-short-ton-per-year clinker capacity.

Clays.—Clay production (excluding common clay and kaolin, which were withheld to protect proprietary company data) was 828,635 tons valued at $44,572,000 in 1991. These figures cannot be compared with the figures published for 1990 because that year production data for fuller's earth were withheld while data for common clay and kaolin were included in the published data.

Tennessee ranked 11th in volume and 4th in value with respect to the 44 States that produced clay in 1991. Nine companies mined clay from 35 pits at 20 operations in 10 counties.

Tennessee produced 65.6% of the ball clay mined in the United States, a decrease from the 69.0% produced in 1990. Ball clay was produced by 4 companies with 10 operations and 17 pits in 4 counties. Almost three-fourths of the ball clay was mined in Weakley County.

The types of ball clay sold or used by producers in 1991 were air-float (45%), water-slurried (25%), and unprocessed (30%). The percentage of water-slurried ball clay decreased from that of 1990, whereas that of both air-float and unprocessed ball clay increased. Ball clay production increased to 566,941 metric tons, 4.3% more than that produced in 1990. The major end uses of ball clay, in order of amount sold or used by producers, were sanitaryware; pottery; floor and wall tile; fiberglass; common brick; electrical porcelain; miscellaneous fillers, extenders, and binders; and asphalt tile.

Ball clay was produced by Kentucky-Tennessee Clay Co. (K-T Clay), Old Hickory Clay Co., H. C. Spinks Clay Co. Inc., and United Clays Inc. K-T Clay, a subsidiary of Hecla Mining Co., mined and processed specialty grades of ball clay in Kentucky, Mississippi, and Tennessee. Mining and processing facilities were in Gleason and Whitlock, TN; Mayfield, KY; and Crenshaw, MS. Old Hickory mined from one pit in Henry County and from three pits in Weakley County. Its processing plant and office are in Gleason.

Spinks' headquarters and laboratory are south of Paris, Henry County. Spinks had several active pits and two processing plants near Gleason. United Clays, a subsidiary of Britain's Watts Blake Bearne & Co. PLC, operated six pits in Weakley County and a processing plant at Gleason. In addition to its ball clays, United produced a high-alumina ball clay that was marketed as kaolin for use in the manufacture of fiberglass.

Common clay was mined by two companies with six pits in five counties. The State's largest clay producer was General Shale Products Corp., a Johnson City brick manufacturer. General operated one pit each in Anderson, Knox, and Washington Counties and two pits in Sullivan County. Tennessee's other common clay producer, Signal Mountain Cement Co., mined from one pit in Hamilton County for its plant at Chattanooga.

TABLE 2

TENNESSEE: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	95	483	$5.08
Riprap and jetty stone	1,346	5,919	4.40
Filter stone	279	1,255	4.50
Other coarse aggregate	W	W	4.41
Coarse aggregate, graded:			
Concrete aggregate, coarse	3,972	14,665	3.69
Bituminous aggregate, coarse	6,255	27,454	4.39
Bituminous surface-treatment aggregate	1,621	10,167	6.27
Railroad ballast	211	1,039	4.92
Fine aggregate (-3/8 inch):			
Stone sand, concrete	1,265	7,935	6.27
Stone sand, bituminous mix or seal	347	1,247	3.59
Screening, undesignated	2,693	12,522	4.65
Coarse and fine aggregate:			
Graded road base or subbase	10,080	45,664	4.53
Unpaved road surfacing	230	1,114	4.84
Crusher run or fill or waste	2,678	10,276	3.84
Other construction materials[2]	1,052	4,885	4.64
Agricultural:			
Agricultural limestone	1,056	4,846	4.59
Other agricultural uses[3]	335	3,555	4.41
Chemical and metallurgical[4]	1,396	22,428	16.07
Special:[5]	761	6,566	8.63
Mine dusting or acid water treatment	18	237	13.17
Other miscellaneous uses:			
Chemicals	22	91	4.14
Unspecified:[6]			
Actual	7,424	31,791	4.28
Estimated	953	9,421	9.89
Total[7]	44,088	223,561	5.07

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes dolomite, granite, limestone, miscellaneous stone, and sandstone.
[2]Includes withheld amounts for coarse aggregates (+1 inch), terrazzo and exposed aggregate, roofing granules, building products, and waste materials.
[3]Includes poultry grit and mineral food.
[4]Includes cement manufacture, lime manufacture, flux stone, glass manufacture, and sulfur oxide removal.
[5]Includes asphalt fillers and extenders, whiting or whiting substitute, and other fillers or extenders.
[6]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[7]Data may not add to totals shown because of independent rounding.

All of the fuller's earth mined in Tennessee was classified as montmorillonite. Fuller's earth was mined by Moltan Minerals Co. from two pits in Hardeman County and processed at its plant near Middleton. Southern Clay Inc., a subsidiary of Edward Lowe Industries Inc., renamed its operations near Paris to Golden Cat Corp. The new subsidiary reported production from two pits in Henry County. Major end uses of the fuller's earth were for pet waste, industrial absorbents, and as a fungicide carrier.

Gemstones.—Tennessee once again led the Nation in the value of natural gemstones produced, the value of which increased for the second consecutive year after experiencing a sharp decline in 1989. Gemstone production consisted almost entirely of cultured freshwater pearls and mother-of-pearl derived from freshwater mussel shells of the family Unioidae. Although cultured pearl farming has been established in Tennessee since the late 1970's, the majority of the mussel harvest in Tennessee was exported to Japan where the shells were used to make the bead nucleus for its cultured pearl industry. The shells were also used to make cameos and as mother-of-pearl. The largest producer of cultured pearls in Tennessee was American Pearl Farms, which operated five farms. An associate company, Tennessee Shell Co., was the major producer of mother-of-pearl in the Nation.

Lime.—Tennessee ranked 14th in both volume and value of lime produced in 1991 with respect to the 32 States producing lime. This represented an improvement from 17th in quantity, while the value retained the same ranking as that in 1990. Both quicklime and hydrated lime were produced and sold by Tenn-Luttrell Co. in Union County. Quicklime was produced as a byproduct by the Bowater Paper Co. at its Calhoun plant in McMinn County.

Phosphate Rock.—Phosphate rock production was not reported to the Bureau, although Rhône-Poulenc Basic Chemicals Co. did not terminate mining operations until February 28 and Occidental Chemical Corp. continued mining until April 29. Refinery operations continued at both companies until the end of June.

The Rhône-Poulenc facility at Mount Pleasant had been in continuous operation since 1938 when Victor Chemical Works of Chicago completed construction of the first electric furnace unit in Tennessee. Victor had mined phosphate in Maury County since 1929. The ore was shipped to its blast furnace in Nashville for

TABLE 3

TENNESSEE: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	W	W	W	W	865	3,770
Coarse aggregates, graded[2]	W	W	W	W	6,037	28,352
Fine aggregates (-3/8 inch)[3]	W	W	W	W	2,333	13,295
Coarse and fine aggregates[4]	W	W	6,511	26,727	W	W
Other construction materials	3,379	12,920	7,379	32,379	5,852	28,311
Agricultural[5]	W	W	304	2,775	856	4,498
Chemical and metallurgical[6]	—	—	(7)	(7)	(7)	(7)
Special[8]	—	—	(7)	(7)	(7)	(7)
Other miscellaneous uses	—	—	1,308	7,623	889	21,699
Unspecified:[9]						
Actual	—	—	5,881	23,264	1,543	8,527
Estimated	—	—	301	6,348	652	3,073
Total	3,379	12,920	21,684	99,116	19,027	111,525

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap and jetty stone, filter stone, and other coarse aggregates.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, railroad ballast, and other fine aggregates.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), and fine aggregate (screening-undesignated).
[4]Includes building products, graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run or fill or waste, and roofing granules.
[5]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[6]Includes cement manufacture, chemicals, glass manufacture, lime manufacture, flux stone, and sulfur oxide removal.
[7]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[8]Includes asphalt fillers or extenders, mine dusting or acid water treatment, whiting or whiting substitute, and other extenders and fillers.
[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.

processing. Stauffer Chemical Co. purchased Victor's operation in the mid-1960's and was in turn purchased by Rhône-Poulenc in 1988. Occidental had operated its refinery at Columbia since it purchased Hooker Chemical Corp.'s operations in 1968.

Sand and Gravel.—Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Estimated production of construction sand and gravel decreased 12.1% to 6.7 million short tons in 1991 and its value decreased 10.1% to $21.1 million. This marked the third decline in production in the past 4 years. Although the total value decreased, construction sand and gravel's unit price increased from $3.08 per ton in 1990 to $3.15 in 1991. Tennessee ranked 37th in quantity and 36th in value in comparison with the 49 States producing construction sand and gravel. The rankings were appreciably higher than the 1990 rankings of 42d in quantity and 40th in value.

In 1991, MSHA inspected 52 sand and gravel pits and dredging operations owned by 45 companies in 24 of Tennessee's 95 counties. Of the 52 operations inspected, 24 were worked intermittently and 6 had permanently closed.

Industrial.—Industrial sand and gravel production increased significantly in both quantity and value in 1991, offsetting the drop that occurred in 1990. Tennessee had two industrial sand and gravel producers, The Morie Co. Inc. with two operations and Short Mountain Silica Co. (SMS) with one operation. Morie, the Nation's fourth largest industrial sand and gravel producer, had operations near Camden in Benton County and near Bruceton in Carroll County. The sand was sold to the container, molding and core facing, sand blasting, filtration, and traction sand industries. SMS was near Mooresburg in Hawkins County. An article in Mining Engineering published by the Society for Mining, Metallurgy, and Exploration details the geology of the Short Mountain deposit and the operations of SMS.[8]

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Crushed.—Tennessee crushed stone statistics are compiled by geographic districts as depicted on the State map. These data are summarized by major-use category in table 2, by district and use in table 3, and by kind in table 4.

TABLE 4
TENNESSEE: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	116	48,965	$238,418	$4.87	108	38,524	$196,188	$5.09
Dolomite	7	W	W	3.59	11	W	W	4.22
Granite	—	—	—	—	2	W	1,927	W
Sandstone	1	W	W	5.46	3	W	W	12.04
Miscellaneous stone	1	W	W	4.34	1	W	W	5.13
Total[1]	XX	52,917	252,785	4.78	XX	44,088	223,561	5.07

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

Crushed stone production was 54.6 million short tons, a decrease of 19.3% from the tonnage estimated for 1990. Its value decreased 16.8% to $223.6 million, accounting for 60% of the value of industrial mineral production and 41% of the total value of nonfuel mineral commodities produced in Tennessee in 1991. Nationally, the State dropped from 6th to 11th in the quantity of crushed stone produced, but maintained its ranking of 8th in value as the unit value increased from $4.92 per ton in 1990 to $5.07 per ton in 1991.

Sixty companies with 120 operations and 125 quarries in 62 of Tennessee's 95 counties reported crushed stone production. This compares with 71 companies, 124 operations, 125 quarries, and 60 counties in 1989, the last year that crushed stone producers were surveyed. The five largest companies were Vulcan Materials Co. (26 quarries—same as in 1989), American Limestone Co. (11 quarries—1 more than in 1989), Rogers Group Inc. (16 quarries—2 more than in 1989), Beazer/Hanson (4 quarries—same as in 1989), and Franklin Industrial Minerals Co. (2 quarries—2 less than in 1989).

Major uses of crushed stone, each accounting for more than 5 million short tons, were graded road base, unspecified uses, bituminous aggregate, and fillers. The list is quite different from a comparable list in 1989 that included crusher-run fill, concrete aggregate, bituminous aggregate, lime manufacture, surface treatment, cement manufacture, and concrete sand from crushed stone.

High-purity limestone used for whiting and $CaCO_3$ fillers and extenders was quarried by Franklin Industrial Minerals at Crab Orchard, Cumberland County, and at Anderson, Franklin County.

Four quarries operated by The Stoneman Inc., headquartered in Chattanooga, were acquired by Hanson PLC when it purchased the assets of Beazer USA. The quarries are in Bedford, Hamilton, Rutherford, and Warren Counties. Vulcan Materials Co. acquired three ready-mix concrete plants in the Chattanooga area. The Cocke County Road Commission voted unanimously not to lease or sell its limestone quarry near Newport. Both Vulcan and American Limestone had expressed an interest in acquiring the property.

Dimension.—The output of dimension stone decreased 65.8% in quantity and 87% in value from the estimated production reported from 1990. Compared to 1989, the last year the industry was surveyed, dimension stone production fell from 4,888 short tons valued at $437,000 to 3,460 short tons valued at $260,000. Two companies, Crab Orchard Stone Co. and the Houston Co., reported production in 1989 but did not report any in 1991. Companies reporting production in 1991 included Ross L. Brown Cut Stone Co. and Turner Brothers Stone Co. Inc., both quarrying sandstone in Cumberland County, and Imperial Black Marble Corp., quarrying marble in Grainger County. Luck Stone Co. operated a marble finishing plant in Blount County but did not report dimension stone production from Tennessee in 1991. The Luck Stone plant, which finished marble shipped from the Yule Quarry in Colorado, was reported for sale at yearend. Luck Stone donated the building that had served as the marble display center to the city of Friendsville. The marble-facade building, together with the display samples, was moved to the town's center where it will be restored as a library and museum.

Other Industrial Minerals.—At least 10 industrial mineral commodities were shipped into Tennessee where they were used to manufacture higher value products. The value of these added-value products is not included in table 1. Tennessee ranked first nationally in the production of synthetic graphite in 1991. Union Carbide Corp. produced anodes, electrodes, unmachined shapes, and graphite powder at plants in Clarksville and Columbia. High-modulus fibers were manufactured by the Fortafil Fibers Div. of Akzo-Enka America Inc. at Rockwood, Roane County, and by Great Lakes Resources Corp. at Elizabethton, Carter County.

Eastman Chemical Co. completed a $200 million expansion of its chemicals-from-coal complex in Kingsport, Sullivan County. The expansion will increase the production of acetic anhydride from 560 million pounds to 1.2 billion pounds.

About 80% of the acetic anhydride is used to manufacture cellulose acetate, which is used to manufacture photographic films, textile fibers, packaging sheets, and varnishes.

Sulfuric acid was manufactured at Copperhill, Polk County, by BIT Manufacturing Co. BIT began construction of a new sulfur burner that is part of a $12 million upgrade of the No. 1 acid plant expected to be completed early in 1992. Sulfuric acid and byproduct gypsum were produced as byproducts of zinc refining operations at Jersey Miniere Zinc Co.'s facility in Clarksville. Byproduct gypsum was also produced by the phosphate refining operations in Maury County before they closed. Tennessee ranked seventh in quantity and fifth in value out of nine States in which byproduct gypsum was produced.

Cyprus-Foote Mineral Co. (CFM) began an expansion of its butyllithium production facilities at New Johnsonville, Humphreys County. Completion of the project was scheduled for 1993. CFM also indicated that it was beginning studies to increase production 50% by building a second plant at New Johnsonville. Butyllithium is used in rubber and pharmaceutical products produced from lithium metal as the raw material.

Olin Corp., Charleston, Bradley County, used 448,000 short tons of salt to produce chlorine at its 256-ton-capacity chlor-alkali plant. In all, Tennessee manufacturers used 708,000 tons of salt in 1990, 2% more than the 696,000 tons used in 1989.

Perlite from the Western United States was expanded by the Chemrock Corp. of Nashville for use in lightweight aggregates, insulation, absorbents, horticultural products, and insulation.

Du Pont manufactured titanium tetrachloride from rutile, ilmenite, and high-TiO_2 slag at its New Johnsonville titanium dioxide pigment plant. The $TiCl_4$ was oxidized to form TiO_2, which is calcined to remove the residual chlorine to produce the TiO_2 pigment.

Metals

Zinc was the only metal mined in Tennessee in 1990. Minor quantities of several other metals, cadmium, germanium, lead, and silver, were recovered as byproducts when the zinc ore was refined. Secondary metals manufactured from raw and recycled materials shipped in from out-of-State or originating in Tennessee were significant contributors to the State's mineral industry, although they were not included in table 1. Included in this group are aluminum, ferroalloys, lead, manganese, steel, uranium, and zinc.

Zinc.—Zinc was mined by Asarco and Union Zinc Co. Inc., a subsidiary of Belgium's Union Meniére SA. Asarco operated the Young, New Market, Immel, and Coy Mines, all in eastern Tennessee. Union Zinc's operations included two mines and mills in eastern Tennessee, a mine and mill in central Tennessee, and a refinery at Clarksville. The facilities are run by three divisions of Union Zinc. The Davis Mine and mill at Jefferson City and the Idol Mine in the Copper Ridge Zinc District were operated by the Jefferson City Zinc Co. and the Clinch Valley Mining Co., respectively. In middle Tennessee, Jersey Miniére Zinc Co. operated the Elmwood-Gordonville Mine and mill in Smith County and the zinc refinery at Clarksville. Although the Bureau withholds zinc production data in Tennessee to protect proprietary company data, outside sources[9] reported that Asarco's four mines in Tennessee had a production of approximately 67,000 tons of zinc in 1991. Overall, Tennessee maintained its ranking as the second leading State in the production of zinc.

Zinc Products Div. of the Ball Corp. produced penny blanks, zinc battery cans, and rolled strip zinc at its plant at Greeneville, Greene County. North American Oxide produced 12 grades of zinc oxide for the rubber, chemical, paint, plastics, ceramics, and other industries from its new Clarksville plant. Specific uses included paint pigment and as a rubber curing agent in the manufacture of tires.

Before closing in mid-1991, Pasco Zinc Products Corp., a subsidiary of Canada's Pigment & Chemical Co., Memphis, produced zinc oxide powder from raw zinc mined in Canada supplemented with purchased recycled zinc milled from scrapped metal.

Horsehead Resource Development Co. (HRD), Rockwood, Roane County, recovered cadmium, lead, and zinc from electric arc furnace (EAF) udust. The concentrate was sold to HRD's sister company, Zinc Corp. of America, which recovered the metals. HRD claims to recover 98.5% usuable products from the dust, saving 7.7 million cubic feet of uncompacted landfill space and conserving 500,000 tons of zinc ore annually.[10]

EAF dust was also processed at the Florida Steel Co. plant in Jackson, Madison County. IMS Inc., a wholly owned subsidiary of EnviroSource Inc., Stamford, CT, operated the on-site facility.

Other Metals.—The Aluminum Co. of America operated a two-potline, 200-metric-ton-per-year plant at Alcoa, Blount County. Alcan Aluminum Ltd. operated an aluminum scrap facility at Shelbyville, Bedford County. An Alcan subsidiary, Alcan Recycling Co., operated a 140-million-pound-per-year secondary aluminum smelter at Shelbyville, Bedford County. The plant processed recycled aluminum diecaster scrap but did not process used beverage cans (UBC). A secondary aluminum smelter and milling facility was operated by Consolidated Aluminum Corp. at New Johnsonville. Metal Resources Inc. recycled scrap metals and processed aluminum drosses and UBC in Loudon County. The plant has five furnaces with a capacity of 12 million pounds, about one-half of which comes from 2 billion UBC.

Two companies in Maury County, Occidental Chemical Corp., Columbia, and Rhône Poulenc, Mount Pleasant, produced ferrophosphorus until they terminated their phosphate refining operations.

Secondary lead was smelted from scrap by General Smelting and Refining Co., College Grove, Williamson County; Refined Metals Corp., Memphis; and Ross Metals Inc., Rossville, Fayette County.

Manganese dioxide for use in dry cell batteries was manufactured by ESB Materials Corp. and Rayovac Corp., both in Covington, Tipton County, and by Chemetals Inc. in New Johnsonville. Rayovac discontinued the production of electrolytic manganese dioxide at Covington at midyear. DMS Refineries Inc., Dallas, TX, opened a plant in Jefferson County to extract silver from used X-ray film. Secondary steel was produced by Florida Steel Co. with plants in Jackson and Knoxville; Leclede Steel Co. in Memphis; and Tennessee Valley Steel Corp. in Harriman, Roane County.

Titanium Metals Corp. of America operated an alloy plant in Morristown, Hamblen County. The bar, sheet, plate, and tube-finishing facility was opened in 1990 and became fully operational in 1991.

Martin Marietta Energy Systems operated a plant for the Department of Energy at the Oak Ridge facilities in Anderson and Roane Counties. The plant used a gaseous diffusion process to produce U^{235} from uranium mined in New Mexico and Wyoming. Uranium and thorium metal alloys were manufactured by Nuclear Fuels Services Inc. at Erwin, Unicoi County.

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[1]State Mineral Officer, U.S. Bureau of Mines, Tuscaloosa, AL. He has 33 years of industry and government experience and has covered the mineral activities in Tennessee since 1989. Assistance in the preparation of the chapter was given by Maylene E. Hubbard, editorial assistant.

[2]Chief geologist, Tennessee Division of Geology, Knoxville, TN.

[3]Chief geologist, Tennessee Division of Geology, Nashville, TN.

[4]U.S. Department of Labor. Employment and Earnings. V. 39, No. 5, May 1992, p. 144.

[5]U.S. Mine Safety and Health Administration. Mine Injuries and Worktime, quarterly. Jan.-Dec. 1991, p. 15.

[6]Tennessee Division of Geology Newsletter. Director's Comments. Apr. 1992, p. 2.

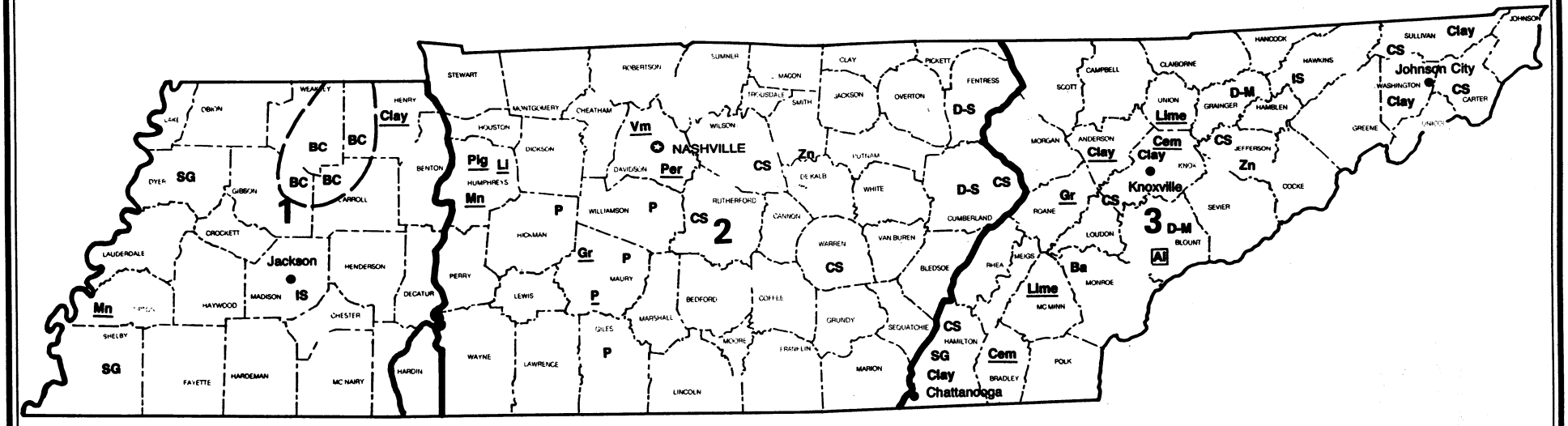
[7]National Association of State Land Reclamationists Newsletter. Tennessee. Jan. 1992, p. 4.

[8]Zdunczyk, M. J. Short Mountain Silica: A New Producer in Tennessee. Min. Eng. (Littleton, CO). V. 44, No. 3, Mar. 1992, pp. 227-229.

[9]Mining Annual Review 1992 (London, United Kingdom). North America Individual Company Reports—Asarco. June 1992, p. 35.

[10]Kingston (TN) News. HRD Consolidates Recovery Activities. Feb. 20, 1991, Sect. 2, p. 17.

TENNESSEE



LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

- Al — Aluminum plant
- Ba — Barite
- BC — Ball Clay
- Cem — Cement plant
- Clay — Clay
- CS — Crushed Stone
- D-M — Dimension Marble
- D-S — Dimension Sandstone
- Gr — Graphite plant
- IS — Industrial Sand
- LI — Lithium plant
- Lime — Lime plant
- Mn — Manganese Dioxide plant
- P — Phosphate rock
- P — Phosphorous plant
- Per — Perlite plant
- SG — Sand and Gravel
- TiPig — Titanium Dioxide pigment plant
- Vm — Vermiculite plant
- Zn — Zinc
- Zn — Zinc smelter
- Concentration of mineral operations

Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum refineries:			
Aluminum Co. of America	Box 158 Alcoa, TN 37701	Plant	Blount.
Barite:			
A.J. Smith Co.	Route 3 Sweetwater, TN 37874	Open pit mine	Loudon.
Cement:			
Dixie Cement Co. Inc.,[1 2] a subsidiary of Southdown Inc.	Box 14009 Knoxville, TN 37914	Plant	Knox.
Signal Mountain Cement Co., a subsidiary of IFI International Corp.	1300 American National Bank Bldg. Chattanooga, TN 37402	do.	Hamilton.
Clays:			
Ball clays:			
Kentucky-Tennessee Clay Co., a subsidiary of Hecla Mining Co.	Box 449 Mayfield, KY 42066	Pits and plants	Carroll, Gibson, Henry, Weakley.
H.C. Spinks Clay Co. Inc.	Box 820 Paris, TN 38229	do.	Carroll, Henry, Weakley.
United Clays Inc., a subsidiary of Watts Blake Bearne & Co. LTD.	Box 111 Gleason, TN 38229	do.	Carroll and Weakley.
Common clays:			
General Shale Products Corp.	Box 3547 CRS Johnson City, TN 37601	do.	Anderson, Knox, Sullivan, Washington.
Fuller's earth:			
Moltan Minerals Co.	3555-T Moltan Dr. Memphis, TN 38115	do.	Hardeman.
Golden Cat Corp., subsidiary of Lowe's Southern Clay Inc.	Box 819 Paris, TN 38242	do.	Henry.
Graphite (synthetic):			
Fortafil Fibers Div., Akzo-Enka America Inc.	Box 1301 Rockwood, TN 37643	Plant	Roane.
Union Carbide Corp.	Box 513 Columbia, TN 38401	do.	Maury.
Lime:			
Bowater Southern Paper Corp.	U.S. Highway 11 Calhoun, TN 37309	Pit and plant	McMinn.
Tenn-Luttrell Lime Co.	Box 69 Luttrell, TN 37779	do.	Union.
Perlite (expanded):			
Chemrock Corp.	826 Third Ave., S. Nashville, TN 37208	Plant	Davidson.
Phosphate rock:			
Occidental Chemical Corp.[3 4]	Box 591 Columbia, TN 38401	Pits and plant	Hickman, Maury, Williamson.
Rhône-Poulenc Basic Chemicals Co. Inc.[3 4]	Box 89 Mount Pleasant, TN 38474	do.	Giles and Maury.
Sand and gravel:			
Construction:			
Ford Construction Co.	Box 527 Dyersburg TN 38024	Pits	Obion.
Memphis Stone & Gravel Co.	Box 1683 Memphis, TN 38101	do.	Shelby.

See footnotes at end of table.

TABLE 5—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued:			
Construction—Continued:			
Standard Construction Co.	Box 38289 Germantown, TN 38138	Pits	Shelby.
Industrial:			
Short Mountain Silica Co.	Box 208 Mooresburg, TN 37811	Pit and plant	Hawkins.
Tennessee Silica Div., Morie Co. Inc.	Box 507 Camden, TN 38320	Pits and plants	Benton and Carroll.
Stone:			
Crushed:			
American Limestone Co., a subsidiary of ASARCO Incorporated	2209 Blount Ave. Knoxville, TN 37901	Quarries and plants	Various.
Rogers Group Inc.	Box 25250 Nashville, TN 37202	do.	Do.
Vulcan Materials Co., Midsouth Div.	Box 7 Knoxville, TN 37901	do.	Do.
Dimension:			
Ross L. Brown Cut Stone Co. Inc.	Box 398 Crab Orchard, TN 37723	Quarry and plant	Cumberland.
Imperial Black Marble Co.	8013 Chesterfield Dr. Knoxville, TN 37909	do.	Grainger.
Turner Brothers Stone Co. Inc.	Box 297 Crossville, TN 38555	do.	Cumberland.
Zinc:			
ASARCO Incorporated [2]	Box 460 Strawberry Plains, TN 37871	Underground mines and plant	Jefferson and Knox.
Jersey Miniére Zinc Co., a division of Union Zinc Co. Inc.	Box 359 Gordonsville, TN 38563	Underground mines, plant, and refinery	Grainger, Jefferson, Montgomery, Smith.

[1]Also clays.
[2]Also stone.
[3]Also ferroalloys.
[4]Terminated operations in 1991.

THE MINERAL INDUSTRY OF TEXAS

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Bureau of Economic Geology, The University of Texas at Austin, for collecting information on all nonfuel minerals.

By Jean A. Dupree[1] and L. Edwin Garner[2]

As a result of the recession's effects on the Texas economy, the value of nonfuel minerals produced in Texas dropped from $1.46 billion in 1990 to $1.26 billion in 1991. The Lone Star State, however, held onto its seventh place ranking in the country (in terms of mineral value) and accounted for 4.2% of the total value of national nonfuel mineral production.

Portland cement, worth more than $289 million in 1991, continued to lead the list of nonfuel mineral commodities produced in Texas. Other nonfuel minerals, in decreasing order of value, were crushed stone, magnesium metal, Frasch sulfur, construction sand and gravel, byproduct sulfur, salt, lime, and Grade-A helium. Excluding synthetic and refined materials, Texas yielded at least 11 other nonfuel minerals.

TRENDS AND DEVELOPMENTS

Near yearend, Japan announced it would be willing to help finance the supercollider, thereby feeding hopes that other countries would help build Texas' proposed $8.25 billion atom smasher. The collider would use about 8,600 magnets to guide beams of protons

TABLE 1
NONFUEL MINERAL PRODUCTION IN TEXAS[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Cement:							
Masonry	thousand short tons	133	$10,735	142	$10,106	W	W
Portland	do.	7,200	286,236	7,678	296,680	e7,498	e$289,341
Clays[2]	metric tons	2,276,629	15,962	2,162,095	14,652	2,265,746	13,247
Gypsum (crude)	thousand short tons	1,993	17,044	1,868	10,166	1,609	9,240
Lime	do.	1,304	60,829	1,337	76,181	1,373	69,400
Salt	do.	7,856	69,934	8,212	75,149	8,935	73,117
Sand and gravel:							
Construction	do.	e43,900	e155,800	46,083	158,080	e38,800	e135,800
Industrial	do.	1,661	29,107	1,849	40,880	1,557	27,002
Stone:							
Crushed	do.	76,823	252,982	e81,800	e285,700	65,813	226,836
Dimension	short tons	81,268	12,449	e84,500	e12,600	W	W
Sulfur (Frasch)	thousand metric tons	2,446	W	2,340	W	2,056	W
Talc and pyrophyllite	metric tons	241,777	4,564	227,138	4,844	212,887	4,561
Combined value of clays [ball (1989, 1991), bentonite (1990-91), fuller's earth (1990-91), kaolin], gemstones, helium (crude and Grade-A), iron ore (usable), magnesium compounds, magnesium metal, sodium sulfate (natural), and values indicated by symbol W		XX	546,812	XX	472,187	XX	416,117
Total		XX	1,462,454	XX	1,457,225	XX	1,264,661

eEstimated. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.

around a 54-mile underground ring at almost the speed of light until they collide with an energy of 40 trillion electron volts. Construction of supercollider buildings and roads south of Dallas/Fort Worth would require enormous quantities of crushed stone, sand and gravel, cement, clay, lime, and metal products and would be a significant and positive stimulus on Texas mineral producers and on the State economy.

In May, the Texas High-Speed Rail Authority voted unanimously to award a $5.5 billion franchise for the Nation's first "bullet train" to Texas TGV, a consortium of four investors: Morrison-Knudsen Corp. (the managing partner), Qatar businessman Ahmad Mannai, former Texas Lieutenant Governor Ben Barnes, and Texan Brad Corbett. The 200-mile-per-hour train would connect the "Texas Triangle" cities of Dallas/Fort Worth, Houston, and San Antonio. Texas TGV planned to rely on steel-wheel trains, French trains à grand vitesse (TGV's). Involving about 600 miles of new steel track, the project could be a major boost to Texas steel, aggregate, and cement industries. According to Morrison-Knudsen, project financing required $170 million to be raised by December 31, 1992. Successful financing, however, was said to depend on the U.S. Congress eliminating the volume cap on issuance of tax-exempt bonds for funding high-speed rail projects.

The National Stone Association announced two research grants, one to the University of Texas and a second to Louisiana Tech University. The University of Texas was granted two installments, $5,000 apiece, to conduct research on the characterization and potential uses for quarry fines.

Shell Oil Co. closed its coal gasification demonstration plant in Deer Park after a successful 4-year demonstration program to test the use of coal for the production of synthetic gas and steam. The program was sponsored jointly by Shell, Shell International Research, and the Electric Power Institute.

The year began with one-fourth of all drill rigs operating in Texas continuing to drill horizontal holes in the Austin Chalk trend in south Texas. Overall, however, the Texas oil and natural gas industry was stagnant and undergoing a fundamental metamorphosis, a basic trait of which was the race toward overseas exploration. Although the "majors" began their exodus near the end of the 1980's, larger independents, suppliers, and service firms with enough cash to make the leap were following as fast as they could. Oil prices were mired in the $20-per-barrel range, and natural gas prices hit an 18-year low of $1.10 per thousand cubic feet. In this setting, Texas oil and gas companies consolidated offices and executed massive layoffs in 1991.

EMPLOYMENT

In 1991, an average of 7.17 million people were employed in nonagricultural jobs in Texas, slightly higher than the 7.10 million people so employed in 1990. Texas unemployment averaged 6.6% in 1991, compared with U.S. unemployment of 6.7%.

Texas Employment Commission statistics include a "mining" employment category formed of two subcategories: an oil and gas category and an "other" category encompassing metals, coal, and nonmetallic minerals. Mining employment averaged 185,100 jobs in 1991. Of that total, oil and gas employment accounted for 175,600 jobs, and other mining, 9,500 jobs.

Although Dallas energy companies lost only 400 jobs last year, the true size of their layoffs was masked by consolidation of field offices and relocation of many company headquarters to Dallas. In Houston, pink slips piled up at Shell Oil Co., Halliburton's Energy Service Group, Oryx Energy, Exxon Corp., Tenneco Inc., and Transco Energy Co. During company restructurings, at least 3,650 Houston people suffered layoffs, according to the Houston Business Journal.

REGULATORY ISSUES[3]

In her 1991 State of the State address, the Governor called for a 2-year moratorium on permits for new commercial hazardous waste incinerators, cement kilns, and salt-dome injection wells. The Texas Water Commission and Texas Air Control Board, which have overlapping jurisdiction on permitting such facilities, abided by the request for a moratorium. According to the Texas Mining and Reclamation Association, the Texas Air Control Board adopted rules in May that amended the Texas Air Control Air Act and made cement kilns, industrial furnaces, and boilers conform to the same emission, testing, and monitoring requirements operative for hazardous waste incinerators.

In March, the Texas Air Control Board revised procedures for facilities to notify the agency of emissions of excessive pollution. The revision addressed concerns that serious air pollution events were going unreported, and it required owners and operators to notify the Board's executive director and appropriate local air pollution authorities as soon as possible of any "major upset" that could cause emissions in excess of permit limits. The rule also required facilities to notify the Board and local authorities in writing 10 days prior to planned maintenance, startup, or shutdown that might cause an excessive emission.

In October, the Texas Air Control Board proposed amendments to temporary concrete batch-plant regulations. The Board proposed exempting companies from notifying the public of construction of a temporary plant if a plant could show 50% or more of its jobs were dedicated to public works projects. In the view of the Board of Directors of the Texas Aggregate and Concrete Association, approval of the proposed regulations would lead to an unfair competitive and regulatory disadvantage for companies that have permanent installations and that must go through lengthy public hearings and zoning applications.

Remedial action began in Falls City in south Texas by the U.S. Department of Energy to curtail radon emissions and leakage of arsenic, selenium, and molybdenum from uranium tailings left from past mining. By August 1994, a hill 40 feet high, 2,200 feet long, and 2,600 feet wide will be constructed to seal 5.7 million cubic yards of tailings. The hill, or containment cell, will be covered with clay to isolate the tailings for 200 to 1,000 years.

A $576,000 fine levied by the Texas Air Control Board against an oil and chemical complex in Brazoria County became the largest administrative fine levied for environmental violations in the State's history. Phillips Corp.'s Sweeney Refinery near Old Ocean was fined for several violations involving tanks that store the carcinogen benzene. Problems at the tanks had led to an uncontrolled air emission of 26 tons of benzene per year.

Owners of the Tex-Tin operating secondary copper smelter (formerly a tin smelter) in Texas City began a remedial site investigation and feasibility study approved by the U.S. Environmental Protection Agency (EPA). The smelter was added to the National Priorities List of Superfund sites in 1990.

LEGISLATION AND GOVERNMENT PROGRAMS[4]

According to the Texas Legislative Research Library, 7,108 bills and resolutions were introduced into the 72d regular legislative session, of which 3,175 passed. Later, during three specially called sessions, 1,722 bills and resolutions were filed, of which 1,038 passed.

One of the most important bills enacted into law, S.B. 2 (first special session), authorized the creation of a new Texas environmental superagency, "the Texas Natural Resources Conservation Commission." Under its aegis will be consolidated the functions of the Texas Water Commission, the Texas Air Control Board, the Texas Water Well Drillers' Board, the Texas Board of Irrigators, and several Texas Health Department divisions. The mission of the agency, scheduled to begin work in 1993, is to enforce State pollution laws, including criminal penalties for polluters. With the notable exception of the Texas Railroad Commission, the new commission will include most State regulatory agencies that have authority over the mining and oil and gas industries.

Spurred by a 1989 school bus accident that caused the deaths of 21 students in south Texas, H.B. 451 (the Texas Aggregate Quarry and Pit Safety Act) was enacted during the regular session. The new law required barriers between quarry pits and public roads and provided for uniform regulation of active, inactive, and abandoned pits within 200 feet of a public road right-of-way. The Texas Railroad Commission was given authority to adopt rules and regulations to implement and enforce the act, conduct related inspections, and inventory all active, inactive, and abandoned quarries and pits. The Texas Railroad Commission estimated that roughly 30,000 quarries and pits could be required to file an initial report in accordance with subchapter C of the act; of that number, about 12,000 may be within 200 feet of a public road and require barrier construction and a safety certificate.

In a landmark case for the crushed stone industry, the Texas Supreme Court ruled in December 1991 on the case of Gifford-Hill & Co. Inc. versus Wise County Appraisal District that a limestone deposit is not to be defined as a mineral, thus disallowing assessment of property taxes on underground rock reserves. The decision reversed a Fort Worth appeals court decision.

In 1991, the State enacted sweeping changes in the corporate franchise tax. Under prior law, corporations paid franchise tax only on their capital (stated capital plus surplus). The new tax law, H.B. 11 (first special session), requires corporations to pay either 0.25% of taxable capital or a 4.5% levy on Federal taxable income, whichever is greater. The levy on Federal taxable income (or earned surplus) was new; the 0.25% tax was reduced from 0.525%. Tax revision was designed to shift corporate tax burden away from the capital-intensive manufacturing, mining, and oil and gas industries to the growing service sector. The State Comptroller's office estimated that the State mining industry, mainly energy exploration and production, would see its share of the total tax burden drop from 16% to 7%.

The Texas Railroad Commission amended State uranium mining regulations to conform to S.B. 980 (regular session) to allow bond amount calculations to be prepared by staff. It will no longer be necessary for companies to contract for independent bond estimates.

Several bills were introduced that affected the oil and gas industry. Texas enacted S.B. 1103 (regular session), which assessed additional royalties on oil/gas wells. Depending on well depth, the new fee structure could double the drilling application fee from $100 to $200. Another charge will be assessed on each barrel of oil and on each thousand cubic feet of gas produced. The new fee system was capped at $10 million, and revenues generated will be used for plugging almost 2,000 abandoned wells. The Governor also signed into law S.B. 14 (regular session), which authorized the General Land Office to assess a tax of 2 cents on each barrel of oil transported through Texas waters to fund a program to clean up oil spills. Opposed by consumer groups, utilities, and Texas lignite producers, companion regular session bills (H.B. 2853 and S.B. 1535) failed to make natural gas the "fuel of choice" for electricity generation by Texas utilities.

The U.S. Bureau of Mines continued its support of the Texas Mining and Mineral Resources Research Institute (TMMRRI), dedicated to research and education in mineral resources. As did other Bureau-funded Mineral Institutes, TMMRRI received $148,000 in 1991. The Texas Bureau of Economic Geology administers TMMRRI; the University of Texas at Austin, Texas A&M, and Prairie View A&M are academic affiliates. In the 1991-92 academic year, four

fellowships were awarded to support graduate research in ore deposition, mineral economics, and petroleum recovery. Research under TMMRRI addressed two major and overlapping topics this year: (1) geologic mapping and geochemical sampling of Trans-Pecos Texas peralkaline rhyolites enriched in fluorine, beryllium, molybdenum, thorium, and uranium; and (2) the use of lead-isotope studies to identify the origin of metals in silver-base metal deposits in the Shafter area, the West Chinati stock area, the Quitman Mountains, and the Indio Mountains.

The Texas Bureau of Economic Geology was involved with 56 research projects, 21 of which were initiated in 1991. Several long-term projects of interest to industry were concluded, including the Tectonic Map of Texas which, with a copyrighted computer program called Restore, allowed users to study migration pathways of hydrocarbons and the evolution of structural traps. Other published research included an estimation of lignite resources in the Wilcox Group of Central and East Texas using the National Coal Resources Data System.

FUELS

In spite of a catatonic oil and gas market, Texas, the Nation's perennial drilling leader, again ranked first in well completions, according to Petroleum Information Corp. Texas' total of 7,944 completed wells was 36% of the domestic tally and an impressive increase of 6.4% over that of 1990. About 5.5% of well completions were new field wildcats (440 wells total), including 81 new field discoveries. Texas accounted for almost 87% of all horizontal wells drilled in the United States. Oil well completions in Texas jumped from 3,594 in 1990 to 4,127 in 1991, while gas well completions fell from 1,631 to 1,471. Total footage drilled was 46,909,647 feet, 42% of the domestic total and an 8.5% increase over that of 1990. Texas operators posted a 70.5% success rate in drilling for oil and gas.[5] According to the Texas Railroad Commission, Texas produced 644.5 million barrels of crude oil in 1991; producing oil wells numbered 196,292. Total 1991 natural gas production was 5.51 trillion cubic feet, and the total number of producing gas wells in Texas was 68,567.[6]

Texas Railroad Commission District 1 in south-central Texas had the most new-field-wildcat completions. However, by the end of 1991, no area mirrored the depressed state of Texas drilling as much as District 1. The year began with 71 rigs drilling in the district, the majority testing the Cretaceous Austin Formation via horizontal drilling. By yearend, however, only 20 rigs were present, and they were no longer matching earlier spectacular results. As activity waned in District 1, the Austin Chalk play drifted northeast into Gonzales County and further northeast into District 3. Although activity remained strong in District 3 at yearend, sluggish permit filing indicated that the Chalk play had run its course.[7]

Chevron Resources Co. was acquired by General Atomics Corp. and became Rio Grande Resources Co. General Atomics bought a package of Chevron's south Texas uranium assets consisting of its 55% interest in the Rhode Ranch open pit mine and its 100% interest in the Panna Maria mill, both still active in 1991.

Despite the depressed value of yellowcake, Uranium Resources Inc. continued mining by its own method of in situ leaching at its Rosita Mine in northeastern Duval County. Production began in October 1990 and continued through December 31, 1991, when the property was placed on standby. Production problems caused by the presence of bacteria that suppressed ore recovery were eventually eliminated by injecting bacteria-killing chemicals. In May 1991, the company accepted a $41 million buyout proposal by Rio Algom Mining Corp., an agreement Rio Algom terminated in December. Reasons given for the termination were the 20% drop in uranium prices and market pessimism related to Soviet dumping of uranium on the world market. Uranium Resources' Kleburg County mine, the Kingsville Dome property, remained idle after its temporary shutdown in September 1990.

According to the U.S. Energy Information Administration, Malpai Resources operated its Holiday-El Mesquite in situ leach plant. Inactive south Texas in situ leach operations included Everest Minerals' operation near Hobson and Total Minerals Corp.'s plant at West Cole.[8]

According to the Energy Information Administration, Texas ranked sixth in national coal production, accounting for 5.4% of the national production total. Total coal production for the year was 53.8 million short tons, down slightly from the 55.8 million short tons produced in 1990. Texas produced lignite and cannel (bituminous) coal. The State is the largest lignite producer in the country and contains the second largest lignite reserves in the United States, after Montana.[9]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Statistics for portland cement for 1991 are estimated figures. Texas output and value of portland cement were estimated to have dropped about 2% below 1990 totals. In 1991, Texas was estimated to have produced 11% of the country's cement and ranked second of 38 producing States, after California. Raw materials consumed in cement manufacture included limestone, anhydrite, cement rock, chalk, clay, fly ash, gypsum, iron ore, marl, mill scale, sand, shale, and both imported and domestic clinker. Kiln fuels included cannel coal from Laredo, petroleum coke, and natural gas.

In December 1990, Lone Star Industries Inc. filed for bankruptcy under chapter 11 of the U.S. Bankruptcy code. According to the company, business had been hurt by falling housing starts and strong foreign competition. A California group, Scope Industries, acquired 14.5% interest in Lone Star Industries. Lone Star Industries owns a cement quarry and

plant at Maryneal and distribution terminals at Amarillo, Houston, and Dallas. During 1991, the company reached labor agreements covering its Maryneal plant.

Houston-based Southdown Inc. adopted a Shareholders Rights Plan that gave its board of directors leverage to guard against aggressive takeovers. The company indicated that the plan provided protection from coercive takeover tactics and prevented an acquisition that did not offer a fair deal to stockholders.

Alamo Cement Co. acquired Barrett Industries and Gulf Concrete Co. Both companies were owned by Barlite Inc. Barrett Industries, in San Antonio, produced construction materials; Gulf Concrete is in Corpus Christi.

Lehigh Portland Cement Co. acquired 100% of the stock in two Houston-area concrete companies: Koy Industries and Gulf Coast Stabilized Materials Co. Inc. The company cited continued vertical integration of Texas markets and an anticipated economic rebound for the Houston area as reasons for the acquisitions.

Texas Industries Inc., in conjunction with the University of North Texas, at Midlothian, tested a new supplemental fuel. The fuel, densified refuse derived fuel (RDF), is made primarily from paper. A 65-hour test used 113 short tons of RDF that replaced 15% to 20% coal by Btu content. Hourly tests of coal, RDF, kiln dust, clinker, and emissions indicated that sulfur trioxide content in the clinker was reduced by 50%, sulfur dioxide emissions were reduced by 20%, and nitrogen oxide emissions dropped by 50%. There were insignificant emissions of tetrachlorinated through octachlorinated dioxins and furans, and increased (but acceptable) hydrogen chloride emissions.

Holnam Inc. terminated its option to purchase the business and assets of Texas-based Box Crow Cement Co., although Holnam was required to manage Box Crow's operations until September 1992. Box Crow Cement operated a large quarry at Midlothian, south of Dallas. Weak sales and uncertain prospects for Texas cement markets led to Holnam's decision to terminate the purchase option.

Texas masonry cement production also fell slightly during the year. Texas ranked seventh of 33 States in its production of masonry cement.

Clays.—Among 44 clay-producing States, Texas was fourth in total clay production in 1991, climbing up from its sixth place ranking in 1990. The State was behind only Georgia, Alabama, and Wyoming in clay output. Products included ball clays, bentonite, common clay and shale, fuller's earth, and kaolin. Combined output of all Texas clays inched slightly above 1990 total clay production, although total value fell.

Ball Clay.—Of five States that produced it, Texas had the third highest output of ball clay, a highly plastic clay with superior green strength properties. Ball clay was mined only in Cherokee County by United Clays of Texas Inc. The company product was used in manufacturing floor and wall tile and other ceramics.

Bentonite.—Texas was sixth among 11 States with bentonite production in 1991. The State's output and value decreased about 10% and 3%, respectively. Bentonite was produced by Milwhite Co. Inc. in Fayette County and by Southern Clay Products in Gonzales County.

In 1991, a United Kingdom company, Laporte PLC, acquired the whole of Southern Clay Products Inc. from ECC Group PLC for $30 million. The Gonzales County company is the second largest supplier of organoclays to the North American market. Laporte indicated that Southern Clay Product's organophyllic clay manufacturing facilities and high-grade bentonite production would dovetail with Laporte's Absorbents Div. According to Industrial Minerals, Southern Clay Products produced organoclay under the name Claytone and also produced high-grade, white bentonites under the trade name Bentolite. Southern Clay's bentonite has tended to have somewhat unusual applications such as use in the detergent industry (as carrier for fabric softener on tear-off sheets), in the pharmaceutical industry, and as plasticisers in whiteware and refractory mixes. The company's product was also used in technical ceramics, catalysts, personal-care products, and cosmetics.[10] Results of the U.S. Bureau of Mines canvass indicate that bentonite produced by the company was also used for drilling mud and pottery.

At its operation near Flatonia, Milwhite Co. produced a refined white, low-brightness calcium bentonite, much of which was sold to the ceramics industry.[11] According to U.S. Bureau of Mines information, bentonite produced by the company was used for drilling mud, animal feed, waterproof seals, and water-treatment filters.

Sodium bentonite was produced by Border Mines of Alpine. The company's deposit is 20 miles north of Study Butte in Brewster County.

Common Clay.—In 1991, Texas led 43 States in common clay output and followed only Alabama in production value. About 88% of Texas' common clay was used to make brick, portland cement, structural concrete, and for highway surfacing. Bastrop, Guadalupe, Henderson, and Navarro Counties accounted for more than one-half of the State's production. Texas Industries, TXI Cement Co., Acme Brick Co., and Lafarge Corp. were the top Texas producers in 1991. Output rose from the 1990 total of 2.16 million metric tons (2.38 million short tons) to 2.27 million metric tons (2.5 million short tons). Total value increased slightly from 1990's total of $13.1 million to $13.2 million.

Fort Worth-based Justin Industries Inc. announced that its Acme Brick Co. division had acquired Elgin Butler Brick. The acquisition included brick manufacturing assets, related properties, and inventory. Elgin Butler retained its glazed tile production facility.

Fuller's Earth.—Texas ranked last of 10 States that reported fuller's earth production. Balcones Mineral Corp. and Milwhite Co. in Fayette County produced

TABLE 2
TEXAS: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1990		1991	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Road stabilization	450,254	$26,703	479,635	$27,505
Other[1]	887,021	49,478	893,377	41,895
Total	1,337,275	76,181	1,373,012	69,400

[1]Includes acid water neutralization, agriculture, aluminum and bauxite, environmental uses (1990), mason's lime, open-hearth steel, other chemical and industrial, paper and pulp, sewage treatment, sugar refining, and tanning.

bentonite used as fuller's earth in oil and grease absorption, as pet waste absorbent, and for use in manufacturing electrical ceramics. Although output was essentially static, price and product value increased in 1991.

Kaolin.—Texas was ninth among 14 States in kaolin output and fourth in production value in 1991. U.S. Silica Co. in Limestone County, Texas' only kaolin producer, mined kaolinitic sand from the Eocene Wilcox Group and produced both kaolin and industrial sand. Output and value declined in 1991. The kaolin product was used in making fiberglass and paint.

Gypsum.—Texas' crude gypsum production continued to decline in 1991, falling from 1.87 million short tons to 1.61 million short tons; it dropped in value from $10.2 million to $9.2 million. Texas remained fourth in national production, following Oklahoma, Iowa, and Michigan. Although crude gypsum was mined by five companies in Gillespie, Hardeman, Kimble, Nolan, and Stonewall Counties, U.S. Gypsum Co.'s Sweetwater Mine in Nolan County was, by far, the leading Texas producer and had the second highest output in the Nation.

Five companies in Fisher, Guadalupe, Hardeman, Harris, and Nolan Counties produced calcined gypsum; their production dropped to 1.12 million short tons from 1.31 million short tons in 1990. Collectively, production value was $13.6 million, compared with $15.5 million in 1990. In 1991, Texas' output fell from second to fourth place, behind California, Iowa, and Florida. U.S. Gypsum (Nolan and Harris Counties) also led in State production of calcined gypsum.

Byproduct gypsum was purchased by U.S. Gypsum's plant in Harris County. Its quantity and value rose about 9% from that of 1990. Texas ranked third, behind Georgia and Maryland, of nine States that produced byproduct gypsum.

National Gypsum, which filed for bankruptcy during October 1990, remained under chapter 11 bankruptcy protection. The company produced crude gypsum in Stonewall and Kimble Counties and also produced calcined gypsum and operated a wallboard plant at Rotan in Fisher County.

Helium.—Texas was second, after Kansas, of only two States in which crude helium was produced and third of five States producing Grade-A helium in 1991. Crude helium was produced from natural gas by the Phillips Petroleum Co. in Moore and Hansford Counties. Output and total value rose by 12% and 30%, respectively. Grade-A helium (99.995% purity or better) was produced by Air Products and Chemicals Inc. in Hansford County and by the U.S. Bureau of Mines in Moore County. Output of Grade-A helium dropped 17%, but total value went up 26%. Major end uses for the helium were cryogenics, welding, and pressurizing-purging applications.

Lime.—Texas kept its sixth place rank in lime production with an output of 1.37 million short tons, up slightly from that of 1990. Total value of the seven Texas lime plants fell from the $76.2 million reported in 1990 to $69.4 million. Five companies (Chemical Lime Southwest Inc., Austin White Lime Co., APG Lime Corp., Texas Lime Co., and Redland Stone Products Co.) in Bexar, Bosque, Burnet, Comal, Hill, and Travis Counties produced both quicklime and hydrated lime. Chemical Lime's Marble Falls plant in Burnet County and Holly Sugar Corp.'s plant in Deaf Smith County produced only quicklime. Texas' lime was primarily used in road stabilization, but was also used for acid water neutralization, agriculture, aluminum and bauxite refining, mason's lime, paper manufacturing, sewage treatment, sugar refining, tanning, and several other applications.

Chemical Lime Co. of Fort Worth, Texas' leading lime producer, entered into a joint venture with Mexico's Sonocal S.A. The intent of the agreement was for Chemical Lime to help improve production from Sonocal's high-calcium lime plant in Naco, Sonora, Mexico. Chemical Lime operated plants in Bosque and Burnet Counties.

Magnesium Compounds.—Texas ranked last of six States with recorded 1991 production of magnesium compounds. Output and value of magnesium chloride extracted from seawater by Dow Chemical Co. in Brazoria County fell again in 1991, continuing a decline that started in 1989. Magnesium chloride was used principally in the manufacture of magnesium metal, but had several other applications, including ceramics.

Salt.—Texas ranked second behind only Louisiana in production of salt in 1991. State output of 8.94 million short tons inched upward from the 8.21 million short tons reported in 1990. Value decreased from $75.1 million to $73.1 million in 1991. Dow Chemical Co., in Brazoria County, remained the largest producer in Texas, although five other companies produced salt from brines or from rock salt in Chambers, Duval, Ector, Fort Bend, Harris, Jefferson, Matagorda, San Patricio, and Van Zandt Counties.

Two of the Nation's 17 underground salt mines are in Texas: the largest, near Grand Saline, is owned by Morton International Inc. and the other, at Hockley, is owned by United Salt Corp. Salt produced was used to control ice on road surfaces and for water softening, hide curing, livestock feed, and film development. No salt mined underground in Texas is used for human consumption.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years; data for odd-numbered years are based on annual company estimates. This chapter contains estimated data for 1989 and 1991 and actual data for 1990. Texas sand and gravel production during 1991 was estimated to have been 39 million short tons, and had an estimated value of $136 million.

Industrial.—Texas ranked fifth in the country in production of industrial sand, down from fourth place in 1990. Ten counties produced industrial sand during 1991. The State production total was 1.56 million short tons, down 16% from that of 1990. Value dropped by one-third to $27 million. Industrial sand was produced by eight companies, five of which (Oglebay Norton Co., Specialty Sand Co., Unimin Corp., Vulcan Materials Co., and U.S. Silica Co.) accounted for the bulk of the State's output. Most of Texas' industrial sand was used as hydraulic fracturing sand, blasting sand, or for the manufacture of glass containers.

Sodium Sulfate.—Texas ranked second among the three States that produced sodium sulfate. At its Seagraves facility in Gaines County, Ozark-Mahoning Co. extracted sodium sulfate from subterranean brines by mechanical refrigeration. Product markets included the pulp, paper, detergent, and textile industries. Some material was also sold as an abrasive to replace sand. Production rose 4% for 1991, although value dropped 16%.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1990 and actual data for 1989 and 1991.

To preserve company confidentiality, crushed stone statistics are grouped by the districts shown on the State map. Tables 3, 4, and 5 present statistics for Texas' nine districts.

Crushed.—The third largest crushed stone producer nationally, Texas ranked behind only Pennsylvania and Illinois in 1991. Output was 66 million short tons, down 14% from that of 1989. Total value of output was $227 million, down from $253 million in 1989. Average price was $3.45, compared with an average national price of $4.70. The largest uses of crushed stone were as road base and in cement manufacture, accounting for 20% and 15%, respectively. Other important uses included concrete, bituminous aggregate, and crusher-run fill.

About 92% of crushed stone produced in 1991 was limestone. Most of Texas' crushed limestone was supplied by the large quarries along the Balcones escarpment that extends from north of Austin to San Antonio (District 7). These quarries supplied not only central Texas markets but also the gulf coast and border areas. Output from Dallas-area quarries (District 5) ran a close second to that of central Texas.

Other rock types mined in Texas included sandstone, traprock, marl, dolomite, marble, and granite. Sandstone was used primarily for concrete and bituminous aggregate, traprock, and railroad ballast. Marl was used for cement manufacture and broken granite for riprap.

A total of 93 companies reported production from 184 quarries. Of Texas' 254 counties, nearly one-quarter (62 counties) had crushed stone operations. Wise, Comal, Bexar, Williamson, and Ellis Counties were the top five producing counties, accounting for well one-half of Texas' output. The top five producers were Lafarge Corp., Beazer USA, Texas Industries Inc., Texas Crushed Stone, and Vulcan Materials Co.

In September 1991, Hanson PLC and Beazer PLC announced a recommended offer for all of Beazer's outstanding shares, an offer that became unconditional in all respects in December. Beazer West operated sand and gravel operations in Brazos, Cooke, Dallas, Ellis, and McLennan Counties and crushed stone operations in Comal, Cooke, Ellis, Limestone, Walker, and Wise Counties. Beazer West ranked second among Texas' crushed stone producers in 1991.

Parker Lafarge Inc. installed a state-of-the-art system for crushing aggregates at its New Braunfels limestone quarry. According to the annual report of Lafarge Corp., the quarry has 500 million tons of reserves. Lafarge led the State in crushed stone production in 1991.

Dimension.—Texas ranked third nationally in production of dimension stone. Both production and value fell in 1991. Granite was quarried as dimension stone in at least three counties: Burnet, Gillespie, and Llano. According to the Texas Bureau of Economic Geology, granite was also quarried in Mason County. Limestone was quarried in Jones and Williamson Counties. Texas had 14 dimension stone quarries in 1991, of which 10 produced granite and the remainder limestone. Cold Spring Granite Co. led the four companies producing in Texas in 1991. Dimension stone was sold principally as rough blocks and as cut veneer stone, but was also marketed as monumental stone and sawed blocks.

Sulfur.—**Frasch.**—Continuing a decline that began in 1989, sales of Frasch sulfur dropped by 12% in 1991 and decreased in value by 14% from the 1990 total. Of the two States that produced Frasch sulfur in 1991, Texas continued to lead Louisiana. As a result of Freeport-McMoRan's Main Pass discovery in offshore Louisiana, however, that picture will likely change in years to come. Sulfur prices declined

TABLE 3

TEXAS: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	W	W	$4.39
Riprap and jetty stone	570	2,888	5.07
Filter stone	128	414	3.23
Coarse aggregate, graded:			
Concrete aggregate, coarse	6,837	27,721	4.05
Bituminous aggregate, coarse	3,257	16,407	5.04
Bituminous surface-treatment aggregate	1,705	7,084	4.15
Railroad ballast	533	2,563	4.81
Fine aggregate (-3/8 inch):			
Stone sand, concrete	1,854	5,348	2.88
Stone sand, bituminous mix or seal	1,024	3,173	3.10
Screening, undesignated	577	1,115	1.93
Coarse and fine aggregate:			
Graded road base or subbase	13,157	31,968	2.43
Unpaved road surfacing	918	2,878	3.14
Crusher run or fill or waste	2,053	3,104	1.51
Other construction materials[2]	853	3,990	4.68
Roofing granules	94	514	5.47
Agricultural: Agricultural limestone[3]	561	3,751	6.69
Chemical and metallurgical:			
Cement manufacture	10,198	26,180	2.57
Lime manufacture	1,251	6,447	5.15
Dead-burned dolomite manufacture	W	W	3.42
Sulfur oxide removal	807	3,274	4.06
Special: Asphalt fillers or extenders[4]	439	4,505	10.26
Other miscellaneous uses[5]	574	2,040	3.55
Unspecified:[6]			
Actual	12,067	40,361	3.34
Estimated	6,356	31,111	4.89
Total	65,813	226,836	3.45

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes dolomite, granite, limestone, marble, marl, miscellaneous stone, quartzite, sandstone, and traprock.
[2]Includes withheld amounts for coarse aggregate (+1 inch), terrazzo, exposed aggregate, and pipe bedding.
[3]Includes withheld amounts for poultry grit and mineral food and other agricultural uses.
[4]Includes whiting or whiting substitute and other fillers or extenders.
[5]Includes withheld amounts for chemical and metallurgical flux stone and chemicals.
[6]Includes production reported without a breakdown by use and estimates for nonrespondents.

precipitously in 1991, a function of reduced European consumption, more recovery of sulfur by refineries, and the struggle of individual marketers to maintain their market share. Sulfur was extracted by Pennzoil Co. in Culberson County and by Texasgulf Inc. in Wharton County.

According to the company's annual report, production from Pennzoil Co.'s mine declined in 1991 as a function of lower market demand for phosphate fertilizer and a planned reduction of inventory. Pennzoil's West Texas sulfur reserves totaled about 27.6 million metric tons (27.2 million long tons) at yearend.

Production from Texasgulf Inc.'s Newgulf Mine, southwest of Houston, also declined in 1991, according to Elf Aquitaine Corp.'s (Texasgulf's parent company) annual report. Although reserves at the mine are declining, the mine has produced a world-record 81.9 million metric tons (80.6 million long tons) of Frasch sulfur since production began in 1929.

Recovered Elemental.—Petroleum refining yielded sulfur as a nondiscretionary byproduct. A total of 52 refineries in 26 counties produced 1.73 million metric tons of sulfur valued at $120.3 million. Although tonnage produced increased slightly in 1991, value declined from that of 1990 by 15%.

Talc.—Production and value of talc slid down 6% in 1991. Of nine talc-producing States, Texas' output dropped from second to third, behind that of Montana and Vermont. Five companies in Hudspeth and Culberson Counties produced 212,887 metric tons (234,668 short tons) of talc used primarily in the manufacture of ceramics, paint, and paper. Dal Minerals (formerly Texas Talc Co. Inc.) and Southern Clay Products Inc. continued to lead State production. Both Dal Minerals and Pioneer Talc Co. are largely captive producers, selling to Texas tile companies, Dal-Tile Co. and Monarch Tile Co., respectively. Pioneer Talc, however, sold a small quantity of white and pink talc to west coast consumers as low-grade fillers.

According to Industrial Minerals, west Texas producers mine "black talcs" in 2-inch lump form without further treatment for Texas and Mexican ceramic building products such as tiles. Talc from the west Texas Allamore District often contains 15% to 20% dolomite, with some quartz, and has a dark color. A very minor amount (1% to 2%) is calcined to clinoenstatite for shrinkage control in ceramics.[12]

United Clays of Texas, a subsidiary of Watts Blaek Bearne & Co. of the United Kingdom, acquired Southern Clay

TABLE 4

TEXAS: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	—	—	—	—	W	W
Coarse aggregates graded[2]	526	3,161	W	W	33	209
Fine aggregates (-3/8 inch)[3]	152	620	W	W	11	52
Coarse and fine aggregates[4]	335	1,167	737	2,677	W	W
Other construction materials	—	—	238	1,316	837	2,195
Agricultural[5]	—	—	—	—	—	—
Chemical and metallurgical[7]	—	—	—	—	W	W
Special[8]	—	—	—	—	—	—
Other miscellaneous uses	—	—	—	—	—	—
Unspecified[9]						
Actual	—	—	321	1,197	135	414
Estimated	513	3,555	107	394	1,105	6,418
Total[10]	1,526	8,504	1,404	5,584	2,121	9,289

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	W	W	125	702	W	W
Coarse aggregates, graded[2]	W	W	6,126	28,002	—	—
Fine aggregates (-3/8 inch)[3]	W	W	1,615	3,579	—	—
Coarse and fine aggregates[4]	564	1,285	4,147	13,900	W	W
Other construction materials	625	2,904	164	811	14	115
Agricultural[5]	(6)	(6)	(6)	(6)	—	—
Chemical and metallurgical[7]	(6)	(6)	5,522	15,500	—	—
Special[8]	—	—	(6)	(6)	—	—
Other miscellaneous uses	390	587	773	7,554	—	—
Unspecified:[9]						
Actual	—	—	4,949	18,804	—	—
Estimated	817	2,558	1,279	4,291	254	1,092
Total[10]	2,396	7,335	24,699	93,143	268	1,207

See footnotes at end of table.

TABLE 4—Continued

TEXAS: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 7		District 8		District 9	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	541	2,588	—	—	W	W
Coarse aggregates, graded[2]	4,945	18,809	—	—	W	W
Fine aggregates (-3/8 inch)[3]	1,424	4,520	—	—	W	W
Coarse and fine aggregates[4]	9,249	17,358	—	—	1,047	2,247
Other construction materials	615	2,048	—	—	276	897
Agricultural[5]	(6)	(6)	—	—	—	—
Chemical and metallurgical[7]	6,146	19,884	—	—	—	—
Special[8]	(6)	(6)	—	—	—	—
Other miscellaneous uses	216	677	—	—	—	—
Unspecified:[9]						
Actual	6,053	18,331	—	—	557	1,430
Estimated	1,994	10,527	56	416	279	2,044
Total[10]	31,184	94,743	56	416	2,159	6,617

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap and jetty stone, and filter stone.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), railroad ballast, other fine aggregate, and other graded coarse aggregate.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), and fine aggregate (screening-undesignated).
[4]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run (select material or fill), pipe bedding, and roofing granules.
[5]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[6]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[7]Includes cement manufacture, lime manufacture, dead-burned dolomite, flux stone, chemicals, and sulfur oxide removal.
[8]Includes asphalt fillers or extenders, whiting or whiting substitute, other extenders and fillers.
[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[10]Data may not add to totals shown because of independent rounding.

TABLE 5

TEXAS: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone[1]	178	72,011	$224,777	$3.12	126	60,277	$195,269	$3.24
Dolomite	1	W	W	2.92	1	W	W	3.04
Marble	24	W	W	26.22	24	W	W	29.73
Calcareous marl	1	W	W	2.19	1	W	W	2.77
Granite	—	—	—	—	2	W	W	4.24
Traprock	2	W	W	5.52	3	978	4,641	4.75
Sandstone and quartzite	11	1,259	7,639	6.07	10	1,542	9,530	6.18
Miscellaneous stone	11	1,527	4,998	3.27	17	1,256	3,402	2.71
Total	XX	76,823	252,982	3.29	XX	65,813	226,836	3.45

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Includes "Limestone/dolomite," reported with no distinction between the two.

Products from ECC Group PLC in mid-1991.

During December, Cyprus Minerals announced the signing of a letter of intent to sell its talc business to RTZ Corp. PLC. Cyprus owned a talc processing facility in Houston.

Other Industrial Minerals.—Several industrial mineral commodities were shipped into Texas for consumption in manufacturing processing streams or were produced synthetically. Such products included expanded perlite, exfoliated vermiculite, iodine, barite, titanium dioxide pigments, ammonia, synthetic calcium chloride, lithium chemicals, gemstones, byproduct sulfuric acid, and zeolites.

Texas ranked seventh of 33 States that produced expanded perlite in 1991. Ten

plants in Bexar, Dallas, Harris, and Tarrant Counties produced 29,531 short tons, up from 23,476 short tons in 1990. Value rose from $5.6 million in 1990 to $7.3 million. Nord Perlite Co., Filter-Media Co., and W. R. Grace and Co. led the five companies producing perlite in 1991. Expanded perlite was used for filter aids, horticulture, concrete aggregate, filler material, plaster aggregate, oil and water absorbent, and low-temperature and cavity-fill insulation.

Texas ranked ninth of 19 States that produced exfoliated vermiculite. Vermiculite Products Inc. in Harris County and W. R. Grace in Dallas County produced exfoliated vermiculite from out-of-State sources. Sales fell during the year by 3%, and value dropped by 6%. Most exfoliated vermiculite was used as concrete aggregate, in horticulture, and in loose-fill and block insulation.

Crude iodine was consumed by Hoechst Celanese Chemical Group in Harris County and elemental iodine by AKZD Chemicals Inc. in Harris County. No iodine was recovered from brines as was the case in Oklahoma. Hoechst Celanese announced plans in mid-1991 to decrease voluntarily all toxic emissions from its Clear Lake plant by 80%, or roughly 10 million pounds annually, by the end of 1995. According to the Houston Business Journal, the company planned to spend $100 million in its effort to do more than required by existing EPA air-quality regulations.

Chaparral Mining Corp. of Austin completed stockpiling 15,000 to 17,000 short tons of unbeneficiated, chemical-grade barite ore recovered from the 67,825-acre Galvan Ranch in Webb County on the United States-Mexico border. According to Industrial Minerals, a trenching and sampling program indicated reserves of approximately 5 million short tons. Stockpiled material from two 50-acre mine sites will be sold as crude ore. The company hoped to establish contacts with processors to micronise and bleach the mineral to provide a chemical-grade product. Purity is 97% to 99% $BaSO_4$, and specific gravity approximates 4.45. Ore was to be trucked to the railhead at Laredo for shipment to either Houston or Corpus Christi.[13]

In related news, M-I Drilling Fluids Co. closed its Brownsville barite grinding plant in 1991, and Milpark Inc. closed its grinding plant in Galveston. In October, Excalibar Minerals opened a grinding plant in Houston.

Several Texas companies manufacture titanium dioxide pigments, including NL Industries Inc. and Hitox Corp. According to Industrial Minerals, Texas-based Hitox Corp. received its first shipment of synthetic rutile from its new plant in Ipoh, Malaysia. Output from the 50,000-short-ton-per-year plant, which came on-stream in January 1991, is the primary raw material for the company's buff-colored titanium dioxide pigment manufactured in Corpus Christi. Previously, Hitox's Corpus Christi milling facilities had bought the rutile it used in manufacturing titanium dioxide pigment.[14]

With plants in Borger, Dumas, and Beaumont, Texas ranked third of 24 States that produced anhydrous ammonia in 1991. In early 1991, Diamond Shamrock reactivated one of two 80,000-short-ton-per-year plants at its ammonia facility at Dumas.

Solid and liquid synthetic calcium chloride was produced by Tetra Technologies Inc. at its Lake Charles plant near Houston.

FMC completed construction in Bayport of a new production facility for the manufacture of lithium chemicals. The new plant will produce butyllithium, which is used in the pharmaceutical and polymer industries.

Although all 50 States produced at least $1,000 worth of gemstones, 10 accounted for 95% of U.S. production, among which Texas ranked eighth. Texas' production of gemstones increased about 3% in value in 1991.

ASARCO Incorporated's El Paso smelter continued to recover byproduct sulfuric acid. Nine companies produced natural zeolite products nationwide in 1991, including one company, Non-Scents Co., which operated a plant in Houston. Zeotech Corp. of New Mexico produced clinoptilolite from its Tilden Pit in McMullen County.

Metals

Aluminum.—Texas' production of primary aluminum was estimated to have remained essentially unchanged from that of 1990. Value, however, declined about 20%. The State ranked third in national production, behind Washington and Kentucky.

Declining demand, rising primary production, and a surge of Soviet aluminum exports made 1991 a difficult year for aluminum producers. Reynolds Metals Co. announced that it would temporarily reduce production at its Sherwin alumina plant near Corpus Christi effective in December, an action affecting 75 employees. The cutback came in response to the temporary shutdown of three production lines at the company's Troutdale, OR, reduction plant. According to Skillings' Mining Review, the Sherwin plant employed 900 people and had an annual capacity of 1.7 million metric tons.[15]

Golden Aluminum Co., a subsidiary of Adolph Coors Co., began the startup and certification process for its new San Antonio aluminum rolling mill. In its annual report, the company anticipated that the mill would move toward its permitted capacity of 130 million pounds of sheet aluminum by 1993. According to Coors, when the new mill becomes fully operational, it will nearly triple the company's aluminum sheet capacity. To manufacture new can bodystock, the company planned to employ continuous casting, a method that directly converts molten metal into rigid aluminum sheet that is rolled into the product used for beverage cans. To date, major aluminum makers have used continuous casting only for less complicated products, such as foil, but have been unable to successfully produce beverage-can bodystock, which must meet far more exacting technical specifications.

Kaiser Aluminum Corp. became a public company headquartered in Houston in 1991. The public offering of Kaiser was completed in early July after an

earlier unsuccessful attempt in February. The corporation is largely owned by Maxxam Corp. of Houston.

Aluminum Co. of America (Alcoa) operated a primary alumina refinery at Point Comfort and a reduction smelter at Rockdale. Fuel for the Rockdale smelter was lignite mined on site from the company's Sandow Mine. Alcoa announced plans to expand its facilities for drying alumina trihydrate at its Point Comfort alumina plant.

Antimony.—Two Texas smelters produced primary antimony metal and oxide products: Anzon Inc. in Laredo and Laurel Industries Inc. in La Porte.

Copper, Silver, and Gold.—According to the company's annual report,[16] Asarco's El Paso smelter produced 96,100 metric tons (105,900 short tons) of copper in 1991, up from 94,200 metric tons (103,800 short tons) in 1990. Asarco's Amarillo refinery produced 408,400 metric tons (450,200 short tons) of copper in 1991, a slight increase over the 400,500 metric tons (441,500 short tons) produced in 1990. Asarco's Amarillo operation also refined 998,000 kilograms (32.1 million troy ounces) of silver, dropping from 1.13 million kilograms (36.3 million troy ounces) for last year. Gold refined at the Amarillo operation also declined to 6,070 kilograms (195,200 troy ounces) from 9,190 kilograms (295,400 troy ounces) in 1990.

Phelps Dodge Corp.'s El Paso refinery produced 350,200 metric tons (386,000 short tons) of copper (down 9% from last year), 1,770 kilograms (56,800 troy ounces) of gold (up by 2%), and 68.4 kilograms (2,199 troy ounces) of silver (down 23% from last year). According to the company's annual report,[17] the Phelps Dodge refinery is the second largest refinery in the world, rated as having the capacity to produce 390,000 metric tons (430,000 short tons) of electrolytic copper per year. Most is sold for electrical wire and cable products. Most of the company's refined copper is cast into rod; Phelps Dodge also owns a rod mill in El Paso.

In 1991, construction of a major copper smelter near Texas City was delayed by permitting problems with Federal and State agencies. Texas Copper Corp., a subsidiary of Mitsubishi Metals Corp., planned to build a smelter designed to produce 200,000 metric tons (220,400 short tons) of copper per year and 600,000 metric tons (661,200 short tons) of byproduct sulfuric acid per year. The company had planned to start operations in December 1992. Although the company received a permit from the Texas Water Commission, another State regulatory agency, the Texas Air Control Board, raised the issue of the effect of airborne particulates on Galveston Bay water quality, and, during the fall of 1991, the board indicated that questions about air quality could delay permitting another year.

Iron and Steel.—East Texas produced a small quantity of iron ore for use in nonmetal markets. Texas tied with South Dakota for fifth place of 10 States reporting iron ore production. Output and production value decreased 23% and 12%, respectively. Mathis and Mathis Mining and Exploration Co. ground limonite and siderite at its mine in Cass County for sale as a nutrient in cattle feed. Hudson Brothers Mining Co., Inc. mined limonite and siderite in Cherokee County for cement manufacture and for road aggregate. Both companies mine iron ore mined from the Weches Formation where iron occurs as a primary deposit and as a secondary material developed from weathering of glauconite and other iron minerals.

Steel slag was processed by International Mill Service Co. from its plants in Gregg, Jefferson, Leon, and Tarrant Counties as a substitute for crushed stone. Production increased 10% from that of 1990.

Begemann USA Inc., a Netherlands heavy-manufacturing firm, bought Adams Profab Inc., a major steel fabricating facility in Tomball. Begemann, an international supplier of heat exchangers and other prefabricated steel elements and containers, planned to use the new facility to expand its line of Begemann Heat Exchangers, which the company has been manufacturing in Sugar Land. According to the Houston Business Journal, Begemann also purchased the Jacintoport steel fabrication facility during November.

Lone Star Steel Co.'s reorganization plan following its 1989 bankruptcy declaration was approved by its creditors. The plan, effective in early April, allowed all prepetition claims except those filed by Amroc/TCW to be paid 84% of the allowed amounts in cash. The Amroc/TCW claims were paid 76% of allowed amounts in cash plus 19.5% of the common equity of Lone Star Steel.

Cargill Steel and Wire moved its concrete-reinforcing wire plant from Houston to Beaumont. The new plant incorporates high-tech machines for wire-rolling, mesh-welding, and material handling and would be closer to North Star Steel Co., Cargill's major raw material supplier.

Horsehead Resource Development Co. Inc. signed a long-term processing and site agreement with North Star Steel to construct and operate a $3.5 million flame reactor facility to process electric furnace dust at North Star's Beaumont plant. Horsehead Resource Development planned to provide its technology for on-site processing and recovery of zinc and other metals at the operations. Startup was expected in the fourth quarter of 1992. The facility will be large enough to accept dust from other electric furnace operations in the Southwest.

O'Neal Steel, one of the largest metal service companies in the United States, purchased USX Corp.'s former U.S. Steel Supply Div. facility on the Houston ship channel. O'Neal will expand onto the property that will be used to process and store steel and aluminum products that O'Neal distributes.

Although bogged down in chapter 11 bankruptcy reorganization since July 1986, Dallas-based LTV Corp. produced hot- and cold-rolled sheet and stainless steel strip and sheet, aircraft products, missiles, electronics, and energy products. LTV's Energy Products Co.,

based in Grand Prairie, posted an operating loss for the year of $15.5 million on sales of $310 million. The loss was attributed to excess and slow-moving inventories and to the depressed condition of the domestic oil and gas industry.

Specialty steelmaker Quanex Corp. became 1 of Houston's top 50 public companies in 1991 after a lackluster record during the 1980's when the company focused on the oil industry. The company manufactured seamless and welded specialty steel tubing at its Gulf States Tube plant in Rosenberg and at its plant in Bellville. The Bellville plant resumed full operations in November 1990, but was operating below capacity in 1991.

Magnesium Metal.—During 1991, Texas led the three States that produced primary magnesium metal ingot. Dow Chemical Co. produced magnesium metal at its plant in Brazoria County. Seawater is reacted at the plant with dolomite to yield magnesium hydroxide, which is neutralized with hydrochloric acid to produce a magnesium chloride solution. The dehydrated solution was used as feed for the electrolytic production of magnesium metal. Although the Dow plant led the Nation, its production and value fell in 1991, continuing a decline that began in 1989.

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[1]State Mineral Officer, U.S. Bureau of Mines, Denver, CO. She has 13 years of mineral-related work with the government and industry. The author gratefully acknowledges assistance in preparation of the chapter given by Pat LaTour, editorial assistant.

[2]Research associate, Bureau of Economic Geology, The University of Texas at Austin, TX.

[3]The lead author thanks the Texas Mining and Reclamation Association and the Texas Aggregates and Concrete Association for much of the information in this section.

[4]The lead author, again, acknowledges the Texas Mining and Reclamation Association and the Texas Aggregates and Concrete Association for their legislative summaries that supplied much of the information in this section.

[5]Petroleum Information Corp. Resume 1991.

[6]Railroad Commission of Texas. 1991 Oil and Gas Annual Report. V. 1 and 2.

[7]Work cited in footnote 5.

[8]Energy Information Administration. Uranium Industry Annual 1991.

[9]Energy Information Administration. Coal Production 1991.

[10]Industrial Minerals. Specialty Clays, June 1991.

[11]Work cited in footnote 10.

[12]Industrial Minerals. Talc Review—Consolidation and Competition. Mar. 1992.

[13]———. World of Minerals—Texas Barytes Prospect. Jan. 1991.

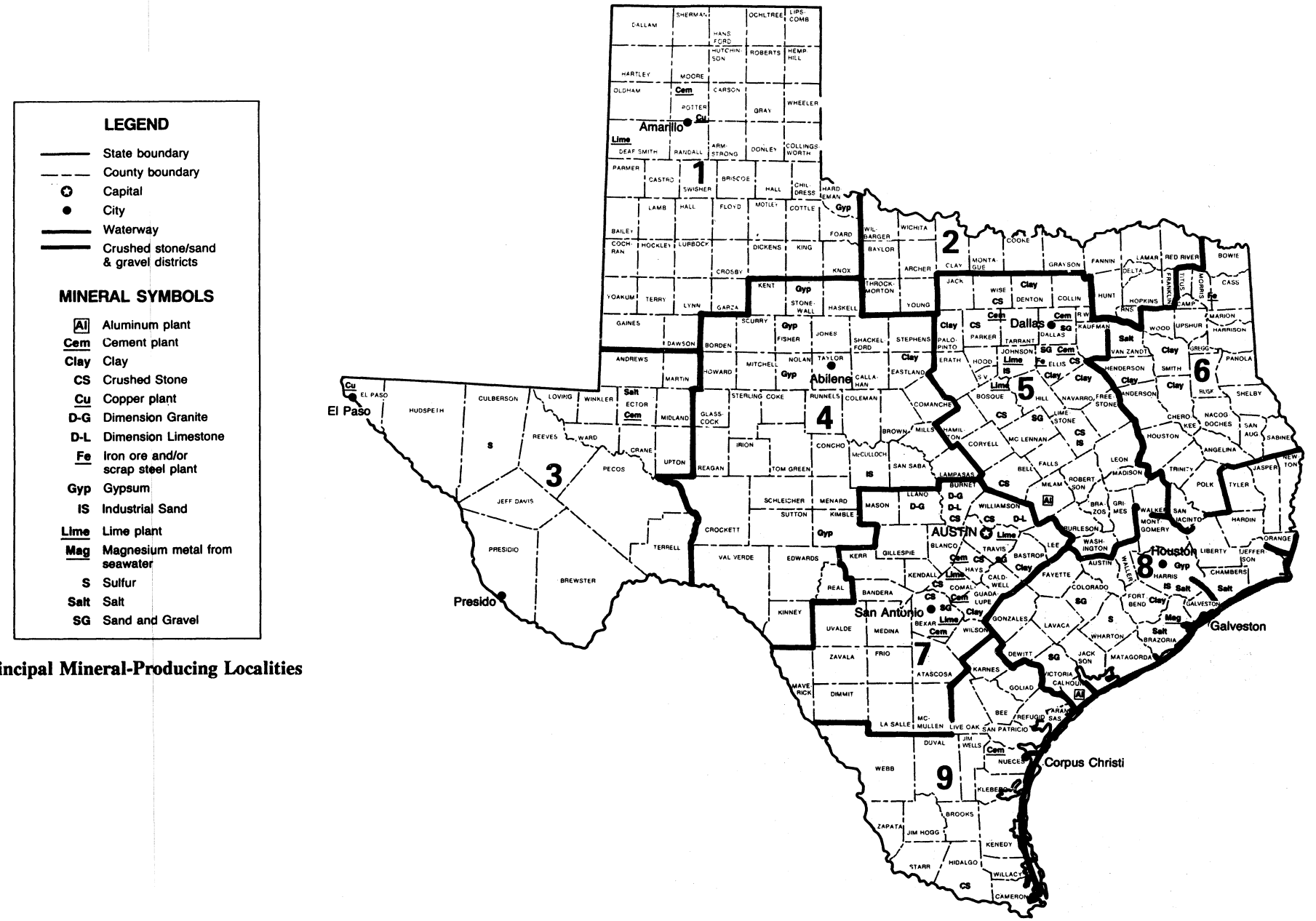
[14]———. World of Minerals—Hitox Synthetic TiO_2 Operation Commissioned. Feb. 1991.

[15]Skillings' Mining Review. Aluminum Oversupply Causes Reynolds Shutdown, Cutback. Oct. 12, 1991.

[16]Asarco Incorporated. 1991 Annual Report.

[17]Phelps Dodge Corp. 1991 Annual Report.

TEXAS



Principal Mineral-Producing Localities

TABLE 6

TEXAS: PRIMARY SMELTERS, REFINERIES, AND REDUCTION PLANTS

Product, company, and plant	Location (county)	Material treated
Aluminum:		
Aluminum Co. of America:		
Point Comfort	Calhoun	Bauxite.
Rockdale (reduction)	Milam	Alumina.
Reynolds Metals Co.:		
Sherwin plant (alumina)	San Patricio	Do.
Antimony:		
ASARCO Incorporated:		
El Paso smelter	El Paso	Ore.
Cadmium:		
ASARCO Incorporated:		
El Paso smelter	do.	Do.
Copper:		
ASARCO Incorporated:		
Amarillo refinery[1]	Potter	Blister and anode.
El Paso smelter	El Paso	Ore and concentrates.
Phelps Dodge Refining Corp.:		
Nichols refinery[2]	do.	Blister and anode.
Magnesium:		
The Dow Chemical Co.:		
Freeport plant, electrolytic	Brazoria	Seawater.

[1]Asarco's Amarillo refinery also produced gold, nickel sulfate, palladium, platinum, selenium, silver, and tellurium.

[2]Phelps Dodge's El Paso (Nichols) refinery also produced copper sulfate, gold, palladium, platinum, selenium, silver, and tellurium.

TABLE 7
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Box Crow Cement Co.	700 Dove Lane Midlothian, TX 76065	Plant	Ellis.
Beazer U.S.A./Hanson (Gifford-Hill & Co. Inc.)[1]	2515 McKinney Ave Dallas, TX 75201	Quarry and plant	Do.
Lafarge Corp.[2]	11130 Sunrise Valley Dr. Suite 300 Reston, VA 22091	Quarries and plant	Comal, Dallas, Tarrant.
Texas Industries Inc.[3]	7610 Stemmons Freeway Dallas, TX 75247	do.	Comal and Ellis.
Texas-Lehigh Cement Co., a division of Centex Corp.	4600 Republic National Bank Tower Dallas, TX 75201	Pits and plants	Hays.
Clays:			
Acme Brick Co., a division of Justin Industries Inc.	Box 425 Fort Worth, TX 76101	do.	Bastrop, Denton, Guadalupe, Nacogdoches, Parker, Van Zandt, Wise.
Gypsum:			
Domtar Gypsum Inc.	Box 720 Sweetwater, TX 79556	Quarry and calcining plant	Nolan.
Georgia-Pacific Corp.	133 Peachtree St. NE Atlanta GA 30348-5605	do.	Hardeman.
National Gypsum Co., Gold Bond Div.	Suite 4500, Lincoln Plaza Dallas, TX 75201	Quarries and calcining plants	Fisher, Kimble, Stonewall.
Standard Gypsum Co.	14901 Quarum Dr. Suite 455 Dallas, TX 75240	do.	Gillespie and Guadalupe.
USG Corp. (parent of United States Gypsum Co.)	101 South Wacker Dr. Chicago, IL 60606	Quarry and calcining plant	Harris and Nolan.
Iron ore:			
Hudson Brothers Mining Co. Inc.	Box 301 Rusk, TX 78785	Pit and plant	Cherokee.
Mathis & Mathis Mining & Exploration Co.	Box 2577 Silver City, NM 88061	do.	Cass.
Lime:			
APG Lime Corp.	Route 6, Box 662 New Braunfels, TX 78132-5011	Plant	Comal.
Austin White Lime Co.	Box 9556 Austin, TX 78766	Quarry and plant	Travis.
Chemical Lime Southwest Inc.	3724 Hulen St. Fort Worth, TX 76107-6816	Plant	Bosque and Burnet.
Holly Sugar Corp.	Drawer 1778 Hereford, TX 79045	do.	Deaf Smith.
Redland Stone Products Co.[4]	Route 2, Box 222 San Antonio, TX 78229	Quarry and plant	Bexar.
Texas Lime Co., a subsidiary of Rangaire Corp.	Box 851 Cleburne, TX 70631	do.	Hill.
Salt:			
Diamond Shamrock/OXY Chemical Corp.	9830 Colonnade San Antonio, TX 78230	Brine	Chambers, Harris, San Patricio.
The Dow Chemical Co.[5]	2020 Dow Center Midland, MI 48640	do.	Brazoria.

See footnotes at end of table.

TABLE 7—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Salt—Continued:			
Morton International Inc.	100 North Wacker Dr. Chicago, IL 60606	Underground mine and brine	Van Zandt.
United Salt Corp./Texas Brine Corp.	2000 West Loop S. Houston, TX 77027	do.	Fort Bend, Harris, Jefferson, Matagorda.
Sand and gravel:			
Construction:			
Capitol Aggregates Inc. (H. B. Zachry Co.)	Drawer 33240 San Antonio, TX 78265	Stationary plants	Bexar, Travis, Val Verde.
Centex Materials Inc.	Box 19000 Dallas, TX 75219	Pits and plants	Hays and Travis.
The Fordyce Co.	Box 1981 San Antonio, TX 78297	do.	Hidalgo and Victoria.
Holnam Inc.	6211 Ann Arbor Road Box 122 Dundee, MI 48131	Pits	Colorado and Fayette.
Parker Bros. & Co. Inc.[6]	Box 107 Houston, TX 77001	Stationary plants and dredges	Colorado, Fayette, Harris.
Pioneer Concrete of Texas Inc.[7]	800 Gessner Road Houston, TX 77024	Pits and plants	Colorado, Liberty, Montgomery, Matagorda.
Industrial:			
Oglebay Norton Co., Texas Mining Co.	2104 East Randol Mill Rd. Suite 101 Arlington, TX 76011	Pits and plant	McCulloch.
Speciality Sand Co.	Box 9877 Houston, TX 77105	Pits	Colorado, Harris, Newton.
Unimin Corp.	50 Locust Ave. New Canaan, CT 06840	Plant	Johnson.
U.S. Silica Co., a subsidiary of U.S. Borax & Chemical Corp.	Box 187 Berkeley Springs, WV 25411	Pits and plants	Limestone, Live Oak, McCulloch.
Sodium sulfate (natural):			
Ozark-Mahoning Co.	1870 South Boulder Tulsa, OK 74119	Brine field and plant	Gaines.
Stone:			
Texas Crushed Stone Co.	Box 1000 Georgetown, TX 78626	Plant and quarry	Williamson.
Vulcan Materials Co.[8]	Box 530187 Birmingham, AL 35253	Plants and quarries	Bexar, Brown, Eastland, Grayson, Kerr, Parker, Taylor, Uvalde, Wise.
Sulfur:			
Byproduct:			
Amoco Production Co. (Standard Oil Co., Indiana)	Box 591 Tulsa, OK 74102	Secondary recovery	Andrews, Ector, Galveston, Hockley, Wood.
Chevron U.S.A. Inc.	575 Market St. San Francisco, CA 94105	do.	Crane, El Paso, Hopkins, Jefferson, Karnes.
Exxon Chemical Americas	225 E. John W. Carpenter Freeway Irving, TX 75062-2298	do.	Atascosa and Harris.
Phillips Petroleum Co.	Bartlesville, OK 74003	do.	Andrews, Brazoria, Crane, Ector, Hutchinson, Moore.
Shell Oil Co.	Box 591 Tulsa, OK 74102	do.	Cass, Harris, Yoakum.
Texaco Production Inc.	Box 4697 Midland, TX 79704	do.	Franklin and Freestone.

See footnotes at end of table.

TABLE 7—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sulfur—Continued:			
Native:			
Pennzoil Co.	100 Milam Pennzoil Place Houston, TX 77002	Frasch mine	Culberson.
Texasgulf Inc., a subsidiary of Elf Aquitaine Inc.	3101 Glenwood Box 30321 Raleigh, NC 27622-0321	do.	Wharton.
Talc:			
Apache Minerals Inc. and Pioneer Talc Co.	1000 Coolidge St. South Plainfield, NJ 07080	Pits and plant	Hudspeth.
Dal Minerals Cop. (Dal-Tile)	Box 17130 Dallas, TX 75217	Pits	Do.
The Milwhite Inc.	Box 15038 Houston, TX 77020	Mine and plant	Culberson.
Southern Clay Products Inc., a divison of LaPorte PLC[9]	Box 44 Gonzales, TX 78629	Pit and plant	Hudspeth.
Vermiculite (exfoliated):			
W. R. Grace & Co.	2651 Manila Rd. Dallas, TX 75212	Exfoliating plants	Dallas.
Vermiculite Products Inc.	3025 Maxroy Houston, TX 77008	do.	Harris.

[1]Also sand and gravel, Brazos, Dallas, Ellis, and McLennan Counties; and crushed stone, Comal, Cooke, Ellis, Limestone, Walker, and Wise Counties.
[2]Also clays, Dallas and Gaudalupe County; sand and gravel, Dallas, Johnson, Tarrant, and Wise Counties; and stone, Comal, Freestone, and Wise Counties.
[3]Also clays, Ellis, Fort Bend, Guadalupe, Henderson, Navarro, and Van Zandt Counties; sand and gravel, Dallas, Ellis, Parker, Travis, and Wise Counties; and crushed stone, Comal, Ellis, and Wise Counties.
[4]Also crushed stone, Bexar, Hidalgo, Limestone, Medina, Midland, and San Patricio Counties.
[5]Also magnesium compounds and magnesium chloride for magnesium metal, Brazoria County.
[6]Also crushed stone, Comal County.
[7]Also crushed stone, Burnet, Parker, and Wise Counties; and industrial sand, Colorado and Liberty Counties.
[8]Also industrial sand, McCulloch County.
[9]Also clays, Gonzales County.

THE MINERAL INDUSTRY OF UTAH

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Utah Geological Survey for collecting information on all nonfuel minerals.

By Rodney E. Jeske[1] and Robert W. Gloyn[2]

Nonfuel mineral production from Utah decreased in 1991. The output value decreased 14% from that in 1990 to about $1.15 billion. This value ranked the State ninth, with 3.8% of the Nation's nonfuel mineral production.

Interest in precious metals continued in 1991. Metal output accounted for 80% ($916 million) of Utah's nonfuel mineral value. Utah provided the only source of mined beryllium in the Nation and was one of only two States that produced selenium. The State ranked third in copper, gold, magnesium, molybdenum, and iron production, and silver production was sixth highest in the Nation.

A relatively strong construction industry encouraged increased output of cement, clays, and sand and gravel. Utah production ranked second nationally in potash, third in sulfuric acid, fourth in magnesium compounds and phosphate rock, and sixth in salt. Other commodities important for their value included portland cement, clays, synthetic graphite, gypsum, limestone (high Ca lime), construction sand and gravel, and crushed stone.

TRENDS AND DEVELOPMENTS

Mine operators continued to place more emphasis on environmentally sound operations to protect fragile ecosystems, and abandoned mine reclamation work was widespread throughout Utah. Concern continued to grow over the loss of salt from the Bonneville Salt Flats, and the U.S. Bureau of Land Management (BLM) developed a program to try to determine how much of the loss was due to natural causes and how much to human activities. BLM estimates that there has

TABLE 1
NONFUEL MINERAL PRODUCTION IN UTAH[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Beryllium concentrates	metric tons	4,592	$5	4,548	$5	4,339	$5
Clays	do.	321,949	2,633	[2]277,795	[2]1,774	[2]210,382	[2]1,028
Gemstones		NA	659	NA	713	NA	489
Lime	thousand short tons	373	17,974	354	18,878	325	18,634
Salt	do.	1,183	40,421	1,171	50,436	1,326	29,959
Sand and gravel:							
Construction	do.	e14,300	e41,500	13,601	44,881	e14,400	e48,200
Industrial	do.	3	60	2	42	—	—
Silver[3]	metric tons	W	W	147	22,750	W	W
Stone (crushed)	thousand short tons	4,683	19,176	e4,600	e20,200	4,450	18,259
Combined value of cement, clays [bentonite (1990-91)], copper, fluorspar (1990), gold, gypsum (crude), iron ore (usable), magnesium compounds, magnesium metal, mercury (1989-90), molybdenum, phosphate rock, potash, sodium sulfate (natural), vanadium ore (1989-90), and values indicated by symbol W		XX	1,168,065	XX	r1,174,213	XX	1,032,493
Total		XX	1,290,493	XX	1,333,892	XX	1,149,067

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.
[3]Recoverable content of ores, etc.

been a 30% reduction of salt in the 10,117-hectare (25,000-acre) area since 1960 and estimate the annual loss at 1% (1.6 million short tons).

EMPLOYMENT

Utah's mining industry employed an average of 8,596 workers in 1991, remaining virtually unchanged from 1990. Metal mining employed 2,978; oil and gas extraction, 2,451; coal mining, 2,277; and nonmetallic minerals mining, 890. The mining industry comprised 1% of employment in Utah in 1991. Coal mining employment was at its lowest level of the past decade, as mine closures kept the industry from expanding. There were 258 fewer miners employed by the coal industry, as employment fell 10% from that of 1990. The mining industry provided $309.6 million in wages to its workers. The average monthly earnings per employee rose $26 from that of 1990 to $3,002.[3]

REGULATORY ISSUES

At the request of the Environmental Protection Agency (EPA), the U.S. Bureau of Mines assessed the characteristics of mill tailings at the Sharon Steel Superfund site, Midvale, Salt Lake County, to determine the feasibility of reprocessing the tailings. The mill processed ores from many different mines during its 50 years of operation, resulting in a mineralogically and chemically complex tailings pile with elevated and highly variable metal contents.

The U.S. Bureau of Mines Western Field Operations Center (WFOC), Spokane, WA, used analytical data generated by the Bureau's Salt Lake City Research Center (SLRC), Salt Lake City, UT, from 453 samples to determine spatial distributions of arsenic, cadmium, lead, and zinc in the tailings pile. Bulk samples were used by the Bureau's Rolla Research Center, Rolla, MO, and SLRC for process and beneficiation testing.

EPA's Bingham Creek Project in West Jordan, Salt Lake County, began in May. The cleanup of lead contaminated soil in residential areas along Bingham Creek was expected to be completed in October. Kennecott Corp. agreed to a financial commitment of about $4.75 million, which includes the cost of hauling the contaminated soil to a permanent disposal site on its property in the Oquirrh foothills. The EPA identified Kennecott and Atlantic Richfield Co. (ARCO) as the "potentially responsible parties," but both companies say the contamination was from unrelated, long-defunct mining operations. ARCO was, however, prepared to share its technical expertise for the cleanup.[4]

A Federal judge put on hold a $12 million settlement between Kennecott and the State of Utah pending further study. The Salt Lake County Water Conservation District will analyze the damage to the water supply to see if it can be remediate.[5]

Utah also focused attention on waste management practices related to oil and gas. The Division of Oil, Gas and Mining considered rule revisions to improve the State's waste management regulatory program and checked 5,740 oil and gas production sites and class 2 water injection wells during 1991. Inspection activities included reclamation of plugged and abandoned well sites and seismic lines, protection of surface and subsurface freshwater zones, and testing of oilfield safety equipment.

EXPLORATION ACTIVITIES

Exploration in Utah continued at a modest pace. Fifty-eight exploration Notices of Intent were issued by the Division of Oil, Gas and Mining, down from the 92 permits issued in 1990. Most permits were for precious metals, but an increasing number were for base metals. Most permits issued were in the Great Basin region of western Utah. The permits were issued for the following counties: Beaver (10); San Juan (9); Tooele (7); Emery (6); Juab (5); Box Elder (4); Garfield, Iron, and Washington (3 each); Millard, Piute, and Sevier (2 each); and Salt Lake and Wasatch (1 each).

Centurion Mines announced a gold discovery on the Kings Canyon property in western Millard County. The discovery contains an estimated 6,221 kilograms (200,000 troy ounces) of gold and could be mined by open pit methods. In addition to the discovery, the Centurion-Crown Resources Corp. Joint Venture has identified a number of other promising targets on the 40,486-hectare (100,000-acre) property.[6]

Sunshine Precious Metals, a wholly owned subsidiary of Sunshine Mining Co., completed a feasibility study and mining plan and has been seeking a joint-venture partner to share in the costs to develop additional areas of the Burgin Mine, near Eureka, Juab County. The Burgin Mine produced lead, silver, and zinc between 1954 and 1978.[7]

LEGISLATION AND GOVERNMENT PROGRAMS

The following Utah legislative bills, signed by the Governor, addressed the environment, reclamation, safety, taxes, and wilderness.

House Concurrent Resolution 13 urged Congress to add no more than 566,802 hectares (1.4 million acres) of BLM administered land in Utah to the National Wilderness Preservation System. Congressional hearings were held in Utah during the year to consider various wilderness proposals. The BLM had recommended approximately 809,717 hectares (2 million acres) be designated for wilderness protection, but the Utah congressional delegation was not unified in its recommendation. One faction proposed 566,802 hectares (1.4 million acres) while another recommended 2,226,721 hectares (5.5 million acres) be classified as wilderness.

House bill 397 amended property tax assessments to eliminate the 20% exemption given to properties that are confined to a single county. It required that small, local properties be assessed at the same rate as large, multicounty properties.

Senate bill 34 established a new Department of Environmental Quality

with a director, appointed by the Governor, who will serve as a member of the Governor's executive cabinet.

Abandoned mine reclamation to protect public health and safety and the environment was a top priority of Utah's Abandoned Mines Reclamation Program. Mining companies began to reclaim many of the historic uranium mine sites in southeastern Utah. Abandoned uranium sites in Capital Reef National Park and 37 silver mining sites near Eureka, Juab County, were being closed.[8]

The Utah Geological Survey (UGS) is involved in the following investigations: a study of Utah building stone; a National Coal Resource Data System project that included compiling and digitizing coal outcrops for all coalfields in Utah; a U.S. Department of Energy (DOE) and industry funded study of the Bluebell Field, in Uinta Basin, Duchesne County, to develop enhanced recovery techniques and extend the life of the field; a geophysical study of geothermal areas in southern Utah in conjunction with the University of Utah Research Institute using a newly developed self-potential technique for locating geothermal hot spots; and a study on the Cane Creek shale, Grand County, using previously drilled oil wells.

The UGS released two publications that have been popular with exploration companies, a report titled "Mines and Prospects Containing Gold in Utah," and the geologic map of Gold Bar Canyon quadrangle, Grand County, that covers one of the hottest oil and gas prospects.

The Board of State Lands and Forestry voted to offer approximately 1,619 hectares (4,000 acres) of trust lands in San Juan and Grand Counties for oil and gas leasing. These trust lands are part of 4,858 hectares (12,000 acres) earlier withdrawn from leasing by the Utah Legislature to accommodate potash mining. Developments in horizontal drilling technology, regulation, and recent oil discoveries in the area induced the board to permit oil and gas leasing.[9]

The SLRC completed research in fiscal year 1991 on Flotations Fundamentals and Redox Control Applications. The project concentrated on surface properties of chalcocite and chalcopyrite, the principal minerals recovered by flotation, and on flotation reagents dispensed according to redox potential. The research was designed to give mills an opportunity to improve flotation process control. Results of the study were used to design a redox control probe for process control.

The following projects are part of the ongoing research at SLRC:

(1) The Concentration and Recovery of Heavy Rare-Earth Elements project investigated electrophoresis methods, in cooperation with biologists at the University of Utah, for separating rare-earth element (REE).

(2) Research on Innovations for Precious Metal Recovery From Refractory Ores used ore samples from Utah, Nevada, and Colorado. The research focused on the extraction of precious metals from disseminated oxide gold ores and researched the leaching of carbonaceous and sulfide ores.

(3) Research on the Biohydrometallurgical Decontamination of Mining and Milling Wastes project included developing biotechnical methods of oxidizing cyanide. Process solutions and ore samples were collected from gold heap leach operations in Utah and Nevada. Test results show that biological cyanide oxidation has potential as a method of destroying the cyanide in spent heaps and may be a feasible technique of decreasing the cyanide concentrations in cyanide-contaminated ponds.

(4) The Immobilized Extractant Technology for Waste Water Treatment project, using porous polysulfone beads (BIO-FIX beads), indicates the beads can successfully remove toxic and heavy metals from acid mine drainage waters from active and abandoned mining operations. One of the field tests, in cooperation with the U.S. Forest Service, was to eliminate iron from water draining an abandoned silver mine in Utah. BIO-FIX bead technology was licensed by Fixed Film Industries, Harrison Western Environmental Services, and the R. A. Hanson Co., and they are working to commercialize the technology.

(5) Research on the Microbial and Chemical Arsenic Removal From Wastes project has included experimenting with tailings from the Olson-Neihart tailings pond near Heber, UT. These lead-zinc-gold ore tailings required relocation because of construction of a dam and reservoir. Potential arsenic-removing bacteria also were cultured from sediment samples from Bingham Creek, an arsenic-contaminated creek bed near Salt Lake City, UT, and sites around the Great Salt Lake, UT. These bacteria sulfate reducers precipitate arsenic as arsenic sulfide. Research shows that arsenic-removing bacteria from the Olson-Neihart tailings function within a very narrow Ph range.

(6) Work on the Treatment of Copper Industry Waste project was conducted under a memorandum of agreement with Kennecott Utah Copper. Research has shown the feasibility of processing smelter flue dust and refinery-bleed electrolyte in an integrated, semicontinuous, bench-scale process and stabilizing arsenic as a vitrified arsenic-sulfide glass.

(7) SLRC conducted research on germanium and gallium extraction from an ore sample collected at the Apex Mine near St. George, Washington County. The sample contained about 0.09% germanium and 0.04% gallium. Researchers using a two-stage countercurrent sulfuric acid leach circuit were able to recover about 87% of the germanium and 97% of the gallium. The germanium ore from the Apex Mine, a depleted copper mine, was found in the iron oxide zone. The Apex Mine is one of only two major reserves of germanium in the United States.

The Intermountain Field Operations Center continued its Inventory of Land Use Restraints Program (ILURP) study of Utah, begun in 1988. This long-term program was initiated by the U.S. Bureau of Mines to inventory Federal land use restrictions to assess accurately the availability of Federal lands for mineral entry. Under ILURP in 1991, the Bureau prepared draft computer plots showing the availability status for locatable and leasable minerals.

Three mineral patents for a total of 275 hectares (679 acres) were issued by the BLM in fiscal year 1991, ending September 30.[10] The BLM received 9,134 mining claims for recordation in 1991, a slight increase from last year's 9,028 claims.

In Utah, the Federal Government owns approximately 66% of the land base. Total royalties on Federal land in Utah, $51.3 million, included $13.3 million for oil, $6.6 million for gas, $30.3 million for coal, and $1.1 million for other products that included gas lost, gas plant products, geothermal, gilsonite, magnesium, potash, and sodium. Utah received $32.4 million from the mineral lease royalties and bonuses in 1991.[11]

FUELS

Utah's coal production remained at a historical peak, with only a slight decrease, even though coal prices were declining. Utah ranked 13th in the Nation for total coal production and 6th for underground coal production. It is the only State with all its coal production coming from underground mines.[12]

Fifteen underground coal mines produced 19.84 million metric tons (21.87 million short tons) of bituminous coal, the second highest annual production level on record, exceeded only by last year's record of 19.97 million metric tons (22.01 million short tons).[13]

The Wasatch Plateau coalfield was the major producing coalfield with more than 86% of Utah's coal production. The rest of the production was from the Book Cliffs coalfield. Carbon County produced more than 9 million metric tons (10 million short tons), Emery County produced 8 million metric tons (8.8 million short tons), and production from Sevier County was a record high of 2.8 million metric tons (3.1 million short tons).

Sunnyside Cogeneration Associates (SCA), a wholly owned subsidiary of Environmental Power Corp., began construction of a gross 58-megawatt waste coal-fired plant located at Sunnyside, Carbon County. The facility will burn waste coal refuse accumulated from the Sunnyside Mine. The refuse pile contains about 10.9 million metric tons (12 million short tons) of waste material that will supply the plant for 30 years. A transmission line to the Utah Power and Light grid at the Columbia Substation is planned.

Utah's average coal price in 1991 was $23.76 per metric ton ($21.56 per short ton) as the price continued to decline from a peak of $32.42 per metric ton ($29.42 per short ton) in 1982. A turnaround in Utah coal prices is expected in 1992. As a result of the 1990 Amendments to the Clean Air Act, low-sulfur Western coal is expected to be in greater demand for midwestern utilities in the next few years. Continued growth also is expected in the Japanese market.

In 1991, oil production decreased 7% to 25.75 million barrels, but gas production, which included recycled injection gas, increased nearly 3% to 329.7 billion cubic feet. San Juan County was the State's leading oil producer (32%), and Summit County lead in gas production (72%). Oil and gas drilling activity continued its upward trend, in large part to take advantage of tight gas sand tax credits due to expire at the end of 1992. Uintah, Duchesne, and San Juan Counties attracted the most exploration and development interest with activity also seen in Carbon, Daggett, Emery, Grand, and Summit Counties. A horizontal drilling play west of Moab continues to attract national attention. Columbia Gas Development completed two wells in the Cane Creek shale of the Pennsylvanian Paradox Formation using horizontal drilling techniques. These two wells tested 914 barrels of oil and 290,000 cubic feet of gas and 1,158 barrels of oil and 234,000 cubic feet of gas, respectively, in 24-hour tests.[14]

Coalbed methane drilling activity increased as four operators were pursuing projects in central Utah. Coalbeds in the Blackhawk and Mancos shale formations appear favorable. Cockrell Oil Co. tested five coalbed methane wells with very promising results. The UGS released new maps of coalbed methane potential for five coalbeds in the Blackhawk Formation of the Book Cliffs coalfield.

Utah Power and Light Co. operated its Blundell geothermal power station at the Roosevelt Hot Springs geothermal area near Milford, Beaver County, producing about 23 megawatts net output. Intermountain Geothermal Co. supplied the Blundell plant with geothermal fluid from four wells. The Utah Municipal Authority and the city of Provo operated their geothermal power station near Sulphurdale, Utah County, with a net output of about 10 megawatts. Geothermal steam is supplied by six wells operated by Mother Earth Industries.

The UGS and University of Utah Research Institute continued geophysical and geochemical studies at geothermal areas in southwest Utah. A geophysical anomaly at the Thermo Hot Spring, Iron County, may indicate a source of geothermal fluids with commercial development potential; and based on earlier studies by the UGS, one company is contemplating a large geothermal greenhouse complex in the Newcastle area.

Funding for the Abandoned Mines Reclamation Program was provided from a coal production tax. Reclamation of abandoned coal mines was the first priority. A survey indicated that almost 17,000 mine openings may need to be reclaimed at an estimated cost of $174 million. Coal mine reclamation work occurred at the Salina coal project, Sevier and Sanpete Counties; in Huntington Canyon, Carbon County; at the Escalante project, Garfield County; near Red Creek, Duchesne County; and at coal sites throughout Emery, Garfield, Kane, and Iron Counties. Coal mine fires were being controlled in Summit County and at the Maclean Mine, Carbon County.

The Utah Division of Oil, Gas and Mining is involved in a major aquifer study in the Aneth oilfield area of San Juan County. The $750,000 study will last 3 to 4 years and is funded by several Federal agencies and four oil companies.

Utah's Division of Energy's Fossil Fuel Technology Advancement Program funded five projects to improve fossil fuel production in Utah. Loans were awarded to: (1) the University of Utah Research Institute to develop imaging technology to

identify oil and gas recovery potential in deltaic reservoirs common in Utah, (2) Resource Enterprises, Inc. to develop horizontal drilling and fracturing techniques in coal mine walls, (3) the University of Utah Fuels Engineering Department to develop a bench-scale catalytic combustor to convert methane from mine vent air into heat to generate electricity, (4) a private company to develop low temperature processing techniques to extract valuable chemicals from oil shale and tar sands, and (5) a grant to the UGS to evaluate potential for using horizontal drilling technology in the Duchesne oilfield and gasfield.[15]

A report on the status of research and development of western oil shale resources was published by the Division of Energy under a contract with the DOE through Western Research Institute.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Beryllium.—Utah had the only beryllium-producing mine in the Nation, the Topaz Mine at Spor Mountain, Juab County. The mine, owned by Brush Wellman Inc., was the largest operating beryllium mine in the world. Mine production continued a decline that started in 1988. Although Brush Wellman reported mine production of 72,576 metric tons (80,000 short tons) of ore, with an average grade of 0.237%, production for 1991 was 4,536 metric tons (5,000 short tons) less than that of 1990.[16] The mine ore consists of bertrandite-bearing tuffs and is open pit mined. Mining operations were expanded and pre-mine stripping completed for two additional pits. An ongoing drilling program has consistently added to proven reserves, which were projected by Brush Wellman as sufficient for more than 50 years of production.

Brush Wellman is the only fully integrated supplier of beryllium products in the world. Bertrandite ore is transported from the mine in Juab County to the company's extraction plant near Delta, Millard County. This plant, the only facility of this type in the world, converts bertrandite ore and some imported beryl ore into beryllium hydroxide concentrate. About 87% of the beryllium in the bertrandite ore is recovered in the extraction process. The beryllium concentrate is shipped to Elmore, OH, where it is converted into beryllium, beryllium alloys, and ceramic-grade beryllia powder.

Beryllium is a strategic metal with unique physical properties of high strength, light weight, and high thermal conductivity that allow it to be used for a variety of products. Beryllium uses include electronic and electrical components, computers, telecommunications, cellular telephones, air-bag restraint systems, oilfield components, experimental fusion reactors, aerospace, defense systems, and lasers.

A 1990 Brush Wellman contract, with the Defense Logistics Agency, was extended to convert beryl ore in the National Defense Stockpile (NDS) to vacuum-hot-pressed beryllium billets. The extension called for an additional 19,500 kilograms of beryllium, worth about $13 million, to be delivered to the NDS in 1993. This extension brings the contracted total to 60,782 kilograms of billets over a 3-year period. Brush Wellman also purchased beryllium scrap from the Defense Reutilization and Marketing Service.

Copper.—In 1991, Utah retained its position as the third largest, out of 12 copper-producing States. This ranking was supported almost exclusively by the output of Bingham Pit, Salt Lake County, operated by Kennecott Utah Copper. Kennecott's Bingham Canyon open pit mine was the second largest domestic producer of copper during the year and it is the deepest manmade excavation in the world. The value of the copper production represented a significant portion of the value of all nonfuel mineral production in Utah.

Kennecott's parent company, The RTZ Corp., reported the Bingham Canyon Mine increased mined production by about 2% above 1990 production to 236,500 metric tons of copper, while refined production decreased about 12% from 1990 production levels to 133,400 metric tons of copper. A fourth grinding line and flotation circuit at the Bingham Canyon mill was completed at a cost of $219 million, and startup was scheduled for January 1992. During its first 5 years of operation, this fourth line will add an average of 32,000 metric tons (35,264 short tons) of copper and 2,600 kilograms (84,000 troy ounces) of gold to annual production figures. The RTZ Corp. approved an $880 million new copper smelter and refinery expansion. Designed to process 1 million metric tons (1.1 million short tons) of concentrate per year, the expansion will provide double the capacity of the current facility and significantly reduce operating and transportation costs while achieving the highest environmental standards in the industry.[17]

Gold.—In 1991, Utah remained the third largest gold-producing State. All of Utah's production was from lode mining, except some from old dumps. Improved production and a higher ore grade at Kennecott's Bingham Canyon mine resulted in a 9% increase in mined production to 14,246 kilograms (458,000 troy ounces) of gold as a byproduct from copper mining.[18] Bingham Canyon was the third largest gold-producing mine in the Nation.

The Mercur Mine, Tooele County, owned by Barrick Mercur Gold Mines, Inc. (subsidiary of American Barrick Resources Corp.), had its fourth consecutive year of record-high gold production in 1991 and was Utah's largest primary gold producer. New dump-leaching facilities increased production 58% from that in 1990. Production from Mercur's two open pits was 3,958 kilograms (127,280 troy ounces) during the year.

At Kennecott's Barneys Canyon Mine, production declined 12% to 3,795 kilograms (122,000 troy ounces) of gold.[19]

Tenneco Minerals Co.'s Goldstrike Mine, about 40 miles northwest of St. George, Washington County, operated in

1991 and produced 1,400 kilograms (35,600 troy ounces) of gold. The ore is mined from several open pits and heap leached. Tenneco announced toward yearend that the property was for sale.

The North Lily Mining Co., Juab County, produced 173 kilograms (5,570 troy ounces) of gold, and Sunshine Mining Co.'s Trixie Mine, Utah County, produced 233 kilograms (7,486 troy ounces) of gold in 1991.

Crown Resources Corp. and Centurion Mines Corp. announced a discovery at their Kings Canyon property in western Millard County. The deposit, which measured 762 meters by 91 meters (2,500 feet by 300 feet), contains an estimated 6,220 kilograms (200,000 troy ounces) of gold. They also identified a number of other targets on the property and drill tested several of these targets. The best drill hole averaged 1 gram per metric ton (0.029 troy ounce per short ton) of gold and 23 grams per metric ton (0.67 troy ounce per short ton) of silver over an 18-meter (60-foot) thickness.[20] Other gold exploration activity included Gold Standard in the Dugway district, Gold Fields Mining at Long Ridge southeast of Mercur, and Goldstack Resources in the Gold Hill district.

Iron Ore and Steel.—Utah was the third largest iron ore (usable) producer in the Nation of 10 States that reported production. Utah ranked ninth of 28 States that produced slag (iron and steel).

Geneva Steel operated two open pit mines, the Comstock and Mountain Lion, in the Pinto District, Iron County, throughout 1991. Reserves were exhausted at its Excelsior Mine during the year. Coarse ore and fines were shipped by railroad to Geneva's plant at Vineyard, Utah County.

Geneva shut down the last eight operating open-hearth furnaces used for steelmaking in the United States. As part of a $287 million modernization program announced in February 1990, Geneva completed installation of two basic oxygen process (Q-BOP) furnaces, a gas blanketing system, and a new coilbox that is the largest in the world. The new equipment enabled Geneva to increase operating efficiencies and significantly reduce air pollutants. During the year, the EPA presented Geneva and Utah County citizens with its Outstanding Achievement Award for their cooperative effort in developing one of the Nation's first State Implementation Plans designed to control fine particulate pollution.

The Linde Div. of Union Carbide Industrial Gases announced it would build a $25 million air separation plant at Vineyard, Utah County. The plant will supply Geneva Steel the three gases needed to operate its new Q-BOP furnaces, which refine molten iron into steel. The Linde Div. has a 15-year contract with Geneva.[21]

Geneva and Alexander Mill Services, Plymouth, Box Elder County, were processors of iron and steel slag in 1991. Alexander Mill Services is a subcontractor, processing slag from Nucor Corp.'s steel mill in Plymouth.

Magnesium.—Utah ranked third of the three magnesium-producing States in the Nation. In terms of value, magnesium metal production was the third largest nonfuel mineral industry in Utah, after copper and gold. Magnesium Corp. of America operated newly installed pollution control equipment in its plant at Rowley, Tooele County, for the entire year and used an electrolytic process to recover magnesium from lake brines.

Molybdenum.—Utah ranked third of the eight States reporting molybdenum production. Molybdenite concentrates were recovered as a byproduct of copper production at Kennecott's Bingham Canyon Mine. Molybdenum mined production increased about 35% over production in 1990 to 7,000 metric tons (15.7 million pounds).[22] The sulfide concentrates were roasted and converted to molybdic oxide in the company plant at Magna.

Silver.—Utah remained the sixth largest silver-producing State in the Nation, out of 16 States that reported silver production. Production of byproduct silver at Kennecott's Bingham Canyon Mine ranked the mine fifth among all silver producers in the Nation. Silver production at Bingham Canyon increased 7% over production in 1990 and represented nearly 90% of the silver mined in Utah.[23] Other silver producers included Tenneco Minerals (Goldstrike Mine), Washington County; Sunshine Mining Co. (Trixie Mine), Utah County; Barrick Resources (Mercur Mine), Tooele County; and North Lily Mining Co. (Silver City Mine), Juab County.

Uranium and Vanadium.—Umetco Minerals Corp., a subsidiary of Union Carbide, operated its White Mesa uranium and vanadium mill near Blanding, San Juan County, receiving ore from company-owned and independent mines located in San Juan County. However, in late 1991, Umetco suspended mining operations and placed its company-owned mines and the White Mesa mill on standby. No vanadium production was reported for Utah in 1991.

Other Metals.—Mercury was produced as byproduct from gold mining at Mercur Mine, Tooele County, and platinum-group metals were recovered as byproducts of copper refining.

Of two States that reported selenium production, Utah was second. The selenium was recovered from anode slimes generated in the electrolytic refining of copper.

Operation of a tungsten mine in Box Elder County was proposed by the Ensign Co. The underground mine would be opened near the mouth of George Creek Canyon near the Idaho border.

Industrial Minerals

Cement.—Production of cement in Utah stayed about the same as 1990 production. The State was 21st of 38 States producing portland cement and 31st of 33 States producing masonry cement. Ash Grove Cement West, Inc. (subsidiary of Ash Grove Cement Co.) produced portland cement at its dry-process plant at Leamington, Millard County, and

Holnam, Inc., Ideal Div. (subsidiary of Holderbank Financiere Glaris Ltd.) produced portland and masonry cement from its wet-process plant at Morgan, Morgan County.

Clays.—Utah produced bentonite and common clay and ranked 29th out of 44 States for total clay and shale production. Bentonite production decreased significantly from 1990 production. Utah ranked 8th among 11 States for bentonite production and 26th out of 43 States for common clay production.

Interpace Industries, Utah and Weber Counties, and Interstate Brick Co., Box Elder, Piute, Summit, Tooele, and Utah Counties, were the two largest clay producers in the State. They blended clays from several quarries to manufacture brick. Bentonite was mined by the Western Clay Co. in Sevier County and by the Redmond Clay and Salt Co. in Sanpete County. Western Clay Co. produced fuller's earth at its mine near Aurora, Sevier County. Utelite Corp. mined an organic-rich shale in western Summit County, which is expanded and used as lightweight aggregate.

Gypsum.—Both crude gypsum and calcined gypsum were produced in Utah during 1991. Crude gypsum production decreased from 1990 levels. Most gypsum was mined from several open pits northeast of Sigurd in Sevier County by Georgia-Pacific Corp. and the United States Gypsum Co.

Lime.—Lime production decreased 8% from production in 1990. Utah ranked 15th among 32 States in lime production, producing both high-calcium and dolomitic lime. Chemstar Inc. in Tooele County and Continental Lime Inc. in Millard County were the major producers. Continental Lime announced plans to expand its Cricket Mountain Lime Plant near Delta, Millard County. With the addition of a third rotary kiln, the plant capacity would increase 50%.

Magnesium Compounds.—Magnesium compounds production increased 12% over production reported in 1990. Great Salt Lake Minerals and Chemicals Corp. produced magnesium chloride from Great Salt Lake brines at their plant west of Ogden in Weber County, and Reily Industries Inc. produced magnesium chloride form subsurface brines of the Bonneville Salt Flats at its plant south of Wendover in Tooele County.

Phosphate Rock.—Utah's phosphate rock production decreased slightly from that in 1990. Chevron Resources Co.'s operation near Vernal, Uintah County, mined and beneficiated phosphate rock. The ground phosphate was pumped through a slurry pipeline to the company's fertilizer plant at Rock Springs, WY. Toward yearend, Chevron sold its phosphate mine near Vernal to FS Industries, a joint venture between Farmland Industries of Kansas City, MO, and J.R. Simplot of Boise, ID.

Potash.—Utah was the second largest of four potash-producing States in 1991. Potash production decreased about 11% from that reported in 1990, while the price stayed essentially the same as in 1990.

Moab Salt Inc. produced muriate of potash, for Texas-Gulf Chemical Co., from underground bedded deposits by two-well solution mining and solar evaporation near Moab, Grand County. Beneficiation by flotation of the sylvinite salts from the solar ponds separated sylvite from the halite.

Great Salt Lake Minerals & Chemical Corp. (GSL) produced sulfate of potash from brines of the North Arm of Great Salt Lake by solar evaporation and beneficiation. GSL planned to construct additional solar-evaporation ponds on the west side of the lake and dredged a 20-mile underwater channel to carry concentrated brines across the lake to the intake of the Weber County facility. GSL planned to spend approximately $20 million to increase potash production from 181,440 metric tons (200,000 short tons) per year to about 308,448 metric tons (340,000 short tons) per year.

Reilly Industries Inc. produced muriate of potash and manure salts by solar evaporation of near-surface brines at the Reilly-Wendover plant at the west end of the Bonneville Salt Flats. The potash was beneficiated by froth flotation.

One plant, which did not mine any ore, manufactured sulfate of potash from muriate of potash and sulfuric acid. Production of about 11,340 metric tons (12,500 short tons) was reported in 1991. Crystal Peak Minerals Corp. was laying salt in solar ponds at the south end of Sevier Lake in Beaver and Millard Counties with the objective of producing potassium sulfate by late 1992.

Salt.—The production of Utah salt (sodium chloride) decreased 12% in 1991 from that in 1990. Utah ranked 6th out of 14 States producing salt. Four companies, Akzo Salt Inc., Great Salt Lake Minerals and Chemicals Corp., Morton International Inc., and North American Salt Co., used shallow solar evaporation ponds to harvest solar salt from the Great Salt Lake brines. Reilly Wendover at its plant near the Bonneville Salt Flats in Tooele County and Crystal Peak Minerals Corp. at its plant at the southern end of Sevier Lake in Millard County produced solar evaporated salt obtained from shallow subsurface brines. The Redmond Clay & Salt Co. mined rock salt from a bedded salt deposit at its underground mine in Sevier County. Moab Salt Inc., Grand County, produced salt as a byproduct from its potash solution mining operation.

Morton International Inc. sold its 2,600-acre Saltair property at the north end of the Oquirrh Mountains to Kennecott and purchased North American Salt Co.'s facility on the southern shore of Great Salt Lake near Grantsville, Tooele County. This purchase provided Morton with increased solar salt production capacity.

North American Salt planned to invest a portion of the proceeds from its property sale to Morton in the GSL (sister company of North American Salt) expansion. In return, North American

TABLE 2
UTAH: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch): Riprap and jetty stone[2]	68	475	$6.99
Coarse and fine aggregate: Crusher run or fill or waste	150	222	1.48
Other construction materials[3]	1,240	4,567	3.68
Agricultural: Poultry grit and mineral food[4]	3	80	26.67
Chemical and metallurgical: Lime manufacture	1,369	6,269	4.58
Other miscellaneous uses[5]	1,408	5,798	4.12
Unspecified:[6]			
Actual	180	737	4.09
Estimated	31	110	3.55
Total[7]	4,450	18,259	4.10

[1]Includes dolomite, limestone, sandstone, and volcanic cinder (scoria).
[2]Includes macadam.
[3]Includes bituminous aggregate, coarse, railroad ballast, stone sand, concrete, stone sand, bituminous mix or seal, screening, undesignated, graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregate, and drain fields.
[4]Includes other agricultural uses.
[5]Includes cement manufacture, flux stone, and mine dusting or acid water treatment.
[6]Includes production reported without a breakdown by use and estimates for nonrespondents.
[7]Data may not add to totals shown because of independent rounding.

Salt would receive the right to market all of the salt byproduct GSL extracts.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1990 and estimates for 1989 and 1991.

Utah construction sand and gravel statistics are compiled according to geographical districts as depicted on the State map. The State's production is estimated to have increased about 5.9% from that of 1990. Utah's estimated production in 1991 was ranked 19th of 50 States.

Sodium Sulfate.—Utah was one of three States that produced natural sodium sulfate in 1991. Brines were pumped from the concentrated northwest segment of Great Salt Lake and placed in solar evaporation ponds. As winter weather cools the brine to 4° to -1° C (40° to -30° F), sodium sulfate precipitates in a fairly pure state. The sodium sulfate crystals are picked up and stored for further processing to anhydrous sodium sulfate, with a purity of 99.5% to 99.7%.

Stone.—Both crushed and dimension stone were produced in Utah during 1991. Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1990 and actual data for 1989 and 1991.

Crushed.—Crushed stone production decreased 5% from 1989 production. Utah ranked 36th out of 49 States that produced crushed stone. A variety of rock types were quarried; these included limestone, dolomite, granite, sandstone, quartzite, volcanic cinder, and scoria. Crushed stone was used for construction, agricultural, chemical, and metallurgical products. The largest use for crushed stone was for lime manufacturing, followed closely by cement manufacturing.

Sixteen companies in Utah had reported crushed stone production in 1991 from 21 counties and 40 quarries. The largest producers of crushed stone were Ash Grove Cement Co., Juab County; Cache County Road Dept., Cache County; Chemstar Inc., Tooele County; Continental Lime Inc., Millard County; Geneva Steel, Utah County; Holnam Inc., Morgan County; and Staker Paving & Construction Co., Salt Lake County. The U.S. Forest Service had 20 operations in 17 counties, with the major production from quarries in Piute and Wasatch Counties.

Dimension.—Two companies had operations producing dimension stone in 1991. Northern Stone Supply quarried quartzite flagstone in Box Elder County. State Stone Corp. quarried red and buff sandstone blocks for building stone in Box Elder, Sanpete, and Wayne Counties.

Other Industrial Minerals.—Three operations mined natural asphalt from tar sand deposits in Uintah County for use in local road paving. Chevron Corp. sold its asphaltite (gilsonite) mine, operated by the American Gilsonite Co. near Bonanza, Uintah County, to Stratford Enterprises Co. of Tulsa, OK, which then dissolved and became American Gilsonite Co.

Chlorine gas was recovered as a byproduct by Magnesium Corp. of America at its magnesium plant.

The value of gemstones produced in Utah declined 31% from that reported in 1990. Gemstones produced in Utah included topaz, variscite, obsidian, and red beryl. The Violet claims in the Wah Wah Mountains were the only known location for commercial production of red beryl.

Fiber Technology Corp. in Provo, Utah County, and Hercules Inc. in Salt Lake City, Salt Lake County, were among the top 15 producers of synthetic graphite in 1991.

Perlite that was mined in Idaho was expanded in Utah, ranking Utah 22d out of 33 States that produced expanded perlite in 1991.

Sulfur and sulfuric acid were produced as byproducts of copper smelting and oil refining, ranking Utah 3d among 11

States that reported sulfuric acid production.

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[1]Geologist, U.S. Bureau of Mines, Denver, CO.
[2]Senior Geologist, Utah Geological Survey, Salt Lake City, UT.
[3]Newman R. W., and K. Beckstead. Annual Report of Labor Market Information 1991. Utah Department of Employment Security Labor Market Information & Research, Salt Lake City, UT. Oct. 1992, pp. 1, 2, 7, 21-22.
[4]Deseret News. July 11, 1991.
[5]———. Nov. 22 and 23, 1991.
[6]Rocky Mountain Pay Dirt (Bisbee, AZ). Jan. 1991.
[7]Sunshine Mining Company. 1991 Annual Report, 20 pp.
[8]Utah Department of Natural Resources. 1991-92 Annual Report. Salt Lake City, UT, 1992, 80 pp.
[9]Page 38 of work cited in footnote 8.
[10]Bureau of Land Management. Public Land Statistics 1991, p 11.
[11]Minerals Management Service. Royalty Management Program, Mineral Revenues 1991, Report on Receipts From Federal and Indian Leases. pp. 47, 61, 64-68.
[12]U.S. Department of Energy, Coal Production 1991. Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, Washington, DC, DOE/EIA-0118 (91), Distribution Category UC-950. Oct. 1992, pp. 18, 21, 29, 62, 79, 81.
[13]Jahanbani, F. R. 1991 Annual Review and Forecast of Utah Coal Production and Distribution. UT Dep. of Nat. Resour., Div. of Energy, Salt Lake City, UT, Nov. 1992, 20 pp.
[14]Pages 18 and 19 of work cited in footnote 8.
[15]Pages 10-11 of work cited in footnote 8.
[16]Brush Wellman Inc. 1991 Annual Report. 25 pp.
[17]The RTZ Corporation PLC. Annual Report and Accounts 1991. 66 pp.
[18]Work cited in footnote 17.
[19]Work cited in footnote 17.
[20]Mining Engineering, Nov. 1991, p. 1305.
[21]Rocky Mountain Construction, Jan. 7, 1991.
[22]Work cited in footnote 17.
[23]Work cited in footnote 17.

TABLE 3

UTAH: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	(2)	(2)	60	430	8	45
Coarse aggregates, graded[3]	W	W	W	W	—	—
Fine aggregates (-3/8 inch)[4]	W	W	W	W	—	—
Coarse and fine aggregates[5]	42	179	546	1,629	12	12
Other construction materials	219	930	571	2,039	—	—
Agricultural[6]	(7)	(7)	(7)	(7)	—	—
Chemical and metallurgical[8]	(7)	(7)	(7)	(7)	—	—
Special[9]	(7)	(7)	(7)	(7)	—	—
Other miscellaneous uses	2,037	8,601	744	3,546	—	—
Unspecified:[10]						
Actual	20	238	10	59	150	441
Estimated	—	—	31	110	—	—
Total[11]	2,317	9,948	1,962	7,813	170	498

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, and riprap and jetty stone.
[2]Less than 1/2 unit.
[3]Includes bituminous aggregate, coarse, and railroad ballast.
[4]Includes stone sand, bituminous mix or seal, and screening, undesignated.
[5]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run or fill or waste, and drain fields.
[6]Includes poultry grit and mineral food.
[7]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[8]Includes cement manufacture, lime manufacture, and flux stone.
[9]Includes asphalt fillers or extenders, whiting or whiting substitute, and other fillers or extenders.
[10]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[11]Data may not add to totals shown because of independent rounding.

TABLE 4

UTAH: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	10	3,338	$13,641	$4.09	28	2,990	$12,590	$4.21
Dolomite	3	425	2,596	6.11	2	W	W	3.53
Granite	3	W	W	3.13	—	—	—	—
Sandstone and quartzite	1	W	W	2.56	4	W	W	4.23
Volcanic cinder and scoria	2	W	W	5.27	6	31	385	12.42
Total[1]	19	4,683	19,176	4.09	40	4,450	18,259	4.10

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Data may not add to totals shown because of independent rounding.

UTAH

LEGEND

- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Asp	Asphaltite
Au	Gold
AuAg	Gold-silver refinery
Be	Beryllium
Be	Beryllium plant
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper
Cu	Copper plant
D-Q	Dimension Quartzite
D-S	Dimension Sandstone
Fe	Iron
Gyp	Gypsum
K	Potash
Lime	Lime plant
Mg	Magnesium
Mg	Magnesium metal plant
Mo	Molybdenum
P	Phosphate rock
Salt	Salt
SG	Sand and Gravel
Steel	Iron and Steel plant
UV	Uranium-Vanadium
UV	Uranium-Vanadium plant

Concentration of mineral operations

Principal Mineral-Producing Localities

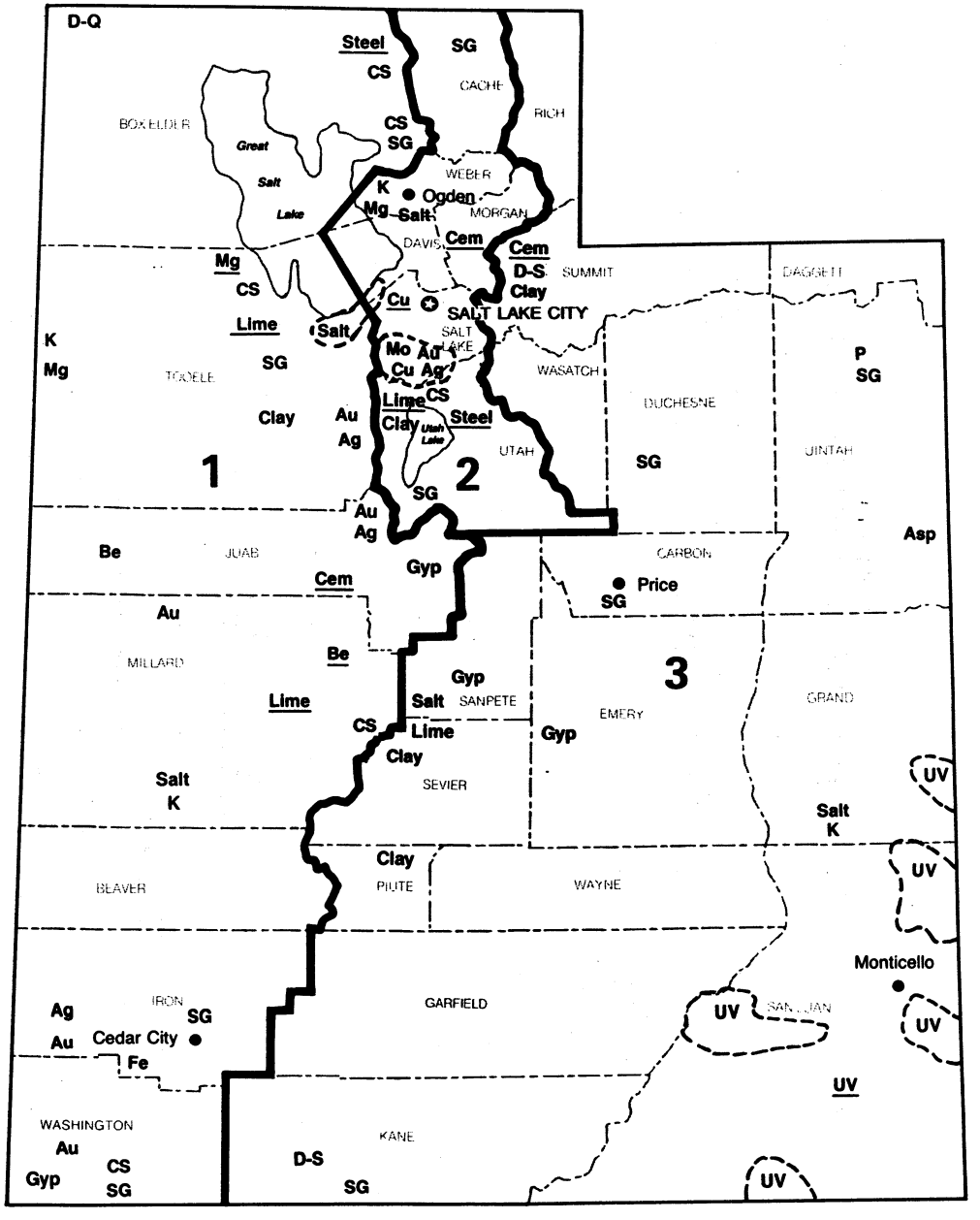

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Asphaltite:			
American Gilsonite Co.	136 East South Temple, St. Suite 1460 Salt Lake City, UT 84111	Underground mines and plant	Uintah.
Ziegler Chemical & Mineral Corp.	Star Route Little Bonanza Vernal, UT 84078	do.	Do.
Beryllium:			
Brush Wellman Inc.	Box 815 Delta, UT 84624	Open pit mines and plant	Juab and Millard.
Cement:			
Ash Grove Cement West Inc.[1] a subsidiary of Ash Grove Cement Co.	Box 51 Nephi, UT 84648	Quarries and plant	Do.
Holnam Inc., Ideal Basic Div.,[1] a subsidiary of Holderbank Financier Glaris Ltd.	Aux. Route 3 6055 East Croydon Rd. Morgan, UT 84050	do.	Morgan.
Clays:			
Interpace Industries	Box 12118 Ogden, UT 84412	Open pit mines and plant	Utah and Weber.
Interstate Brick Co., a division of Pacific Coast	9780 South 5200 West West Jordan, UT 84088	do.	Box Elder, Piute, Tooele, Utah.
Redmond Clay & Salt Co., Inc.[2]	6005 North 100 West Redmond, UT 84652	Underground mine	Sanpete.
Utelite Corp.	Box 387 Coalville, UT 84017	Open pit mine and plant	Summit.
Western Clay Co.	Box 127 Aurora, UT 84620	Quarry and open pit mines	Sevier.
Copper:			
Kennecott Utah Copper,[3] a division of Kennecott Corp.	8362 West 10200 South Box 525 Bingham Canyon, UT 84006	Open pit mine, mill, smelter, refinery	Salt Lake.
Gold:			
Barrick Mercur Gold Mines Inc.,[4] a subsidiary of American Barrick Resources Corp.	Box 838 Tooele, UT 84074	Open pit mine, heap leach, mill, plant	Tooele.
Kennecott Corp., a subsidiary of The RTZ Corp. PLC	Box 311 Bingham Canyon, UT 84006	Open pit mines, heap leach, mill, refinery	Salt Lake.
North Lily Mining Co.[4]	Box 421 Eureka, UT 84628	Heap leach and plant	Juab.
Sunshine Mining Co.[5]	Box 250 Eureka, UT 84628	Underground mine and mill	Utah.
Tenneco Minerals Co.[4]	Box 2650 St. George, UT 84771	Open pit mines, heap, leach, plant, refinery	Washington.
Gypsum:			
Georgia-Pacific Corp.	Box 570080 Sigurd, UT 84657	Quarries and plant	Sevier.
United States Gypsum Co., a subsidiary of USG Corp.	Box 570160 Sigurd, UT 84657	do.	Do.
Iron and steel:			
Alexander Mill Services	7285 West 21200 North P.O. Box 99 Plymouth, UT 84330	Plant	Box Elder.
Geneva Steel[1]	Box 2500 Provo, UT 84603	Mines quarries, plant	Iron and Utah.

See footnotes at the end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Lime:			
Chemstar Lime[1]	Box 537 Grantsville, UT 84029	Quarry and plant	Tooele.
Continental Lime Inc.,[1] a subsidiary of Steel Bros. Canada Ltd.	Box 669 Delta, UT 84624	do.	Millard.
Materials Energy Research & Recovery Corp.,[1] a subsidiary of United States Pollution Controls Inc.	Box 596 Grantsville, UT 84029	do.	Tooele.
Magnesium:			
Magnesium Corp. of America, a subsidiary of Renco Group Inc.	238 North 2200 West Salt Lake City, UT 84116	Plant and solar evaporation ponds	Do.
Phosphate rock:			
Chevron Chemicals, a subsidiary of Chevron Corp.	9401 North Highway 191 Vernal, UT 84078	Open pit mine and plant	Uintah.
Potash:			
Great Salt Lake Minerals & Chemicals Corp.,[6] a division of GSL Acquisition Corp.	765 North 10500 West Ogden, UT 84404	Plant, concentrator, solar evaporation ponds	Weber.
Moab Salt Inc.,[2] a division of Texasgulf, Inc., a subsidiary of Societe Nationale Elf Aquitaine	Box 1208 Moab, UT 84532	Solution mine, solar evaporation, concentrator, plant	Grand.
Reilly Wendover Inc.,[7] a division of Reilly Industries Inc.	Box 580 Wendover, UT 84083	do.	Tooele.
Salt:			
Akzo Salt Inc.	1428 James Palmer Rd. Lake Point, UT 84074	Solar evaporation ponds and plant	Do.
North American Salt Co.	Box 477 Grantsville, UT 84029	do.	Do.
Morton International Inc.	Box 506 Grantsville, UT 84029	do.	Salt Lake and Tooele.
Sand and gravel (construction):			
Big Cottonwood Sand & Gravel Co.	6695 Wasatch Blvd. Salt Lake City, UT 84121	Pits and plants	Salt Lake.
Concrete Products Co., a division of Gibbons & Reed Co.	Box 7356 Murray, UT 84107	do.	Davis, Salt Lake, Summit, Utah, Weber.
Geneva Rock Products Inc.	Box 538 Orem, UT 84057	do.	Salt Lake.
Harper Excavating Inc.	4655 West 5415 South Kearns, UT 84118	do.	Do.
J and J Mill & Lumber Co. Inc.	180 North 300 East St. George, UT 84770	do.	Washington.
LeGrand Johnson Corp.	Box 248 Logan, UT 84321	do.	Cache, Grand, Rich.
Pioneer Sand & Gravel Co.	Box 18457 Kearns, UT 84118	do.	Salt Lake.
Savage Rock Products	748 West 300 South Salt Lake City, UT 84104	do.	Davis and Salt Lake.
Staker Paving & Construction Co.[1]	Box 27598 Salt Lake City, UT 84127	do.	Salt Lake.
Western Rock Products Corp.	820 North 1080 East St. George, UT 84770	do.	Washington.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone (crushed):			
U.S. Forest Service	324 25th Street Ogden, UT 84401	Quarries	Cache, Carbon, Duchesne, Garfield, Iron, Juab, Kane, Millard, Piute, San Juan, Sevier, Summit, Uintah, Utah, Wasatch, Washington, Wayne.
Cache County Road Department	525 North 1000 West Logan, UT 84321	Quarries and mill	Cache.
Stone (dimension):			
Northern Stone Supply	Box 249 Oakley, ID 83346	Quarry	Box Elder.
State Stone Corp.	4640 South 300 West Salt Lake, UT 84107	Quarries and plant	Box Elder, Sanpete, Wayne.

[1]Also stone (crushed).
[2]Also salt.
[3]Also gold, molybdenum, and silver.
[4]Also silver.
[5]Also copper and silver.
[6]Also magnesium compounds, salt, and sodium sulfate.
[7]Also magnesium compounds.

THE MINERAL INDUSTRY OF VERMONT

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Agency of Natural Resources, Division of Geology and Mineral Resources, for collecting information on all nonfuel minerals.

By Donald K. Harrison[1]

The value of nonfuel mineral production in Vermont in 1991 was $59.8 million, a decrease of $22 million from that of 1990. The 1991 value was the lowest since 1986, when the value totaled $55.2 million. Decreases in both output and value were reported for most of the nonfuel minerals produced in the State. Principal minerals produced, in descending order of value, included dimension stone, crushed stone, construction sand and gravel, and talc. Nationally, the State ranked second of eight States that produced talc. It ranked third in quantity but first in value of dimension stone and was one of only two States that produced asbestos.

EMPLOYMENT

In 1991, the average number of workers employed in the mineral extractive industries in Vermont was 1,039, about the same as that in 1990.[2] This included 22 workers in underground mines, 650 at surface operations, and 367 working in mineral-related mills and preparation plants.[3]

REGULATORY ISSUES

The Chittenden Regional Solid Waste Management District (CRSWMD) nominated one of Vermont's largest sand and gravel operation sites as the top choice for a proposed 20-year regional lined landfill. The CRSWMD, a government body made up of representatives from each of the member towns, named the 75-acre Hinesburg Sand & Gravel Co. (HS&G) sandpit in Williston for the site of its new, double-plastic-lined landfill. State law (Act 78) mandates that all unlined landfills be closed by July 1992. Currently, there are no lined landfills in the district that could accept the region's trash after that date. The CRSWMD indicated that if it does not obtain a site for the new landfill by then, the residents of the county would be forced to pay $3.3 million per year in additional costs to ship and dispose of the trash in an acceptable landfill outside of the county.[4]

The owner of HS&G opposes the landfill plan at the sand and gravel site and has vowed to fight. Although the CRSWMD commissioned a study to determine whether the sand and gravel operation and the proposed new landfill could operate on the site simultaneously, the study was not completed by yearend. If the CRSWMD cannot purchase the land outright, it indicated that it might have to resort to condemnation proceedings to obtain the land. Voters in the district are expected to be asked in March 1992 to ratify the site as the proposed landfill.

LEGISLATION AND GOVERNMENT PROGRAMS

Over the past several years, there has been a continuing effort to override the State's control over sand and gravel removal from streambeds since the bill was signed into law in 1987. Act No. 67 (H. 339), passed in 1987, provides for the designation of certain river segments in the State as Outstanding Resource

TABLE 1
NONFUEL MINERAL PRODUCTION IN VERMONT[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gemstones		NA	$10	NA	$10	NA	$5
Sand and gravel (construction)	thousand short tons	e6,900	e20,400	3,675	11,948	e3,000	e9,900
Stone:							
Crushed	do.	3,119	28,110	e3,700	e35,000	2,685	12,666
Dimension	short tons	100,698	31,413	e99,243	e28,950	92,676	31,013
Combined value of other industrial minerals		XX	8,969	XX	6,046	XX	6,236
Total		XX	88,902	XX	81,954	XX	59,820

eEstimated. NA Not available. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Waters. The most controversial section of the law addresses gravel removal from a streambed. The law prohibits gravel removal from a watercourse if the gravel was for construction or sale. Since passage of this law, many municipalities have been struggling to obtain adequate supplies of sand and gravel for routine maintenance.

In 1991, two bills were introduced that would simplify a municipality's ability to remove sand and gravel from streambeds. House bill 116 would provide municipalities more leeway in controlling streamflow by allowing municipalities to permit gravel extraction from a watercourse for the purpose of protecting farm land, highways, and bridges. House bill 218 would enable municipalities to preserve bridges and farm land by dredging watercourses to the extent necessary to maintain and restore traditional flow and to use dredged material to control future flow. At the end of the legislative session, both of these bills remained in committee and may be taken up again in the next legislative session.

The Vermont State Geologist, together with the other New England State Geologists, investigated the future demand for construction aggregates—sand and gravel and crushed stone—in the six-State New England region. The aggregates demand study was initiated by the New England Governors Council with funds provided by the U.S. Department of the Interior, Minerals Management Service. The study was the first of a two-part investigation to determine what potential difficulties may exist in establishing the availability of construction aggregates in New England. Results of the first part of the investigation, which focused on aggregate demand and the problems faced by aggregate producers in opening new production facilities, was published in January 1992.[5] The second part of the investigation, which will focus on the location and quantities of sand and gravel deposits that are available for eventual development, will be initiated in 1992.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Asbestos.—The Vermont Asbestos Group Inc. (VAG), one of two active asbestos companies in the country, operated an open pit mine and dry-processing mill near Lowell, Orleans County. VAG produced a wide range of chrysotile grades 3, 4, 5, 6, and 7 with respective tonnages varying from year to year. In terms of distribution, about four-fifths of VAG's production was exported to the Far East, South America, and Europe, with the remaining 20% for domestic usage.[6] Most of the asbestos was used to manufacture clutches, brake components, and diaphragms for chlorine production.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Construction sand and gravel was the State's third leading mineral commodity produced in terms of value. Based on estimates, output and value of construction sand and gravel decreased 18% and 17%, respectively, from those of 1990. A total of 65 companies and towns mined construction sand and gravel from 81 operations in all of the State's counties. Leading counties, in order of descending output, were Washington, Rutland, and Chittenden. Main uses were for road base and coverings, concrete aggregate, and fill.

Pike Industries Inc. and Crushed Rock Inc. together paid a fine of $250,000 for violating the State's land use and development law, Act 250. According to Vermont's Attorney General, the fine was imposed for violating conditions of a permit issued for their gravel operation in Clarendon. The violations occurred between April 1986 and August 1986, while the quarry was supplying gravel for the construction of the Route 4 bypass south of Rutland. The Attorney General indicated that the quarry had exceeded its permit conditions for blasting, excavating, and trucking. Crushed Rock owned the quarry and leased it to Pike, who did the actual excavation. The $250,000 fine is the largest ever imposed for an Act 250 violation. The payment of the fine also ended a 5-year legal battle against the two companies.[7]

In December, the Essex Selectboard indicated that it would take the town's planning commission to court over the commission's approval of a sand and gravel operation in the community. In November, the planning commission unanimously approved a 20-acre, 10-year sand and gravel operation proposed by the Forestdale Heights Inc. Members of the Selectboard indicated that the planning commission had "overstepped its authority" in approving the project that would extract 2.4 million cubic yards from the 20-acre site.[8]

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Crushed.—Crushed stone was the State's second leading mineral commodity produced and accounted for 21% of the State's total mineral value in 1991. Output of crushed stone declined by 27% from the estimated output of 1990. The decline was largely the result of the continuing building slump in the northeast. Limestone was the primary rock quarried, followed by marble and granite. Other stone quarried included dolomite and quartzite. Crushed stone was produced at 22 quarries in 10 of the State's 13 counties. Leading counties, in order of output, were Chittenden, Rutland, Addision, Caledonia, and Washington. Crushed stone was also quarried in Franklin, Lamoille, Orange, Orleans, and Windham Counties. Major uses were for road base and bituminous concrete.

TABLE 2
VERMONT: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Riprap and jetty stone	25	112	4.48
Filter stone	41	232	5.66
Coarse aggregate, graded: Concrete aggregate, coarse[2]	216	1,733	8.02
Fine aggregate (-3/8 inch):			
Stone sand, bituminous mix or seal	196	1,332	6.80
Coarse and fine aggregate: Other construction materials[3]	133	671	5.05
Unspecified:[4]			
Actual	1,433	4,987	3.48
Estimated	641	3,599	5.61
Total	2,685	12,666	4.72

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes dolomite, granite, limestone, marble, miscellaneous stone, quartzite, and traprock.
[2]Includes bituminous (coarse) and surface-treatment aggregate, and railroad ballast.
[3]Includes graded road base or subbase, unpaved road surfacing, crusher run or fill or waste, and other construction materials.
[4]Includes production reported without a breakdown by end use and estimates for nonrespondents.

Despite protests from neighboring residents, Earth Construction Inc. received approval from the Troy Zoning Board of Adjustment to open a crushed stone quarry within the town limits. The approval was contingent on the company complying with 11 conditions set by the board. Earth Construction plans to mine 40,000 to 50,000 cubic yards of crushed stone annually from 13 acres of a 160-acre parcel. Before any mining can begin, the company must first obtain a permit under Vermont's Act 250.

Dimension.—Dimension stone, the State's leading mineral commodity produced, accounted for more than 50% of the State's mineral production value. Nationally, the State ranked third in output but first in value. Dimension stone production declined 7% from the estimated output of 1990. A total of 15 companies operated 22 quarries in 4 of the State's 13 counties. Leading counties, in descending order of output, were Windsor, Washington, Rutland, and Caledonia. Types of rock quarried, in descending order of tonnage, were granite, slate, and marble. Major uses were for monumental stone, roofing slate, rough blocks, and veneer.

During the year, the Pama Corp. received the necessary permits to reopen the Mackville Quarry in Hardwick. The company began mining a monument-grade granite from the former 34-acre quarry site. The life of the mine is expected to be 7 to 10 years.

In November, English China Clays of America was given a 1-year extension for its permit to reopen a former marble quarry in Brandon. The Brandon Zoning Board of Adjustment unanimously granted approval for the extension, which is expected to generate as many as 70 jobs if full-scale quarrying and processing operations begin. The company had dewatered the quarry, which revealed plentiful deposits of marble that earlier technologies were unable to remove. Formerly, the quarry had been owned by the Georgia-based Cyprus-Thompson Weinman Co.

Talc.—Nationally, Vermont ranked second of 8 States that produced talc. Cyprus Industrial Minerals Co. operated three mines and four mills in the State. The company's 40-year-old underground talc mine in Hammondville was permanently closed at yearend 1990. Although output of talc in Vermont in 1991 declined 13% from that of 1990, the overall value increased because of higher unit values. Most of the talc was sold for domestic use; some was exported.

In October, Cyprus Windsor Minerals requested that the Ludlow Planning Commission and the State Agency of Natural Resources grant the company a 50-year amendment to its original 1973 permit for mining operations on East Hill in Ludlow. The Cyprus application requested a permit for 50 years, which the company expects will be the lifetime of the talc mines on East Hill. In addition to the town planning commission approval, the company must also receive a State Act 250 land use permit from the District Environmental Commission.

At yearend, Cyprus signed a letter of intent to sell its talc business to the RTZ Corp. PLC, a London-based international mining company, for an undisclosed price. The sale, which is expected to close in the second quarter 1992, is contingent upon the approval of the boards of directors of both companies and the receipt of government approval. In addition to the talc operations in Vermont, which employs about 150 workers, the company also owns talc operations in Alabama, California, Montana, and Nebraska, and in Spain and Belgium.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related experience and has covered the mineral activities in Vermont for 7 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]"Average number of workers" is a summary of the average number of persons working at individual mining establishments during periods (not necessarily continuous) of active operations.

[3]U.S. Department of Labor, Mine Safety and Health. Mine Injuries and Worktime Quarterly, Jan.-Dec. 1991, 33 pp.

[4]Burlington Free Press. Legislation Would Speed Reviews of Landfill Sites. Mar. 11, 1991.

[5]Construction Aggregates Demand in the New England States. The New England Governors' Conference Inc. in cooperation with Minerals Management Service, U.S. Department of the Interior, Boston, MA: The Conference (1992), 219 pp.

[6]Industrial Minerals. Asbestos Production, The Chrysotile Crisis? No. 296, May 1992, p. 44.

[7]Rutland Daily Herald. Gravel Companies Fined. Aug. 30, 1991.

Union Ledger (Manchester, NH). Pike, Partner Fined $250,000. Aug, 30, 1991.

[8]Essex Reporter. Essex Takes Essex to Court on Sand Pit. Dec. 5, 1991.

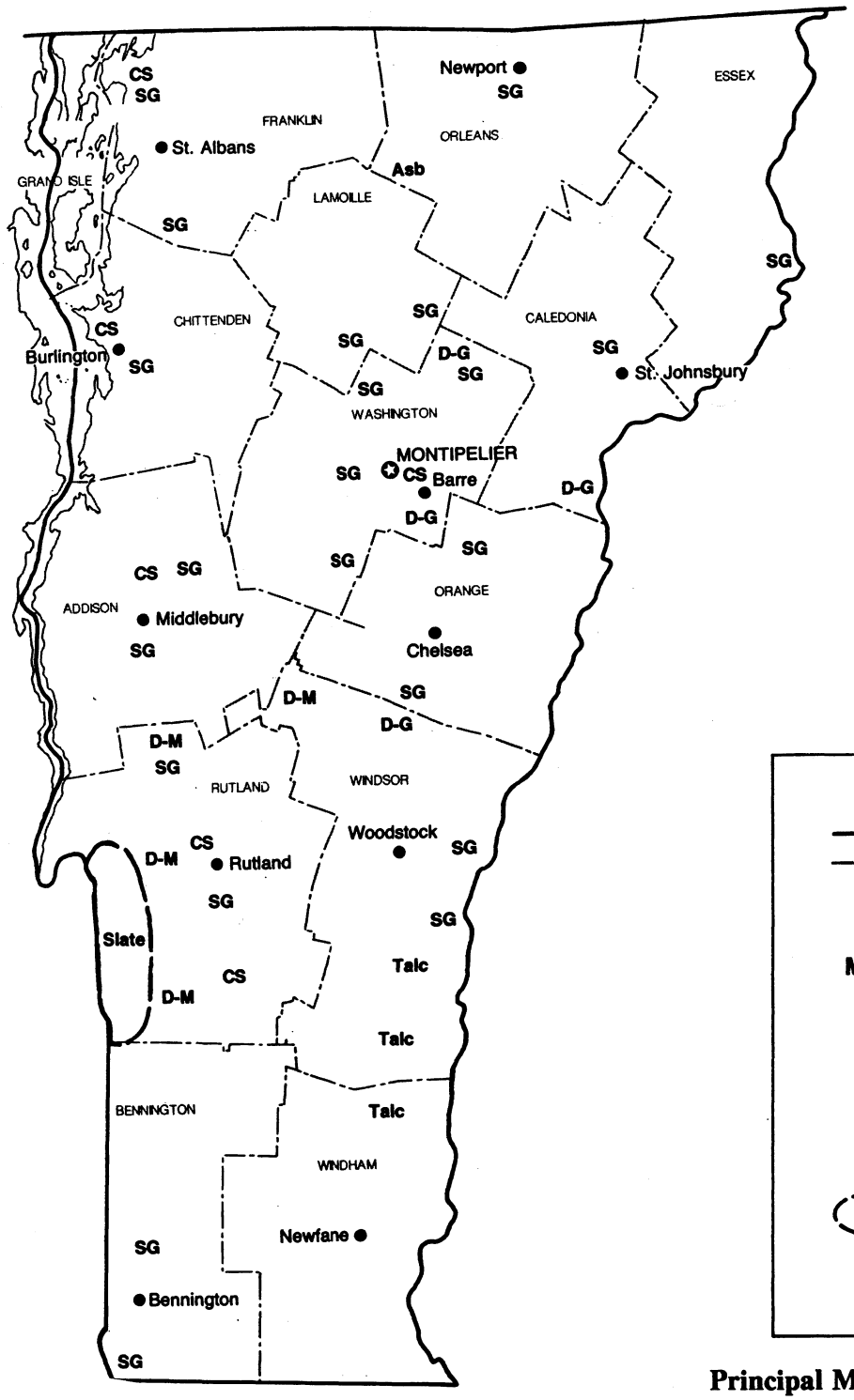
TABLE 3

VERMONT: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	8	1,716	$7,895	$4.60	6	1,342	$6,177	$4.60
Dolomite	—	—	—	—	2	215	1,369	6.37
Marble	6	1,120	18,477	16.50	2	W	W	3.90
Granite	1	W	W	6.36	5	265	1,792	6.76
Traprock	—	—	—	—	1	(1)	1	4.76
Quartzite	—	—	—	—	2	W	W	6.60
Miscellaneous stone	2	W	W	5.70	4	464	1,347	2.90
Total[2]	XX	3,119	28,110	9.02	XX	2,685	12,666	4.72

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

VERMONT



LEGEND

- State boundary
- County boundary
- Capital
- City

MINERAL SYMBOLS

Asb	Asbestos
CS	Crushed Stone
D-G	Dimension Granite
D-M	Dimension Marble
SG	Sand and Gravel
Slate	Slate
Talc	Talc minerals
	Concentration of mineral operations

Principal Mineral-Producing Localities

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Asbestos:			
Vermont Asbestos Group Inc.[1]	Box 54B Morrisville, VT 05661	Pit	Orleans.
Sand and gravel (construction):			
Calkins Sand & Gravel Inc.	Box 82 Lyndonville, VT 05851	Pits and plant	Caledonia and Orleans.
Joseph P. Carrara & Sons Inc.	Route 116 Middlebury, VT 05753	Pits	Addison and Rutland.
William E. Daily Inc.	Route 1, Box 51 Shaftsbury, VT 05262	do.	Bennington.
Hinesburg Sand & Gravel Co.	Box 200 Hinesburg, VT 05461	Pit	Chittenden.
Stone:			
Crushed:			
L. F. Carter Inc.	Field Ave., Box 224 Pittsford, VT 05763	Quarry	Rutland.
L. A. Demers Co.	Box 359 Essex Junction, VT 05452	do.	Addison.
Pike Industries Inc.[2]	Route 3, Box 91 Tilton, NH 03276	Quarries	Addison, Caledonia, Washington.
Swanton Limestone Corp.	Box 359 Essex Junction, VT 05452	do.	Chittenden and Franklin.
Frank W. Whitcomb Construction Corp.[2]	Box 429 Bellows Falls, VT 05101	do.	Caledonia, Chittenden, Rutland.
Dimension:			
Hilltop Slate Inc.	Main St. Mid-Granville, NY 12849	do.	Rutland.
Rock of Ages Corp., a subsidiary of John Swenson Co. Inc.	Box 482 Barre, VT 05641	do.	Washington and Windsor.
Vermont Marble Co.	Box 240 Danby, VT 05739	do.	Rutland and Windsor.
Vermont Structural Slate Co. Inc.	3 Prospect St. Fairhaven, VT 05743	Quarry	Do.
Talc:			
Cyprus Industrial Minerals Co.	Box 117 Chester, VT 05143	Mines and mills	Lamoille, Windham, Windsor.

[1]Also crushed stone.
[2]Also sand and gravel.

THE MINERAL INDUSTRY OF VIRGINIA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Virginia Division of Mineral Resources for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.,[1] and Palmer C. Sweet[2]

The value of nonfuel mineral production in Virginia declined to about $428 million in 1991. During the year, output of every nonfuel mineral commodity produced in Virginia declined with the exception of one specialty clay. A sluggish economy and, in particular, weakened demand from the construction industry, resulted in an overall decline in the State's value of mineral production of about $80 million.

EMPLOYMENT

The Virginia Department of Mines, Minerals, and Energy (DMME), Division of Mineral Mining, reported 2,286 plant workers and 1,647 quarry workers were employed in the nonfuels mining industry in 1991. Compared with that of 1990, employment of plant workers dropped by 84 and quarry workers by 146. Overall, in 1991, the limestone industry employed the most workers, with a total of 1,254 employees.

The State's coal industry employed about 9,105 workers according to the U.S. Mine Safety and Health Administration. Of that total, about 82% was underground coal miners and 18% worked at surface mine operations.

EXPLORATION

Several companies continued exploration work on titanium sands mineralization on large acreages in Dinwiddie, Greensville, and Sussex Counties. During the year, premine development work was under way. The work included delineation of ore bodies, water availability studies, and assessment of mining and processing equipment requirements. About 7.3 million metric tons of heavy minerals had been discovered with ilmenite, leucoxene, rutile, and zircon comprising almost 80% of the heavy-mineral concentrate.[3]

At least one of the companies involved in the exploration began to address State regulatory and permit requirements in anticipation of mine development by 1993. However, by late 1991, the sluggish economy and a decline in titanium dioxide pigment prices caused speculation that mine development plans may be delayed.

On a much smaller scale, exploration continued for precious metals in southern Virginia near Danville. Toward yearend, a small operator was planning to seek local and State government permission to investigate in an area referred to as the "Kentuck Prospect."

TABLE 1
NONFUEL MINERAL PRODUCTION IN VIRGINIA[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	metric tons	1,001,394	$6,302	882,383	$3,741	723,429	$3,248
Gemstones		NA	27	NA	34	NA	70
Lime	thousand short tons	821	38,353	846	39,784	825	39,612
Sand and gravel (construction)	do.	e12,900	e49,700	13,096	48,950	e9,700	e36,900
Stone:							
Crushed	do.	64,061	328,050	e59,400	e320,000	48,861	260,966
Dimension	short tons	W	W	W	W	11,046	3,061
Combined value of aplite, cement, clays (fuller's earth), gypsum (crude), iron oxide pigments (crude), kyanite, sand and gravel (industrial), talc and pyrophyllite, vermiculite, and values indicated by symbol W		XX	86,669	XX	94,766	XX	84,188
Total		XX	509,101	XX	507,275	XX	428,045

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.

LEGISLATION AND GOVERNMENT PROGRAMS

The Virginia Division of Mineral Resources (DMR), Department of Mines, Minerals, and Energy at Charlottesville, was the primary State agency investigating the geology and economic potential of the State's mineral resources. In 1991, the DMR conducted studies on the State's carbonate resources as demand for these resources was expected to increase. Growth in lime and limestone markets was anticipated nationwide because of amendments to the Federal Clean Air Act passed in 1990, which required a reduction in sulfur dioxide and nitrogen oxide emissions. In Virginia, existing coal-fired powerplants and construction of powerplants in the southern part of the State were expected to generate additional demand for lime and limestone products.

During the year, the DMR completed a report on the analyses of carbonate rocks in northern Virginia.[4] Fieldwork continued in other areas, and more than 500 samples were expected to be analyzed by yearend 1992. In conjunction with this work, high-calcium limestone samples were specifically tested to determine suitability for removal of sulfur dioxide and nitrogen oxide emissions from coal-fired boilers.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Virginia remained one of the Nation's most diverse producers of industrial minerals. In 1991, industrial minerals were produced in the State at about 219 operations, according to data reported to the U.S. Bureau of Mines and listed in table 1. Crushed stone was produced at 105 quarries; sand and gravel at 78 pits; common clay and shale at 12 pits; lime at 5 plants; cement at 4 plants; dimension stone at 4 quarries; kyanite, fuller's earth, and iron oxide pigments at 2 operations each; and feldspar, gypsum, industrial sand, soapstone, and vermiculite at 1 mine each. Output from these operations accounted for the State's value of mineral production of $428 million in 1991.

In addition, the following mineral commodities were processed in Virginia: calcined gypsum, sulfur (recovered), and exfoliated vermiculite. The combined value of these commodities as reported to the U.S. Bureau of Mines was about $12 million.

Clays and Shale.—Output of common clays and shale, used primarily in brick manufacturing, declined for the fourth year in a row. The decrease in residential and commercial building construction that began in 1990 continued throughout 1991, resulting in less demand for brick. Production dropped by about 18% in 1991 and, compared with that of 1989, the output was down 28%.

Fuller's earth was the only nonfuel mineral commodity in Virginia for which an increase in output was reported. Production of fuller's earth increased by about 10% in 1991 compared with that of 1990. Late in the year, the Virginia Clay Co. Inc. received a permit from the Virginia Division of Mineral Mining to mine fuller's earth in King William County. The firm expected to be in full operation in 1992. The fuller's earth from this deposit was considered suitable for use as liner material for landfills.

Lime.—The State's lime industry remained stable in 1991 despite a slight decline in output for the year. Limestone was mined at three surface operations and two underground mines for subsequent manufacturing of lime.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Production of construction sand and gravel fell below 10 million short tons for the first time since 8.9 million tons was reported in 1984. According to the Virginia DMR, sand and gravel produced south of Fredericksburg was shipped by rail into the northern Virginia-Washington, DC, market. Sand and gravel produced southeast of Richmond was barged to markets in the Norfolk area along the James River. A decline in construction in these areas accounted for most of the State's decline in sand and gravel output of 3.4 million tons in 1991.

In an acquisition, Tarmac Mid-Atlantic Inc. purchased Massaponax Sand & Gravel Corp.'s operation in Spotsylvania County. Tarmac also produced crushed stone in Virginia in Botetourt, Chesterfield, Dinwiddie, and Henrico Counties.

Stone (Crushed).—Crushed stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

TABLE 2
VIRGINIA: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1990		1991	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Acid water neutralization	W	W	42,417	$2,283
Steel, basic oxygen	74,893	$3,448	76,145	3,559
Steel, electric	W	W	58,012	2,674
Other[1]	771,557	36,336	648,676	31,096
Total	846,450	39,784	825,250	39,612

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1]Includes, agriculture, citric acid (1990), ladle desulfurization, mason's lime, ore concentration, other chemical and industrial, paper and pulp, precipitated calcium carbonate, road stabilization, sewage treatment, water purification, tanning, and uses indicated by symbol W.

TABLE 3

VIRGINIA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	93	196	$2.11
Riprap and jetty stone	1,080	6,843	6.34
Filter stone	295	1,554	5.27
Other coarse aggregate	W	W	1.98
Coarse aggregate, graded:			
Concrete aggregate, coarse	6,233	34,714	5.57
Bituminous aggregate, coarse	3,252	19,344	5.95
Bituminous surface-treatment aggregate	1,401	7,677	5.48
Railroad ballast	1,233	5,253	4.26
Fine aggregate (-3/8 inch):			
Stone sand, concrete	989	5,416	5.48
Stone sand, bituminous mix or sea	518	2,809	5.42
Screening, undesignated	2,344	11,830	5.05
Coarse and fine aggregate:			
Graded road base or subbase	10,625	51,197	4.82
Unpaved road surfacing	1,343	7,672	5.71
Crusher run or fill or waste	4,340	19,925	4.59
Other construction materials[2]	3,270	20,256	6.19
Agricultural:			
Agricultural limestone	962	11,714	12.18
Other agricultural uses[3]	227	1,955	8.61
Chemical and metallurgical[4]	2,636	9,199	3.49
Special: Other fillers or extenders[5]	504	7,536	14.95
Other miscellaneous uses[6]	6	29	4.83
Unspecified:[7]			
Actual	4,902	24,200	4.94
Estimated	2,609	11,642	4.46
Total[8]	48,861	260,966	5.34

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and "Other miscellaneous uses."
[1]Includes dolomite, granite, limestone, miscellaneous, quartzite, sandstone, slate, and traprock.
[2]Includes withheld amounts for coarse aggregate (+1 inch), drain fields, and roofing granules.
[3]Includes withheld amounts for poultry grit and mineral food.
[4]Includes withheld amounts for cement manufacture, lime manufacture, flux stone, chemical stone, glass manufacture, and sulfur oxide removal.
[5]Includes mine dusting or acid water treatment, asphalt fillers or extenders, whiting or whiting substitute, and other fillers or extenders.
[6]Includes abrasives and other specified uses not listed.
[7]Includes production reported without a breakdown by use and estimates for nonrespondents.
[8]Data may not add to totals shown because of independent rounding.

Virginia crushed stone statistics are compiled by geographical districts as depicted in the State map. Table 4 presents end-use statistics for Virginia's three districts.

Production of crushed stone dropped below 50 million short tons for the first time since 1984. From 1987 through 1990, Virginia's crushed stone industry reported the highest production of any other period in State history. In 1991, output dropped by about 10.5 million tons as a slowdown in the State's economy resulted in a decline in construction activity. The drop in Virginia's production of 18% was about twice that reported nationwide by the crushed stone industry. The State ranked sixth in output in the United States in 1991, down from fifth in 1990.

Despite the lower production in 1991, anticipated increases in demand resulted in the opening and expansion of some quarries during the year. James River Limestone Co. reopened its Rocky Point quarry in Buchanan. The quarry was last operated in 1978. The reopening was partially in response to expected growth in the demand for high-calcium limestone in environmental and pollution control applications. In Louisa County, north of Mineral, Luck Stone Corp. opened a granite quarry.

The State's top stone producer, Vulcan Materials Co., was also active during the year. In Mecklenburg County, local government officials approved a special exception zoning permit allowing Vulcan to reopen the Buggs Island Quarry. The firm, which initially planned to mine about 250,000 tons of granite per year at the site, was permitted for extraction of 750,000 tons per year.[5] Dewatering operations began late in the year and were expected to continue for about 8 months. In 1990, Mecklenberg Rock Inc. began producing crushed granite at a quarry near South Hill. Stone had last been quarried in the county in 1961. Both operations were anticipating increased demand for crushed stone in connection with road construction improvements planned for U.S. Route 58 and Highway 47.

In Gainsville, Prince William County, Vulcan withdrew a quarry permit application.

Acquisitions during the year included Vulcan Materials Co.'s purchase of W. W. Boxley & Co.'s granite quarry in Greensville County. For the second time in 4 years, General Crushed Stone Co. was purchased. In 1988, Beazer PLC of the United Kingdom had purchased Koppers Co., which operated in the State as General Crushed Stone Co. In 1991, Hanson PLC, also of the United Kingdom, purchased Beazer. The transaction included the Verdon Quarry in Hanover.

TABLE 4

VIRGINIA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	533	2,423	W	W	74	4,842
Coarse aggregates, graded[2]	2,248	11,391	2,003	10,959	7,868	44,637
Fine aggregates (-3/8 inch)[3]	1,273	6,929	606	3,141	1,972	9,986
Coarse and fine aggregates[4]	3,402	15,627	2,670	13,042	10,236	50,125
Other construction materials	385	1,820	411	2,293	2,770	18,097
Agricultural[5]	944	11,816	(6)	(6)	W	W
Chemical and metallurgical[7]	2,636	9,199	—	—	—	—
Special[8]	509	7,562	—	—	—	—
Other miscellaneous uses	—	—	145	1,234	—	—
Unspecified:[9]						
Actual	2,998	14,759	1,121	5,626	783	3,816
Estimated	2,471	11,009	138	633	—	—
Total[10]	174	92,536	7,094	36,928	24,367	131,502

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes macadam, riprap and jetty stone, filter stone, and other coarse aggregates.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), screening (undesignated).
[4]Includes graded road base or subbase, unpaved road surfacing, crusher run (select material or fill), roofing granules, and drain fields.
[5]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[6]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[7]Includes cement manufacture, lime manufacture, glass manufacture, and flux stone.
[8]Includes mine dusting or acid water treatment, asphalt fillers or extenders, whiting or whiting substitute, abrasives, and other fillers or extenders.
[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[10]Data may not add to totals shown because of independent rounding.

TABLE 5

VIRGINIA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	54	18,359	$79,597	$4.34	46	15,258	$71,874	$4.71
Dolomite	8	2,122	17,070	8.04	11	2,914	25,239	8.66
Marble	1	W	W	4.00	—	—	—	—
Granite	31	29,985	161,737	5.39	29	19,185	101,034	5.27
Traprock	6	9,439	52,049	5.51	10	9,170	51,105	5.57
Sandstone and quartzite	6	1,250	5,686	4.55	7	1,942	9,910	5.10
Slate	1	W	W	2.00	1	W	W	2.20
Miscellaneous stone	2	W	W	4.88	1	W	W	5.32
Total[1]	XX	64,061	328,050	5.12	XX	48,861	260,966	5.34

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 17 years of mineral-related and government experience and has covered the mineral activities in Virginia for 6 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]Head geologist, Economic Geology Section, Virginia Division of Mineral Resources.

[3]Sweet, P. C. Virginia. Min. Eng., v. 44, No. 5, May 1992, p. 443.

[4]Giannini, W. F. Analyses of Carbonate Rocks in Northern Virginia. Publication 108, VA Div. of Min. Res., 1991, 104 pp.

[5]Mecklenberg Sun (Clarksville, VA). Vulcan Gains Okay To Reopen Quarry. Mar. 13, 1991, p. 1.

VIRGINIA

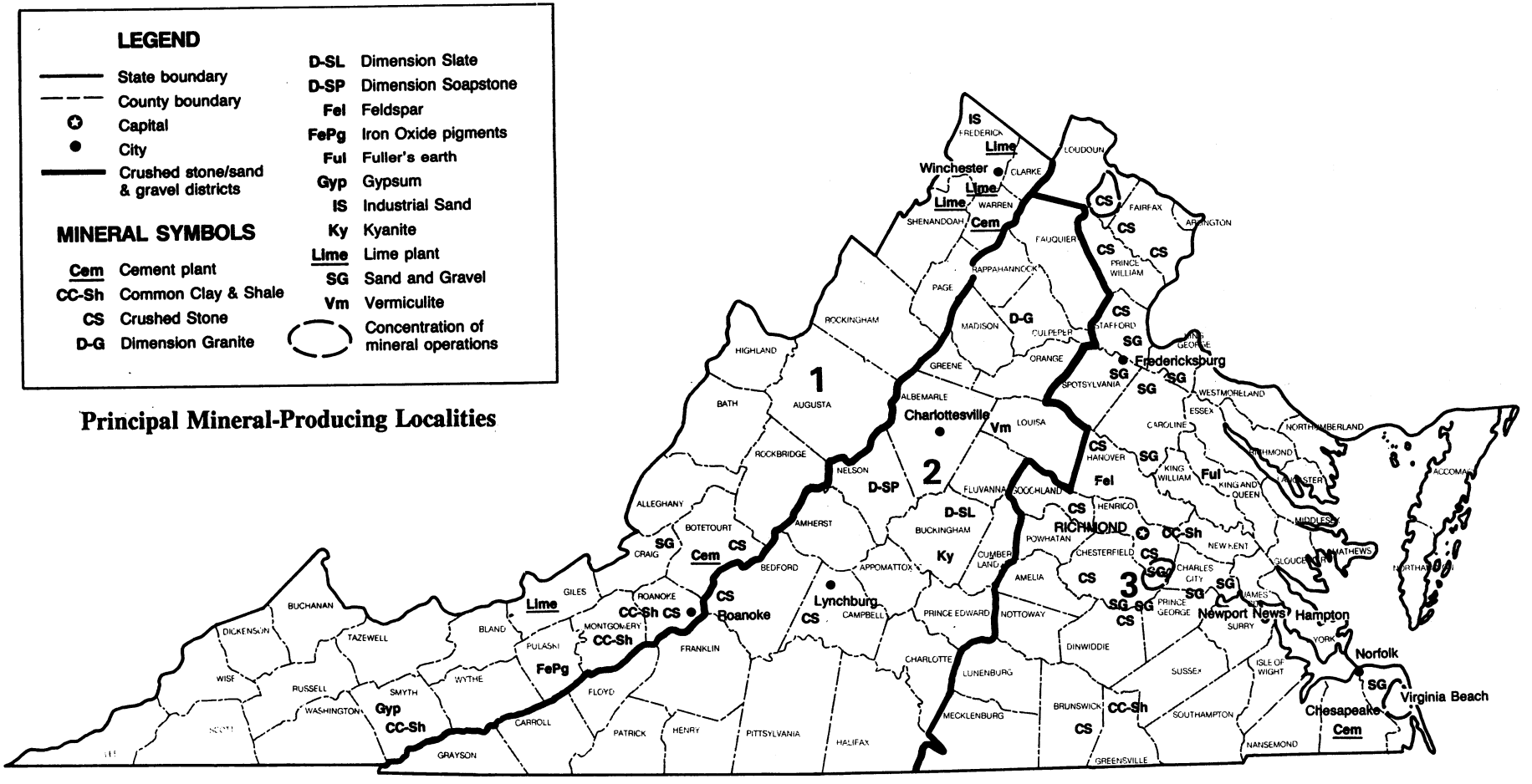

LEGEND
State boundary
County boundary
Capital
City
Crushed stone/sand & gravel districts
MINERAL SYMBOLS
Cem Cement plant
CC-Sh Common Clay & Shale
CS Crushed Stone
D-G Dimension Granite
D-SL Dimension Slate
D-SP Dimension Soapstone
Fel Feldspar
FePg Iron Oxide pigments
Ful Fuller's earth
Gyp Gypsum
IS Industrial Sand
Ky Kyanite
Lime Lime plant
SG Sand and Gravel
Vm Vermiculite
Concentration of mineral operations
Principal Mineral-Producing Localities
1
2
3
Winchester
Fredericksburg
Charlottesville
RICHMOND
Lynchburg
Roanoke
Newport News
Hampton
Norfolk
Virginia Beach
Chesapeake
FREDERICK
CLARKE
WARREN
SHENANDOAH
PAGE
ROCKINGHAM
HIGHLAND
AUGUSTA
BATH
ROCKBRIDGE
ALLEGHANY
BOTETOURT
CRAIG
GILES
BUCHANAN
DICKENSON
TAZEWELL
WISE
RUSSELL
WASHINGTON
SMYTH
WYTHE
BLAND
MONTGOMERY
PULASKI
ROANOKE
FRANKLIN
FLOYD
CARROLL
GRAYSON
PATRICK
HENRY
PITTSYLVANIA
HALIFAX
CAMPBELL
BEDFORD
AMHERST
APPOMATTOX
BUCKINGHAM
CUMBERLAND
PRINCE EDWARD
CHARLOTTE
LUNENBURG
MECKLENBURG
NOTTOWAY
AMELIA
NELSON
ALBEMARLE
GREENE
MADISON
ORANGE
CULPEPER
RAPPAHANNOCK
FAUQUIER
LOUDOUN
FAIRFAX
ARLINGTON
PRINCE WILLIAM
STAFFORD
SPOTSYLVANIA
LOUISA
FLUVANNA
GOOCHLAND
POWHATAN
CHESTERFIELD
HENRICO
HANOVER
CAROLINE
KING GEORGE
WESTMORELAND
ESSEX
KING WILLIAM
KING AND QUEEN
NORTHUMBERLAND
RICHMOND
LANCASTER
ACCOMACK
NORTHAMPTON
MIDDLESEX
MATHEWS
GLOUCESTER
NEW KENT
CHARLES CITY
JAMES CITY
PRINCE GEORGE
SURRY
DINWIDDIE
SUSSEX
BRUNSWICK
GREENSVILLE
SOUTHAMPTON
ISLE OF WIGHT
YORK
NANSEMOND

TABLE 6
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Masonry:			
Riverton Corp.	Box 4004 Front Royal, VA 22630	Quarry and plant	Warren.
Portland:			
Tarmac Mid-Atlantic Inc.[1]	Box 34527 Richmond, VA 23234	do.	Botetourt.
Clays and shale:			
Common:			
Brick & Tile Corp.	Box 45 Lawrenceville, VA 23868	Pits and plant	Brunswick and Greensville.
General Shale Products Corp.	Route 4, Box 127 Marion, VA 24354	do.	Rockbridge and Smyth.
General Shale-Webster Inc.	Box 306 Blue Ridge, VA 22064	do.	Botetourt and Orange.
Fuller's earth:			
Bennett Mineral Co.	Box 28 Walkerton, VA 23177	do.	King and Queen.
Virginia Clay Co. Inc.	Route 1, Box 215 King William, VA 23086	do.	King William.
Feldspar:			
The Feldspar Corp.	Route 1, Box 305 Montpelier, VA 23192	Quarry and plant	Hanover.
Gypsum:			
USG Corp.	Route 1 Saltville, VA 24370	Mine and plant	Smyth.
Iron oxide pigments (crude):			
Hoover Color Corp.	Box 218 Hiwassee, VA 24347	Mines and plant	Pulaski.
Virginia Earth Pigments Co.	Box 1866 Pulaski, VA 24301	Mine	Wythe.
Kyanite:			
Kyanite Mining Corp.	Box 486 Dillwyn, PA 23936	Mines and plant	Buckingham.
Lime:			
APG Lime Corp.	Route 635 Ripplemead, VA 24150	Underground mine and plant	Giles.
Chemstone Corp.	Route 629, Box 71 Strasburg, VA 22657	Quarry and plant	Shenandoah.
Virginia Lime Co.	Route 635 Ripplemead, VA 24150	Underground mine	Giles.
Sand and gravel:			
Construction:			
Henry S. Branscome Inc.	Drawer 260 Williamsburg, VA 23187	Pits and plant	Charles City and James City.
Culpepper Stone Co. Inc.	Box 1318 Culpepper, VA 22701	do.	Caroline, King George, Stafford.
Isle of Wight Material Co. Inc.	Box 216 Carrollton, VA 23314	Pits and plants	Isle of Wight.
Solite Corp.[2]	Box 883 Fredericksburg, VA 22404	Pit and plant	King George.
Tarmac Mid-Atlantic Inc.	Box 34527 Richmond, VA 23234	Pits and plants	Botetourt, Chesterfield, Henrico, Prince George.

See footnotes at end of table.

TABLE 6—Continued
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued:			
Construction—Continued:			
West Sand & Gravel Co. Inc.	Box 15480 Richmond, VA 23227	Pits and plants	Henrico and Rockingham.
Williams Corp. of Virginia	Box 938 Norfolk, VA 23501	Pits and plant	Suffolk and Virginia Beach.
Industrial:			
Unimin Corp.	Box 38 Gore, VA 22637	Mine and plant	Frederick.
Soapstone:			
New Alberene Stone Co. Inc.	Box 300 Schuyler, VA 22969	Pit and plant	Nelson.
Stone:			
Crushed:			
W. W. Boxley Co.	Box 13527 Roanoke, VA 24035	Quarries and plants	Augusta, Bedford, Campbell, Henry, Nelson.
Luck Stone Corp.	Box 29682 Richmond, VA 23229	do.	Albemarle, Augusta, Fairfax, Fauquier, Goochland, Greene, Loudoun, Louisa, Nottoway, Powhatan, Rockingham.
Tarmac Mid-Atlantic Inc.	Box 34527 Richmond, VA 23234	do.	Botetourt, Chesterfield, Dinwiddie, Henrico.
Vulcan Materials Co., Mideast Div.	Box 1590 Manassas, VA 22110	do.	Brunswick, Fairfax, Fauquier, Goochland, Greensville, Halifax, Prince William, Stafford, Wise.
Dimension:			
LeSueur-Richmond Slate Corp.	Box 8 Arvonia, VA 23004	Quarries	Buckingham.
Vermiculite:			
Virginia Vermiculite Ltd.	Box 70 Louisa, VA 23093	Mine and plant	Louisa.

[1]Also masonry cement.
[2]Also lightweight aggregate.

THE MINERAL INDUSTRY OF WASHINGTON

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Washington Division of Geology and Earth Resources for collecting information on all nonfuel minerals.

By R. J. Minarik,[1] R. E. Derkey,[2] and C. W. Gulick[3]

Nonfuel mineral production value in Washington rose to $482.7 million in 1991, an increase of 2% over that of 1990. Increases in the production values of construction sand and gravel, crushed stone, and zinc more than offset decreases in value for portland cement, gold, and magnesium metal. Construction sand and gravel was the leading commodity in terms of value, followed in order by gold, magnesium metal, crushed stone, and portland cement.

Washington ranked 22d in the Nation in the value of nonfuel minerals production, up from a 23d ranking in 1990.

TRENDS AND DEVELOPMENTS

The 1991 value of industrial minerals produced in Washington increased almost 8% from that of 1990. The increase was led by construction sand and gravel and crushed stone, which together accounted for more than 41% of the State's total nonfuel mineral production. The combined value for all industrial minerals accounted for 57% of the State's total nonfuel mineral production value, compared with 54% in 1990.

The production value of Washington's metallic minerals—gold, lead, magnesium metal, silver, and zinc—dropped nearly 5% from that of 1990. Five metal mines at four operations reported production, with gold and silver the primary commodities. Early in the year, mining commenced at a zinc-lead mine that had last operated in the early 1970's. The mine operated through August and the mill through October, when the entire operation was shut down for economic reasons. Although not included in the Bureau's mineral production table, Washington was the Nation's largest producer of aluminum, accounting for nearly 31% of total production.

EMPLOYMENT

The State's mining industry employment increased slightly over that of 1990. According to the State of Washington Employment Security Department, average mining and quarrying employment rose to 3,730 workers from the 3,681 recorded in 1990. Employment in the State's primary metals industry fell to 12,285 workers in 1991, a decrease of 848 workers from that of 1990. A slight decrease in persons employed in aluminum production, which averaged 6,009 during 1991, reflected the weakness in that market.

TABLE 1
NONFUEL MINERAL PRODUCTION IN WASHINGTON[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	233,267	$1,591	158,257	$1,357	263,374	$2,633
Gemstones		NA	208	NA	281	NA	85
Gold[2]	kilograms	W	W	9,620	119,671	9,954	116,260
Sand and gravel (construction)	thousand short tons	e37,800	e124,700	40,251	133,067	40,200	140,700
Stone (crushed)	do.	13,259	55,624	e12,700	e41,900	13,126	59,588
Combined value of cement, diatomite, gypsum (crude), lead (1991), lime, magnesium metal, olivine, peat, sand and gravel (industrial), silver, stone (dimension), zinc (1991), and value indicated by symbol W		XX	298,756	XX	176,953	XX	163,393
Total		XX	480,879	XX	473,229	XX	482,659

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Recoverable content of ores, etc.

REGULATORY ISSUES

Structures at ASARCO Incorporated's former copper smelter at Ruston, Pierce County, including the landmark 171-meter-tall smokestack, were demolished or set to be demolished following final approval from the U.S. Environmental Protection Agency. Soil at the site, often referred to as the Tacoma smelter, contains arsenic and other chemical contaminants and is on the national Superfund list. Also, a State court and Federal judge ruled that Asarco should bear the bulk of a multimillion-dollar cleanup of heavy metals detected in several Tacoma-area log yards. Arsenic and other metals reportedly leached from smelter slag that was marketed by Asarco as an inexpensive alternative to gravel and used to pave the log yards. Asarco planned an appeal of the rulings.

Del Hur Industries of Port Angeles completed work on a 3-year, $3.1 million U.S. Forest Service contract to clean up the extensive tailings pile at the former Holden Mine in Chelan County. The reclamation included revegetation and the placement of riprap along a creek. The mine, near Holden Village, was operated by Howe Sound Mining Co. between 1939 and 1957 and produced copper and some gold, silver, and zinc. High above Lake Chelan, the remote area can only be reached by boat and then a steep winding mountain road. The property is now owned by a nearby Lutheran Church retreat.

EXPLORATION ACTIVITIES

Exploration continued at a strong pace, especially in the northeastern and north-central part of the State. Precious metals continued to be the primary target.

Battle Mountain Gold Co. exercised its right to purchase a 51% interest in the Crown Jewel gold project from Crown Resources Corp. Sited east of Chesaw, the deposit covers about 60 acres on and adjacent to Buckhorn Mountain in Okanogan County. Battle Mountain Gold will manage the project for the joint venture. The company reported significant new reserves following an extensive drilling program in 1991. The deposit contains two main zones, the Gold Bowl and the Gold Axe. The companies initiated the permitting process in preparation for mining.

Also in Okanogan County, Crown Resources explored its Strawberry Lake property west of Chesaw, drilled and sampled its Molson Gold project south of Molson, and in a joint venture with Cambior USA Inc., drilled the Ida prospect. Keystone Gold Inc. drilled and conducted geochemical sampling on its Crystal Butte property. Weaco Resources Ltd. acquired the Kelsey property, and Pegasus Gold Corp. drilled the Hot Lake property. Centurion Mines Corp. acquired the Mazama porphyry copper deposit 18 miles northwest of Winthrop, reevaluated existing data, and initiated exploration work, including restaking claims, drilling, and geochemical sampling. Cyprus Exploration and Development Corp. conducted geological and geochemical exploration on the Parmenter Creek property on the Colville Indian Reservation. Hunter Mines Inc., a subsidiary of Waseco Resources Ltd., carried out mapping, geochemical, and geophysical programs at the Say Energy property. Other companies or individuals reporting exploration activities in the county included Wilbur Hallauer, Magill and Associates, Northwest Minerals Inc., Pacific Northwest Resources Inc., and Sunshine Valley Minerals Inc.

In Ferry County, the Kettle River Project, a joint venture between Echo Bay Minerals Co. (70%) and Crown Resources Corp., completed exploratory drilling from the surface at its Lamefoot property south of Curlew. The company was seeking permits to drive an exploration drift. The joint-venture partners also prepared permit applications seeking to drive an exploratory drift to test the validity of drill indicated reserves at Lamefoot. The Kettle River Joint Venture acquired the right to earn 60% interest in the Leland property, approximately 5,000 acres of land located between the Overlook and Lamefoot properties of the Kettle River Project. The Leland property was leased by the consortium of Inland Gold & Silver Corp., Pegasus Gold, and N. A. Degerstrom Inc. The partnership of the Kettle River Joint Venture, Pathfinder Gold Corp., and Boise Cascade drilled the K-2 property. The joint venture of Equinox Resources Ltd. and Placer Dome drilled its Wardlaw property, adjacent to the Lamefoot gold discovery, and at Kellogg, a property to the south.

Also in Ferry County, permits were granted to the joint venture of Gold Express Corp. and N. A. Degerstrom to mine at the Gold Mountain Mine, south of Danville. Commencement of mining is dependent upon gold prices. Johnson Explosive performed geological and geochemical exploration at its Irish project; Morse Brothers' Morning Star Mines Inc. drilled and sampled the Morning Star property; Phelps Dodge drilled its Snow Peak and Copper Mountain properties; Curlew Lake Resources Inc. and Kettle River Resources Ltd., drilled and conducted geophysical work on the Empire Creek property; Westmont Gold Inc. mapped and sampled its Manhatten Mountain property; and Gold Fields Mining Corp. drilled its Iron Mountain project. Other companies and individuals conducting exploration in Ferry County included Atlas Mine and Mill Supply Inc., Wilbur Hallauer, Hecla Mining Co., and Sutton Resources Inc.

In Stevens County, Bitteroot Resources Ltd. explored at the Advance, Deep Creek, Scandia, Calhoun, and Iroquois lead-zinc properties. Pathfinder Gold drilled and performed geophysical work on its McNally, Gold Hill, Toulou Mountain, Big Iron, and Fifteen Mile Creek properties. Pathfinder Gold, in a joint venture with Billiton Minerals U.S.A. Inc., carried out exploratory drilling at the First Thought Mine. Cominco American Inc. drilled at its Bechtol project and Kennecott Exploration drilled and later dropped an option on the Napoleon property. Other companies operating in the county included Hope Mountain Mining Ltd., Leadpoint Consolidated Mines Co., Lovejoy Mining Inc., Pegasus Gold, and Silver Hill Mines Inc.

In Pend Oreille County, Raven Hill Mining Co. explored its Cooks Copper silver-copper prospect near Newport and performed preliminary mine development work at its Glass Mountain Mine. N. A. Degerstrom explored a property on Harvey Creek.

In Chelan County, Asamera Minerals (U.S.) Inc. actively explored in the Wenatchee area near its Cannon underground gold mine; Gold Ring Mine Inc. collected bulk samples from the Gold Ring property; and Montana d'Oro Inc. drilled and trenched the MDOI No. 1 property. Kennecott drilled the Lockwood massive sulfide project near Everett, Snohomish County, after entering into an agreement with Island-Arc Resources and Formosa Resources, allowing Kennecott to earn a 51% working interest in the property.

In Skamania County, Plexus Resources Corp. drilled and conducted geological and geochemical exploration on its Black Jack project. Champion International drilled at the Polar Star property. Elsewhere, Double Dragon Exploration Inc. initiated a preliminary study of the Azurite property and Seattle-St. Louis Mining Co. conducted a sampling program on the Minnesota project, both in Whatcom County. In King County, mine repair and development continued, by CSS Management Corp. at the Apex-Damon property and by Joel Ray on the Lenox group. Weyerhaeuser Co. continued its extensive evaluation of mineral potential on its lands in western Washington, especially in King County. Ardic Exploration and Development Ltd. drilled at a property on Morse Creek in Yakima County.

LEGISLATION AND GOVERNMENT PROGRAMS

According to the Washington Department of Natural Resources, Division of Lands and Minerals, total revenue to the State from prospecting, mining, and quarrying on State lands was $841,650 for the fiscal year ending June 30, 1991. This represented a 2% increase from the 1990 total. Additional revenues, estimated at about $240,000, were received from mineral activity on Washington's aquatic lands.

The U.S. Bureau of Mines Spokane Research Center (SRC) continued its research on advanced concepts for mining ore deposits. Research projects were conducted on in situ mining of deep mineral deposits, new methods for mining shallow ore deposits, mining with backfill, and underground mining methods for Alaska deep placers. Fundamental studies of ground support technology were ongoing, along with research on remote systems for ground control, improved retreat mining support systems, and the development of expert systems for ground control in coal mines. Macroseismic systems were expanded in the North Idaho Seismic Network to provide information for the application of rock mechanics to rock burst control. Research on hydrogeological factors in mine waste involved ground water monitoring at an inactive mine and geochemical modeling of data to determine plausible pathways for ground water flow and contamination. Physical modeling was conducted to simulate the effects of air injection into heavy-metal contaminated ground water. Factors that influence the generation and movement in sulfitic waste piles also were being investigated. Research continued on mine closure in arctic, subarctic, and alpine environments, particularly placer mines. Research also was conducted on subaqueous disposal of mining wastes.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Barite.—Mountain Minerals Northwest, a subsidiary of Mountain Minerals Co. Ltd. of Lethbridge, Alberta, Canada, refurbished a mill on Sheep Creek near Northport. The company planned to produce from a bedded barite deposit on Flagstaff Mountain and market it as drilling mud.

Calcium Chloride.—Occidental Chemical Corp. in Tacoma, Pierce County, manufactured synthetic calcium chloride using hydrochloric acid and limestone barged in from British Columbia, Canada. Washington was one of two States reporting production. Output remained essentially unchanged in both quantity and value from that of 1990.

Cement.—The production of portland cement in Washington decreased about 13% in both quantity and value from that of 1990. The State total included a modest amount of masonry cement production, which also dropped in quantity and value.

Holnam Ideal Inc. produced portland cement at its wet-process facility in Seattle, King County. The company barged limestone to the plant from Texada Island, British Columbia, and clay from its Twin River quarry along the Strait of Juan de Fuca, west of Port Angeles, Clallam County. At Bellingham in Whatcom County, Tilbury Cement Co. operated a grinding facility, using imported clinker from the company's portland cement plant at Delta, British Columbia.

In King County, Ash Grove Cement West Inc. mined silica from the Superior quarry, operated a grinding facility, and maintained a bulk cement distribution center for its portland cement. The company continued construction of its new $65 million state-of-the-art cement manufacturing facility in Seattle. At completion, the plant is expected to be the largest in the State, with a projected production capacity of 750,000 short tons per year. Limestone used to manufacture cement will be barged in from the company's quarry on Texada Island in British Columbia. The company also was expanding its distribution plant in Spokane. The expansion will nearly double the plant's storage capacity and will give the company the ability to load two trucks simultaneously.

The bulk of Washington's cement production was general use, moderate-heat, Types I and II gray portland

cement, with lesser amounts of high-early-strength Type III and high-sulfate-resistant Type V; oil well and pozzolanic cements also were produced. Portland cement was used by ready-mixed concrete companies, building material dealers, other contractors, concrete products manufacturers, highway contractors, and government agencies.

The cement plants used a mix of fossil fuels, including natural gas, fuel oil, and bituminous and anthracite coal for fuel; electricity also was purchased for energy. Raw materials used to produce the different grades of portland cement included aluminum dross, clay, gypsum, iron ore, limestone, and sand.

Clays.—Total clay production increased by almost two-thirds in quantity and nearly doubled in value from that of 1990. Common clay production was reported by three companies from five pits in three counties. Clallam County accounted for the bulk of the output.

Mutual Materials Co. was the State's largest clay producer. A large part of the company's production came from two pits in King County, with lesser amounts from Pierce and Thurston Counties. In Spokane County, Mutual Materials also mined from the 1990 stockpile at its Mica pit, formerly owned by Interpace Corp. Holnam Ideal mined the Twin River quarry, the largest clay pit in the State; the high-aluminum clay was barged from the quarry along the Strait of Juan de Fuca to Holnam's cement plant at Seattle for the production of portland cement. Other clay producers included Moulden & Sons Inc., which operated a pit in King County, and Quarry Tile Co. in Spokane County.

Diatomite.—Washington's diatomite production dropped almost 7% in quantity and 2% in value from that of 1990. The State was the Nation's third-ranked producer in value of production. The Inorganic Specialties Div. of Witco Corp., the State's sole producer of diatomite, was purchased by Celite Corp., a subsidiary of The Allegheny Corp. Celite operated three pits in the Frenchman Hills in Grant County and processed and calcined the diatomaceous earth at its plant in Quincy. The bulk of the diatomite was used for filtration, with a modest quantity consumed as paint filler.

Gemstones.—Gemstone production in Washington included petrified wood and picture rock by Northwest Gem Co., Rockhanger Minerals, Lee and Son, and others. Quartz and pyrite crystals were mined from breccia pipes in the Snoqualmie batholith near North Bend, King County. Other Washington gemstones included agate, jasper, common opal, and realgar crystals.

Gypsum.—Washington's production of gypsum remained unchanged in both quantity and value from that of 1990. Agro Minerals Inc. operated the Poison Lake Mine near Tonasket, Okanogan County, the only gypsite mine in the State. Agro Minerals has mined gypsite from small, saline lake bottoms since 1948; the dried and sized product was used as a soil conditioner. Calcined gypsum was produced by James Hardie Gypsum in Seattle and by Domtar Gypsum America Inc. at Tacoma. These wallboard manufacturers import raw gypsum by barge from Mexico.

Lime.—Lime production in Washington dropped 39% in quantity and more than 6% in value from that of 1990. The State's largest producer, Northwest Alloys Inc., produced quicklime as a byproduct of magnesium metal production at a plant in Addy, Stevens County. A cutback in production at Northwest Alloys' magnesium metal plant was primarily responsible for the reduction in lime produced. The Tacoma Lime Div. of Continental Lime Inc., a wholly owned subsidiary of Graymont Ltd., produced both quicklime and hydrated lime at its Tacoma plant in Pierce County.

Olivine.—Washington was one of two States to produce olivine in 1991. Although quantity of production remained essentially unchanged, the value rose from that of 1990. In Whatcom County, Olivine Corp. mined and milled fresh, unaltered olivine from the Swen Larsen quarry in the Twin Sisters dunite. A small portion of the production was used in fabrication of modular olivine refractory slabs for wood- and municipal-waste incinerators. For the most part, Olivine Corp. sold its crude production to Applied Industrial Minerals Corp. (AIMCOR), which processed the material at its plant near Hamilton, Skagit County. AIMCOR made a variety of refractory products, including foundry and blasting sands used both domestically and for export to South America and Pacific Rim countries.

Peat.—The quantity of Washington's peat production was unchanged, but value increased by almost 4% from that of 1990. Three companies—Asbury's Topsoil in Kitsap County, Bonaparte Peat Co. in Okanogan County, and Chrystel Soils in Grays Harbor County—reported production of sold-in-bulk peat.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Washington's 1991 estimated quantity of construction sand and gravel production remained essentially unchanged, but the value increased by almost 6% from that of 1990. In 1990, the most recently surveyed year, the State was the fifth largest producer of construction sand and gravel in the Nation. Most Washington counties reported production of construction sand and gravel. The majority of the production came from the aggregate-rich, ice-margin deposits in the Puget Sound region of Clark, King, Pierce, and Snohomish Counties and from Lake Missoula flood deposits near Spokane. Major uses included fill, concrete aggregates, concrete sand, and road base and coverings.

TABLE 2
WASHINGTON: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	40	127	$3.18
Riprap and jetty stone	928	5,747	6.19
Filter stone	198	514	2.60
Other coarse aggregate	92	500	5.43
Coarse aggregate, graded:			
Concrete aggregate, coarse	168	540	3.21
Bituminous aggregate, coarse	665	2,539	3.82
Bituminous surface-treatment aggregate	577	2,524	4.37
Railroad ballast	179	895	5.00
Fine aggregate (-3/8 inch):			
Stone sand, concrete	203	631	3.11
Stone sand, bituminous mix or seal	17	90	5.29
Screening, undesignated	24	87	3.63
Coarse and fine aggregate:			
Graded road base or subbase	2,303	9,060	3.93
Unpaved road surfacing	1,262	3,874	3.07
Terrazzo and exposed aggregate	147	1,130	7.69
Crusher run or fill or waste	533	4,307	8.08
Other construction materials	241	1,154	4.79
Agricultural:			
Agricultural limestone	18	189	10.50
Poultry grit and mineral food	4	8	2.00
Chemical and metallurgical:			
Flux stone	34	W	W
Glass manufacture	(2)	W	W
Special:			
Asphalt fillers or extenders	13	W	W
Other fillers or extenders	W	W	W
Other miscellaneous uses[3]	47	4,244	90.30
Unspecified:[4]			
Actual	4,090	16,365	4.00
Estimated	1,341	5,063	3.78
Total	[5]13,126	59,588	4.54

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[1]Includes dolomite, granite, limestone, miscellaneous stone, sandstone, and traprock.
[2]Less than 1/2 unit.
[3]Includes withheld amounts for chemical and metallurgical, special, paper manufacture, and other specified uses not listed.
[4]Includes production reported without a breakdown by use and estimates for nonrespondents.
[5]Data do not add to total shown because of independent rounding.

Industrial.—Production of industrial sand and gravel fell by more than 16% in quantity and by almost 19% in value from that of 1990. Lane Mountain Silica Co., a division of Hemphill Brothers Inc., was the State's largest producer of industrial sand. The company operated a mine and plant near Addy in Stevens County. In King County, silica was mined by Reserve Silica Corp. from the Ravensdale pit and by Ash Grove Cement from the Superior quarry.

Uses for industrial sand and gravel included cement manufacture, fiberglass, flat-glass manufacture, glass containers, and sandblasting.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates made before yearend. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

Crushed.—The volume of crushed stone produced in 1991 increased by more than 3% from estimated production in 1990, but was essentially unchanged from that surveyed in 1989. Value of production rose more than 42% from the 1990 estimate and 7% from that of 1989. Production was reported in 35 of the State's 39 counties; 5 counties—Clark, Cowlitz, Franklin, Snohomish, and Spokane—accounted for 46% of the State's total production. Reflecting the volcanic nature of the State's geology, traprock accounted for the bulk of the production, more than 74% of the total Washington crushed stone output, followed by limestone and granite.

Dimension.—Rough construction stone was quarried from andesite, basalt, marble, and quartzite by Heatherstone Inc. in Yakima County, Gilbert Western Corp. in Clark County, Whitestone Co. in Stevens County, and Raymond Fosback Masonry Co. in Ferry County. Products included ashlar, flagstone, rubble, and veneers.

Sulfur (Recovered).—All of the State's sulfur production was recovered as byproduct from petroleum refining in the Puget Sound area. Companies reporting production were Shell Oil Co. and Texaco Inc. from their Skagit County refineries and Atlantic Richfield Co. and British Petroleum Oil Co. from refinery operations at Cherry Point and Ferndale in Whatcom County.

Metals

Aluminum.—Aluminum production in Washington increased 2% in quantity, but

TABLE 3

WASHINGTON: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[2]	1,153	6,532	46	79	7	31
Coarse aggregates, graded[3]	365	1,582	349	1,343	860	3,508
Fine aggregates (-3/8 inch)[4]	194	588	39	158	12	62
Coarse and fine aggregates[5]	2,299	10,512	612	2,575	711	2,403
Other construction materials	114	611	49	184	—	—
Agricultural[6]	—	—	W	W	W	W
Chemical and metallurgical[7]	—	—	—	—	34	W
Special[8]	—	—	W	W	W	W
Other miscellaneous	—	—	61	3,801	21	639
Unspecified:[9]						
Actual	2,640	11,414	232	382	1,218	4,569
Estimated	956	3,595	166	761	219	707
Total	7,721	34,834	1,554	9,283	3,082	11,919

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."

[1]Excludes 768,640 short tons at a value of $3,551,116 not reported by counties.

[2]Includes macadam, riprap and jetty stone, filter stone, and other coarse aggregate.

[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.

[4]Includes stone sand (concrete), stone sand (bituminous mix or seal), and screening (undesignated).

[5]Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run (select material or fill).

[6]Includes agricultural limestone, and poultry grit and mineral food.

[7]Includes flux stone and glass manufacture.

[8]Includes asphalt fillers or extenders, paper manufacture, other extenders and fillers, and other specified uses not listed.

[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.

value dropped by 18% from that of 1990. The State's seven aluminum smelters produced a total of 1,258,000 metric tons of aluminum ingot, slightly above total annual rated capacity. Washington was the Nation's largest aluminum producer. Production was more than three times that of any other State and accounted for 31% of total domestic output. Prices, which averaged $1.10 per pound in 1988, $0.88 in 1989, and $0.74 in 1990, fell to an average of $0.59 per pound in 1991.

With a rated capacity of 275,000 metric tons, Intalco Aluminum Corp., a subsidiary of Alumax Inc., operated Washington's largest single plant in Ferndale, Whatcom County. Alumax owned 75% of the plant, with three Japanese companies controlling the remaining interest. Kaiser Aluminum & Chemical Corp., with a total rated capacity of 273,000 metric tons, and Intalco were the State's leading aluminum ingot producers.

Kaiser, a division of MAXXAM Inc., operated plants in Mead and Trentwood in Spokane County and a smelter in Tacoma, Pierce County. Kaiser's smelter at Mead produced molten aluminum, ingot, and aluminum shot. The plant has a rated capacity of 200,000 metric tons per year. At its Trentwood rolling mill, Kaiser produced plate and sheet, including coil stock, for the beverage, aerospace, transportation, and other industries.

Washington's other aluminum smelters, by order of rated capacity, were Aluminum Co. of America's (Alcoa) plant in Wenatchee, Chelan County; the Reynolds Metals Co. operation in Longview, Cowlitz County; a plant in Goldendale, Klickitat County, owned by Columbia Aluminum Co.; and a smelter in Vancouver, Clark County, operated by Vanalco Inc.

Gold and Silver.—Value of gold produced in Washington decreased by 3% from that of 1990 despite an almost 4% increase in quantity produced for 1991. The State was the sixth-ranked gold producer in the Nation in 1991. Two companies reported silver produced as a byproduct of lode gold production. The quantity of silver production remained essentially unchanged, but the value dropped 15% from that of 1990.

The Cannon Mine, an epithermal deposit at Wenatchee, Chelan County, was the largest gold operation in the State and the second largest underground gold mine in the Nation; silver also was produced. Production for 1991 was 4,728 kilograms of gold and 8,440 kilograms of silver from 488,660 metric tons of ore. The mine is a joint venture of Asamera Minerals (U.S.) Inc., a subsidiary of Gulf Canada Resources Ltd., and Breakwater Resources Ltd. The mine ranked 15th nationally in terms of value of gold production in 1991. Asamera, as operator, continued underground exploration and

TABLE 4
WASHINGTON: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone[1]	10	456	$5,645	$12.38	10	1,521	$10,767	$7.08
Dolomite	3	W	W	3.73	5	9	W	29.78
Granite	7	309	1,668	5.40	22	798	3,125	3.92
Traprock	105	10,179	40,537	3.98	184	9,733	40,999	4.21
Sandstone and quartzite	4	983	2,989	3.04	22	126	575	4.56
Volcanic cinder and scoria	2	W	W	5.26	8	151	W	6.67
Miscellaneous stone	9	1,017	3,477	3.42	28	787	2,848	3.62
Total[2]	XX	13,259	55,624	4.20	XX	13,126	59,588	4.54

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Includes "Limestone/dolomite," reported with no distinction between the two.
[2]Data may not add to totals shown because of independent rounding.

development, including the driving of an exploration drift to confirm drill indicated reserves. Exploration also was conducted northwest and southeast of the mine in the Chiwaukum graben.

In Ferry County, the Kettle Mine, an epithermal gold deposit west of Curlew, and the Overlook Mine, a replacement-type deposit northeast of Republic, operated during the year. The underground mines are a part of the Kettle River gold project, a joint venture between Echo Bay Minerals Co. and Crown Resources Corp. Echo Bay holds a 70% interest and is the operator. A modified room-and-pillar mining method and a decline ramp system that accommodated rubber-tired vehicles were used at the Overlook. A similar decline ramp was in use at the Kettle Mine. Throughput at the Key mill, which processed ore from both mines, ranged from 1,360 to 1,900 metric tons per day. Sited near the Overlook Mine, the mill processed approximately 270 metric tons per day from the Kettle Mine with the remainder coming from the Overlook Mine. The plant uses a carbon-in-pulp vat-leach system and zinc precipitation (Merrill-Crowe process) to recover the precious metals. Combined production from the Kettle and Overlook Mines was 2,808 kilograms. The joint venture was awaiting approval of permits to begin mining at the nearby Key East and Key West deposits.

Hecla Mining Co.'s Republic Unit (Knob Hill Mine), at Republic, Ferry County, was the State's top-ranked silver producer. The company employed a cut-and-fill mining method and continued to remove ore primarily from the Golden Promise vein system. Once on the surface, the ore was hauled by truck to the 245-metric-ton-per-day Republic mill. According to Hecla, the mine produced 2,418 kilograms of gold and 9,687 kilograms of silver. Hecla completed driving of a new decline ramp to provide a more direct access to the Golden Promise ore bodies. The ramp permits the use of rubber-tired, diesel vehicles for ore loading and haulage to the surface. Previously, the ore was trammed almost 2 kilometers to the Knob Hill No. 2 shaft and hoisted to the surface. The decline also provides access for underground exploration and development of the epithermal deposit. Following completion to the 800 level, the company decided to extend the 3- by 4-meter decline to the 1100 level, ending with a total length of about 2,200 meters.

Magnesium Metal.—Although the quantity of magnesium metal production in 1991 increased almost 8%, value dropped from that of 1990. The State ranked second nationally in production of the metal.

Northwest Alloys, a wholly owned subsidiary of Alcoa, laid off one-half of the 500 person work force at Washington's sole magnesium plant at Addy, Stevens County. Earlier in the year, the company laid off between 40 and 60 employees who had been subcontracted to do maintenance and construction work. The company said the cutbacks were due to falling magnesium prices worldwide and a decrease in demand. The bulk of Northwest Alloys' magnesium metal was used by the parent company, Alcoa, as a strengthening agent in aluminum alloy products. The Addy plant produced magnesium metal from locally quarried dolomite, employing a silicothermic process using ferrosilicon and aluminum-quartzite flux.

L-Bar Products Inc. laid off 52 workers and temporarily closed its magnesium processing plant near Chewelah, Stevens County. L-Bar manufactured fertilizer and magnesium granules by extracting the metal from sludge bars residue obtained from the nearby Northwest Alloys magnesium plant.

Silicon.—Silicon Metaltech Inc. operated a silicon plant at Rock Island, Douglas County; the plant obtained raw material from the company's quartzite mining operations in Golden, British Columbia, Canada. The plant produced silicon metal for the domestic aluminum industry and the manufacturers of adhesives and caulks. Silica fume, a

byproduct of silicon metal and ferrosilicon production, was sold as a strengthener for concrete products. Although both Silicon Metaltech and Northwest Alloys are capable of producing ferrosilicon, prohibitively expensive electric rates and other considerations precluded production.

Advanced Silicon Materials Inc., a subsidiary of Komatsu Electronic Metals Co. Ltd. (KEM) of Japan, operated polysilicon plants in Moses Lake, Grant County, and Washougal, Clark County. Reportedly, KEM was the company's largest polysilicon customer and marketed the product in India, Japan, Republic of Korea, and Taiwan, where it was used in the manufacture of silicon wafers for computer chips and other electronics.

Zinc and Lead.—In early March, Equinox Resources Ltd. reopened the Van Stone zinc-lead mine near Onion Creek, north of Colville, Stevens County. Equinox purchased the mine in 1990 from Callahan Mining Co., U.S. Borax and Chemical Corp., and Brinco Ltd.; it was last operated by Asarco in 1971. In early April, the company began shipping concentrates by truck to be smelted at Cominco Ltd.'s zinc smelter at Trail, British Columbia, about 40 kilometers to the north of the operation. The mill soon reached its 1,100-ton-per-day capacity. Plans were to mine the property as an open pit for 2 years, then begin underground operations. Due to a drop in prices, Equinox suspended mining operations at the end of August but continued to feed the mill from low-grade, stockpiled ore until the end of October, at which time operations ceased.

Resource Finance Corp. (RFC) continued an exploration program at its Pend Oreille zinc-lead property 4 miles north of Metaline Falls, Pend Oreille County. The underground drilling was directed at further delineating the Yellowhead zone, the lower of two mineralized zones previously mined. RFC continued to work on acquiring permits necessary to reopen the property. Kerr Addison Mines Ltd. owns 44% of RFC.

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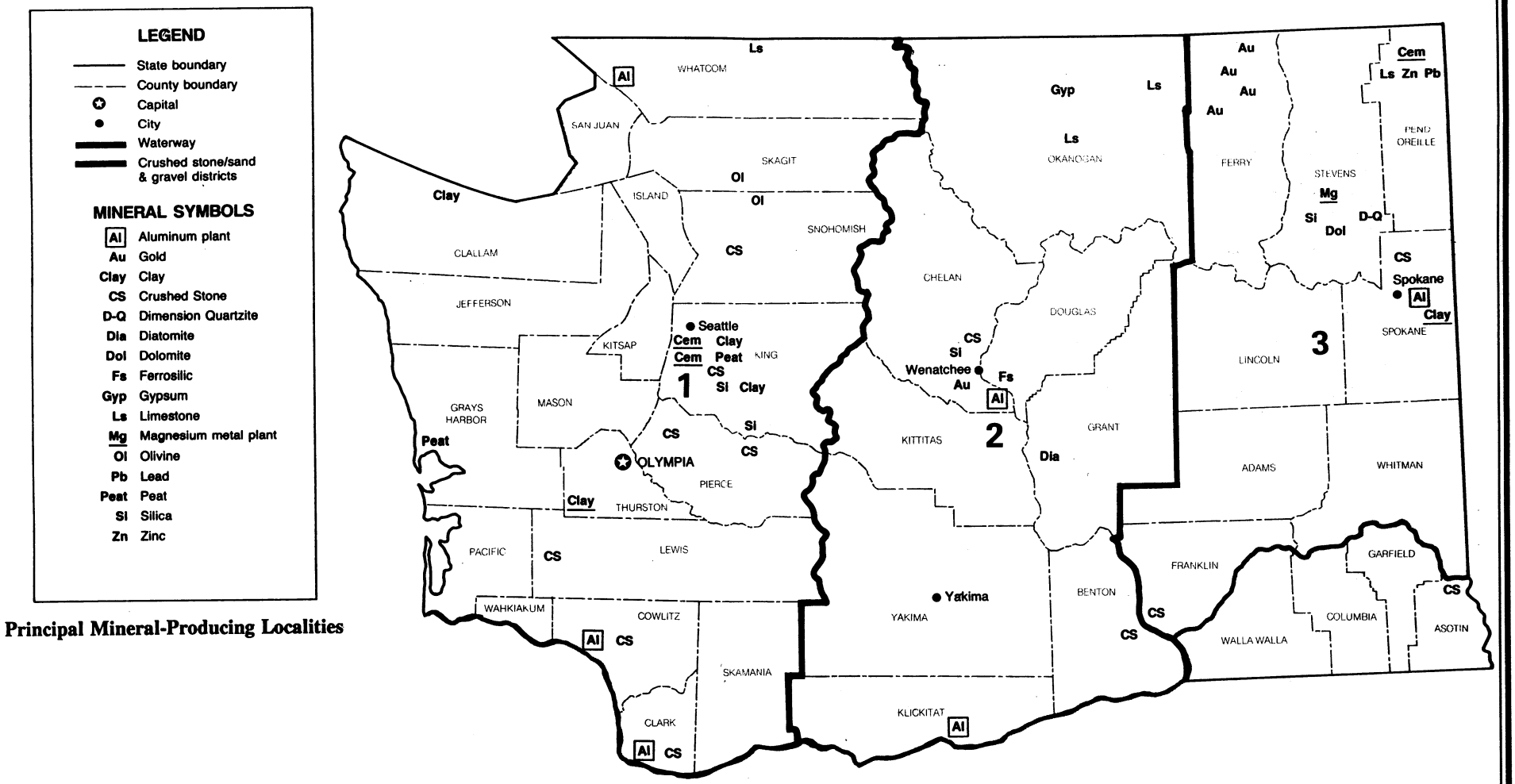
[1]State Mineral Officer, U.S. Bureau of Mines, Spokane, WA. He has 17 years of mineral-related experience in industry and government and has covered the mineral activities in Washington since 1989. Assistance in preparation of the chapter was given by W. A. Lyons, editorial assistant.

[2]Geologist, Metals, Washington Division of Geology and Earth Resources, Spokane, WA.

[3]Geologist, Industrial Minerals, Washington Division of Geology and Earth Resources, Spokane, WA.

WASHINGTON



Principal Mineral-Producing Localities

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Aluminum Co. of America	Box 221 Wenatchee, WA 98801	Plant	Chelan.
Columbia Aluminum Co.	Star Route 667, Box 46 Goldendale, WA 98620	do.	Klickitat.
Intalco Aluminum Corp.	Box 937 Ferndale, WA 98248	do.	Whatcom.
Kaiser Aluminum and Chemical Corp.	Box 6217 Spokane, WA 99207	do.	Spokane.
Do.	3400 Taylor Way Tacoma, WA 98421	do.	Pierce.
Reynolds Metals Co.	Box 999 Longview, WA 98632	do.	Cowlitz.
Vanalco Inc.	Box 120 Vancouver, WA 98660	do.	Clark.
Cement:			
Ash Grove Cement West Inc.	6720 SW Macadam Ave. Suite 300 Portland, OR 97201	do.	King.
Holman Ideal Inc.	Box 8789 Denver, CO 80201	do.	Do.
Clays:			
Holman Ideal Inc.	Box 8789 Denver, CO 80201	Pit	Clallam.
Mutual Materials Co.	Box 2009 Bellevue, WA 98009	Pits and plant	King and Pierce.
Diatomite:			
Celite Corp.	Box 636 Quincy, WA 98848	Mine and plant	Grant.
Gold:			
Asamera Minerals (U.S.) Inc.	1001 Circle St. Wenatchee, WA 98801	Underground mine and mill	Chelan.
Echo Bay Minerals Co.	921 Fish Hatchery Rd. Republic, WA 99166	do.	Ferry.
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d'Alene, ID 83814	do.	Do.
Lime:			
Continental Lime Inc.	1220 Alexander Ave. Tacoma, WA 98421	Plant	Pierce.
Northwest Alloys Inc.	Box 115 Addy, WA 99101	Mine and plant	Stevens.
Magnesium:			
Northwest Alloys Inc.	Box 138A, Route 1 Addy, WA 99101	do.	Stevens.
Olivine:			
Applied Industrial Minerals Corp.	Box 58 Hamilton, WA 98225	do.	Skagit.
Peat:			
Bonaparte Peat	21 Tonasket-Hevillah Rd. Tonasket, WA 98855	Bog	Okanogan.
Chrystel Soils	Ocean City, WA 98569	Bog	Grays Harbor.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Industrial:			
Lane Mountain Silica Co.	Box 236 Valley, WA 99181	Quarry and plant	Stevens.
Reserve Sikuca Inc.	Box 95 Ravensdale, WA 98051	do.	King.
Silver:			
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d'Alene, ID 83814	Underground mine and mill	Ferry.
Stone:			
Crushed:			
Cadman Rock Co. Inc.	Box 790 Monroe, WA 98272	Quarry	Snohomish.
DeAtley Co., a division of Eucon Co.	Box 648 Lewiston, ID 83501	Quarries	Asotin, Benton, Franklin.
Inland Asphalt Co., a division of Development CPM Corp.	Box 11036 Spokane, WA 99211	do.	Yakima.
Meridian Aggregates Co.	Box 839 Granite Falls, WA 98252	do.	Franklin, King, Skagit, Snohomish.
U.S. Forest Service	333 SW First St. Portland, OR 97202	do.	Various.

THE MINERAL INDUSTRY OF WEST VIRGINIA

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the West Virginia Geological and Economic Survey for collecting information on all nonfuel minerals.

By L. J. Prosser, Jr.,[1] and Claudette M. Simard[2]

The value of nonfuel mineral production in West Virginia declined to about $117 million in 1991. The drop in value of almost $20 million resulted from weaker demand for industrial minerals used in construction, particularly cement. A decline in output was also reported for clays, sand and gravel, and crushed stone.

In other sectors of the State's mineral industry, demand was mixed in 1991. Steel production declined as the result of a downturn in economic conditions. Coal production dropped for the first time in 5 years. Output of primary aluminum increased despite a labor dispute that continued throughout the year.

LEGISLATION AND GOVERNMENT PROGRAMS

The West Virginia Legislature during a special session in October enacted House bill 217 restructuring the Division of Energy into a new Division of Environmental Protection (DEP). The legislation called for a 2-cents-per-ton tax on coal mined to partially fund the new DEP. The Office of Miners' Health, Safety, and Training was also created, thus separating the State's environmental regulatory and mine safety functions into two agencies.

The West Virginia Geologic and Economic Survey (WVG&ES) continued cooperative studies with Federal Government agencies to assess the State's mineral resources. In 1991, manganese occurrences were investigated in the counties of Greenbrier, Mercer, Monroe, and Pocahontas in the southeastern part of the State.

Also in 1991, the WVG&ES published the West Virginia Mineral Industries Directory, which listed all permitted surface and underground mining operations, dredges, and oil and gas drilling permit applications in the State.[3] The directory was compiled in cooperation with the following State agencies: Division of Energy, Oil and Gas Conservation Commission, Public Service Commission, and Public Land Corp. The U.S. Bureau of Mines, the U.S. Department of Energy, and private industry also assisted in the compilation. According to the report, the value of fuel and nonfuel mineral production in West Virginia for 1989 was $5.2 billion.

The U.S. Bureau of Mines awarded a $50,000 grant to West Virginia State College to continue a study on how miners use technology in emergency situations. Findings from the work were expected to be published in 1992.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Production of industrial minerals was limited to one producer of each of the following commodities: cement, lime, peat, and industrial sand. Production of these commodities remained about the

TABLE 1
NONFUEL MINERAL PRODUCTION IN WEST VIRGINIA[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Clays	metric tons	251,385	$553	164,257	$384	134,262	$322
Gemstones		NA	1	NA	1	NA	2
Sand and gravel (construction)	thousand short tons	•2,300	•6,700	3,208	14,950	•3,100	•14,300
Stone (crushed)	do.	[2]10,904	[2]42,538	•[2]12,000	•[2]45,200	10,255	50,505
Combined value of cement, lime, peat (1990-91), salt, sand and gravel (industrial), and stone (crushed granite, 1989-90)		XX	75,706	XX	75,803	XX	51,802
Total		XX	125,498	XX	136,338	XX	116,931

•Estimated. NA Not available. XX Not applicable.
[1]Production as measured by mine shipments or marketable production (including consumption by producers).
[2]Excludes certain stones; kind and value included with "Combined value" data.

TABLE 2

WEST VIRGINIA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Riprap and jetty stone	292	1,833	$6.28
Filter stone	197	1,300	6.60
Other course aggregate	W	W	5.50
Coarse aggregate, graded:			
Concrete aggregate, coarse	1,201	5,416	4.51
Bituminous aggregate, coarse	495	2,069	4.18
Bituminous surface-treatment aggregate	93	431	4.63
Railroad ballast	529	2,216	4.19
Fine aggregate (-3/8 inch):			
Stone sand, concrete	550	3,033	5.51
Stone sand, bituminous mix or seal	285	1,319	4.63
Screening, undesignated	409	2,140	5.23
Coarse and fine aggregate:			
Graded road base or subbase	1,841	9,813	5.33
Unpaved road surfacing	134	692	5.16
Terrazzo and exposed aggregate	W	W	5.66
Crusher run or fill or waste	1,016	5,850	5.76
Other construction materials[2]	776	2,614	3.37
Agricultural:			
Agricultural limestone	83	676	8.14
Poultry grit and mineral food	W	W	17.08
Other agricultural uses	4	146	36.50
Chemical and metallurgical[3]	990	3,431	3.47
Other miscellaneous uses[4]	149	2,552	17.13
Unspecified:[5]			
Actual	810	3,017	3.72
Estimated	401	1,958	4.88
Total	10,255	50,505	4.92

W Withheld to avoid disclosing company proprietary data; included with "other construction materials" and "other miscellaneous uses."
[1]Includes dolomite, granite, limestone, and sandstone.
[2]Includes withheld amounts for coarse aggregate (+1 inch), coarse and fine aggregate, and pipe bedding.
[3]Includes withheld amounts for cement manufacture, lime manufacture, and sulfur oxide removal.
[4]Includes withheld amounts for agricultural, mine dusting or acid water treatment, other fillers or extenders, and abrasives.
[5]Includes production reported without a breakdown by use and estimates for nonrespondents.
[6]Data do not add to total shown because of independent rounding.

same as that in 1990 with the exception of cement. Cement shipments, according to estimated data, dropped by about 30% as a result of a decline in demand from the construction industry.

Clays and Shale.—For the past 11 years, common clays and shale have been produced by the same three companies in West Virginia. Fire clay mining ceased in 1985.

Each of the three operations marketed clay and shale for a different end use. Clay and shale was used by Capitol Cement Corp. in cement manufacturing, by Continental Brick Co. in brickmaking, and by Sanders Dummy Co. as stemming for explosives.

In 1991, output dropped for the second year in a row. A decline in production of approximately 20% was reported for the year. But compared with 1989 data, the decline was substantial at about 47%. A decrease in building and construction in West Virginia and surrounding areas lessened the demand for cement and bricks, the two primary uses for the State's clay.

Salt.—By yearend, West Virginia's salt industry had been reduced to one active producer. During the year, Hanlin Chemicals-West Virginia had filed for chapter 11 bankruptcy and halted production at its operations in Marshall County. The State's major producer, PPG Industries Inc., remained in operation producing brine for processing at its Natrium plant.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1989 and 1991 and actual data for 1990.

Estimated production in 1991 of 3.1 million short tons was slightly below the 1990 total.

Slag.—In 1991, Koch Minerals Co., a division of Koch Industries of Wichita, KS, began operating a slag grinding and granulation plant near Weirton, WV. The iron slag was obtained from Weirton Steel Corp. Two other companies also produced slag, Standard Lafarge Co. and International Mill Service Co.

Stone (Crushed).—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1989 and 1991 and estimates for 1990.

West Virginia stone statistics are compiled by geographical districts as depicted in the State map. Table 3 presents end-use statistics for West Virginia's three districts.

A comparison of the actual data reported in 1989 with that of 1991 showed a slight decrease in production

TABLE 3

WEST VIRGINIA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregates (+1 1/2 inch)[1]	293	1,979	38	208	178	1,056
Coarse aggregates, graded[2]	633	2,873	1,213	5,193	472	2,066
Fine aggregates (-3/8 inch)[3]	500	3,246	424	2,027	320	1,219
Coarse and fine aggregates[4]	1,233	8,497	868	3,819	889	4,038
Other construction materials	678	2,230	W	W	W	W
Agricultural[5]	37	363	W	W	W	W
Chemical and metallurgical[6]	W	W	990	3,430	—	—
Special[7]	W	W	W	W	—	—
Other miscellaneous uses	104	1,792	89	1,109	85	387
Unspecified:[8]						
Actual	—	—	296	849	514	2,169
Estimated	19	97	120	583	262	1,278
Total[9]	3,497	21,076	4,038	17,217	2,720	12,212

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[1]Includes riprap and jetty stone, filter stone, and other coarse aggregate.
[2]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[3]Includes stone sand (concrete), stone sand (bituminous mix or seal), screening (undesignated).
[4]Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run (select material or fill), and pipe bedding.
[5]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[6]Includes cement manufacture, lime maunfacture, dead-burned dolomite, and flux stone.
[7]Includes mine dusting or acid water treatment, abrasives, and other fillers or extenders.
[8]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[9]Data may not add to totals shown because of independent rounding.

TABLE 4

WEST VIRGINIA: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	31	9,854	$37,480	$3.80	53	7,327	$37,248	$5.09
Dolomite	—	—	—	—	2	W	W	4.15
Granite	1	W	W	4.50	1	W	W	4.92
Sandstone	13	W	W	4.82	13	977	5,163	5.29
Total[1]	XX	10,904	42,538	3.90	XX	10,255	50,505	4.92

W Withheld to avoid disclosing company proprietary data, included in "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

but an increase in value per ton from $3.90 to $4.92.

About two-thirds of the State's 45 quarries produced limestone in 1991, about the same as that in 1990. Sandstone was produced from 12 quarries, dolomite from 2 quarries, and a small quantity of granite from 1 operation. Overall, the State's crushed stone industry has remained stable over the past 5 years.

Crushed stone was the leading nonfuel mineral produced in West Virginia, accounting for about one-third of the total value. In December, the West Virginia DEP denied Francis O. Day Co. permission to open a limestone quarry near Kearneysville on the Jefferson-Berkeley County border. The decision came after almost 2 years of public hearings on the subject. The quarry was opposed by local residents. In denying the permit, the DEP reasoned that blasting and airborne dust would have a negative impact on residents and facilities in the area and that ground water and future land uses in the area could be adversely affected.[4] Also during the year, W. W. Boxley Co. purchased the limestone quarry of Johnson Limestone

Co. The quarry, near Lewisburg, operated as Greenbrier Limestone Corp.

Metals

Primary and fabricated metals industries in West Virginia provided employment for about 19,000 workers in 1991 or about 23% of the State's manufacturing employment.[5]

Metals discussed in this section were processed from materials received from both foreign and domestic sources; no metals were mined in West Virginia in 1991. Production and value data for these commodities, which are not included in table 1, are given, if available.

Aluminum.—A labor dispute continued throughout the year at Ravenswood Aluminum Corp. in Jackson County. Despite the labor dispute, production of primary aluminum increased over that of the previous year as salaried workers and replacement workers continued operations. The conflict began in November 1990 when the contract for the plant's 1,700 unionized workers expired.

Iron and Steel.—Weirton Steel Corp., the State's leading steel manufacturer, reported a 12% decrease in steel shipments to about 1.9 million short tons in 1991. The decline was attributed to weakness in demand for steel sheet products due to general economic conditions.[6] Since 1988, Weirton has invested $500 million in a modernization program of which $124 million was spent in 1991. The program has enabled the company to produce all its steel using continuous casting technology and increased capacity from 1.9 million tons to 3.0 million tons.

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[1]State Mineral Officer, U.S. Bureau of Mines, Pittsburgh, PA. He has 18 years of mineral-related industry and government experience and has covered the mineral activities in West Virginia for 6 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]Economic geologist, West Virginia Geological and Economic Survey, Morgantown, WV.

[3]WV Geological and Economic Survey. West Virginia Mineral Industries Directory, Box 879, Morgantown, WV 26507-0879, Pub. No. MRS-9, 3d Ed., Oct. 1991, 125 pp.

[4]Spirit of Jefferson Advocate (Charlestown, WV). Quarry Permit Nixed by DOE. Dec. 19, 1991, p. 1.

[5]Economic Summary. West Virginia Bureau of Employment Programs, Labor and Economic Research, Feb. 1992, p. 5.

[6]Weirton Steel Corp. 1991 Annual Report. 38 pp.

WEST VIRGINIA

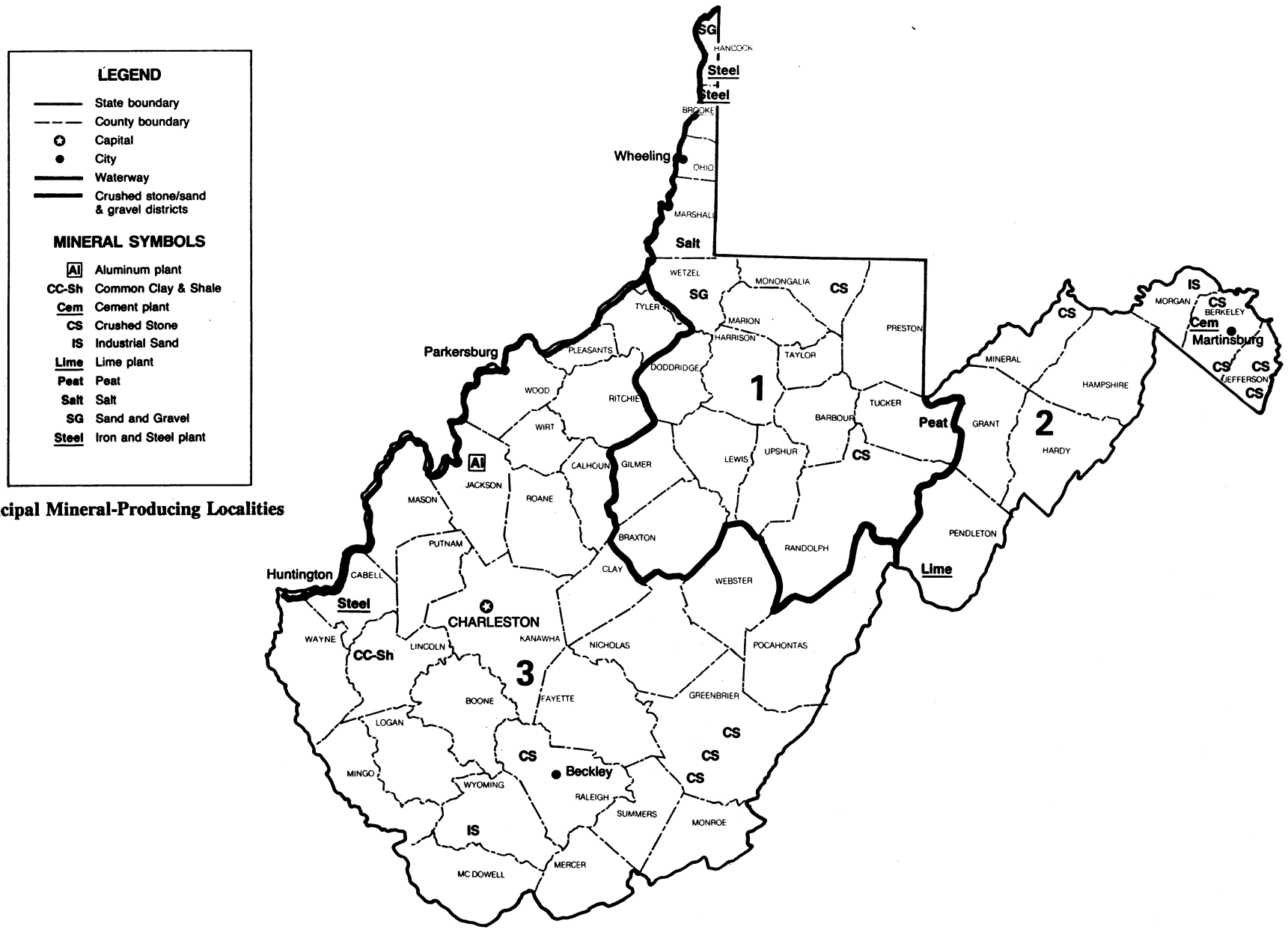

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Capitol Cement Corp.[1]	Box 885 Martinsburg, WV 25401	Quarry and plant	Berkeley.
Clays:			
Continental Brick Co.	Route 9, Box A1 Martinsburg, WV 25401	Pit and plant	Do.
Sanders Dummy Co.	Box 38 Midkiff, WV 25540	Pit	Lincoln.
Lime:			
Germany Valley Limestone Co.	Box 302 Riverton, WV 26814	Quarry and plant	Pendleton.
Salt:			
Hanlin Chemicals-West Virginia Inc.	Drawer J Moundsville, WV 26041	Brine wells and plant	Marshall.
PPG Industries Inc.	1 Gateway Center Pittsburgh, PA 15222	do.	Do.
Sand and gravel:			
Construction:			
Dravo Corp.	5253 Wooster Rd. Cincinnati, OH 45226	Dredge	Wetzel.
ET&S Inc.	Route 1, Box 475A Gallipolis Ferry, WV 25515	Pit	Mason.
Jesco Corp.	Route 2, Box 186-A Letart, WV 25253	Pit	Do.
Pittsburgh Sand & Gravel Inc.	Box 248 Coraopolis, PA 15108	Dredge	Brooke.
Standard-Lafarge	6715 Tippecanoe Rd. Bldg. C Canfield, OH 44406	Pit	Hancock.
Industrial:			
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	Quarry and plant	Morgan.
Stone:			
Acme Limestone Co.	Fort Spring, WV 24936	Quarry	Greenbrier.
J. F. Allen Co.	Box 49 Clarksburg, WV 26301	do.	Randolph.
Evered Materials USA Inc. (Millville Quarry Inc.)	Box 166 Millville, WV 25432	do.	Jefferson.
Fairfax Sand & Crushed Stone Inc. (Laurel Sand & Gravel Inc.)	Box 719 Laurel, MD 20705	Quarries	Grant, Mineral, Tucker.
Greer Limestone Co.	Greer Bldg. Morgantown, WV 26505	do.	Monoongalia and Pendleton.
Pounding Mill Quarry Corp.	Box 5368 Princeton, WV 24740	Quarry	Mercer.

[1]Also clays and crushed stone.

THE MINERAL INDUSTRY OF WISCONSIN

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Wisconsin Geological and Natural History Survey for collecting information on all nonfuel minerals.

By Robert H. Wood II[1] and Thomas J. Evans[2]

Wisconsin's nonfuel mineral production, valued at almost $214 million in 1991, represents the highest annual total in the State's history, 0.8% over the previous year's record value and 31% above the average over the past 10 years. Total value increases were reported for construction and industrial sand and gravel, and dimension stone. Total value decreases were reported for crushed stone, gemstones, lime, and peat.

In order of value, crushed stone, construction sand and gravel, lime, and industrial sand and gravel were the State's leading mineral commodities in 1991. Crushed stone accounted for about 38% of the State's total nonfuel mineral value, about 12% less than the previous year's estimated value. Construction sand and gravel, accounting for 36% of Wisconsin's total nonfuel mineral value, increased about 5% over the previous year's estimated value.

The State ranked 36th nationwide in value of nonfuel mineral production, contributing less than 1% of the U.S. total. Among the mineral commodities produced in Wisconsin during 1991, the quantity of lime produced ranked 11th among 32 States reporting production; peat, 12th of 19; industrial sand, 7th of 37; crushed stone, 19th of 49; and dimension stone, 10th of 34.

TRENDS AND DEVELOPMENTS

Flambeau Mining Co., a wholly owned subsidiary of Kennecott Corp., started construction of its small open pit copper-gold mine south of Ladysmith in Rusk County in July. In June, the Wisconsin Department of Natural Resources (DNR) announced the discovery of two endangered species of clams in the Flambeau River near the mine site. On August 9, the Lac Court Oreilles Band of Lake Superior Chippewa Indians, the Sierra Club, and Gregg Moore (individual) filed a motion of injunctive relief against DNR and Flambeau Mining in Dane County Circuit Court seeking the

TABLE 1
NONFUEL MINERAL PRODUCTION IN WISCONSIN[1]

Mineral		1989 Quantity	1989 Value (thousands)	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)
Gemstones		NA	W	NA	W	NA	$542
Lime	thousand short tons	437	$18,129	461	$24,608	536	23,225
Peat	do.	13	309	12	256	9	227
Sand and gravel:							
Construction	do.	e21,700	e56,400	29,572	73,750	e29,600	e77,500
Industrial	do.	1,514	22,399	W	W	W	W
Stone:							
Crushed	do.	26,520	83,664	e26,600	e91,000	[2]23,676	[2]80,475
Dimension	short tons	35,587	4,376	e31,316	e3,811	[2]37,470	[2]4,347
Combined value of other industrial minerals and value indicated by symbol W		XX	(3)	XX	18,622	XX	27,533
Total		XX	[4]185,277	XX	212,047	XX	213,849

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain stones; value included with "Combined value" figure.
[3]Value excluded to avoid disclosing company proprietary data.
[4]Partial total, excludes values that must be concealed to avoid disclosing company proprietary data.

cessation of further site preparation and all mining activities. The court ruled in favor of the petitioners, requiring cessation of site preparation work until 30 days after the release of the supplemental Environmental Impact Statement and DNR's determination of the impact of mining on the endangered species. Completion of the study was expected in the spring of 1992. The partly constructed site has been stabilized. The massive-sulfide deposit, to be developed in a 13-hectare (32-acre) open pit mine, was reported to contain approximately 1.7 million metric tons (1.9 million short tons) of ore, grading about 10.5% copper, 59 grams of silver per metric ton (2.1 troy ounces per short ton), and 2.82 grams of gold per metric ton (0.1 troy ounce per short ton).

Noranda Minerals Wisconsin Corp. activity centered on subsurface delineation of the massive sulfide deposits discovered in 1990 by Noranda Exploration Co. in the town of Lynne, west-central Oneida County. The Lynne project was proposed as a small open pit mine to develop the 5.9-million-metric-ton (6.5-million-short-ton) massive sulfide ore body. The deposit contains significant amounts of lead, silver, and zinc, and lesser amounts of copper and gold. During 1991, DNR notified Noranda of several environmental issues, including wetlands impact, subsurface-water discharge, and possible presence of lakebeds in the project area. Information about the lakebed was collected by personnel from the Wisconsin Geological and Natural History Survey (WGNHS) during 1991. Submission of a Notice of Intent to collect data to support a mine-permit application was anticipated early in 1992.

Discovered in 1990, the Bend deposit is in the Chequamegon National Forest near the town of Westboro, in north-central Taylor County. The 3.3-million-metric-ton (3.6-million-short-ton) copper-gold massive sulfide deposit has been proposed as an underground mining operation. During the year, activity on the Bend project by Jump River Joint Venture centered on drilling to delineate additional reserves. A preference right lease application was also submitted to the U.S. Bureau of Land Management.

Placer-Dome reported encouraging drilling results from two of four holes drilled to test three gravity and magnetic anomalies 10 miles south of Rinelander in Enterprise Township. The two holes, drilled from the same setup, intersected a 1.5-meter-thick (5-foot-thick) stratabound gold and base metal-bearing zone. Zinc averaged 0.11% to 0.16%, copper up to 0.08%, lead up to 0.92%, and gold up to 0.17 gram per metric ton (0.006 ounce per short ton).

EMPLOYMENT

Wisconsin's Department of Industry, Labor and Human Relations reported that the State's civilian labor force averaged 2.6 million, relatively unchanged from the 1990 level. The State's unemployment rate rose from 4.4% to 5.4%. Employment in the State's mining industry averaged 2,181 workers during the year, a decrease of about 4% compared with the 1990 work force. The average annual wage for all mine workers increased about 5% to $30,329 over that of the previous year.

During the 2.9 million employee-hours worked in 1991 at surface mining operations, 2 fatalities, 88 injuries resulting in lost workdays, and 63 injuries with no workdays lost were reported by the U.S. Department of Labor. Six employees at underground mines worked a collective total of 2,000 hours with no injuries reported. At mills and preparation plants associated with mining operations, an additional 45 injuries occurred to workers resulting in lost workdays and 45 injuries occurred with no lost workdays. A total of 914,212 employee-hours were worked at the mills and plants during the year.

REGULATORY ISSUES

Cornell University's lawsuit filed in 1990 against Rusk County and decided in favor of the county late in that year was appealed to the Court of Appeals. The lawsuit attempts to block the county from extinguishing Cornell's severed mineral interest on land where the surface ownership was tax delinquent. The county was preparing to take ownership of a 65-hectare (160-acre) parcel of land through a tax sale and asserted that in receiving a tax deed on the property, Cornell's severed mineral interests on the same property would be extinguished. County governments in northern Wisconsin have historically acquired large land areas through tax delinquency proceedings. Severed mineral interests on some of these holdings raised questions about the current status of mineral ownership and the county's ability to lease such mineral interests for metallic mineral exploration. A final decision on the case is expected next year.

Wisconsin's attorney general filed a lawsuit against Burlington Northern Railroad Co. (BN) with air pollution charges at its ore transfer facility in Superior. On 11 occasions since mid-1987, taconite dust from the facility allegedly caused or significantly contributed to excessive levels of air pollution. BN also allegedly began construction of two new taconite transfer stations in 1988 before permits were issued. According to local residents, problems occur mainly at night when taconite ore is being unloaded and from wind blowing across stockpiled taconite pellets during winter months. Some local residents have received compensation from BN for their inconvenience.

Several counties, including Sauk and Winnebago, and some local communities are preparing comprehensive rules that would add new restrictions to both existing and future quarries. As metropolitan areas expand, subdivisions come closer to existing proposed quarries, creating tension between residents and quarry operators. Although quarry operations are often noisy and dusty, the rock materials produced in such operations are needed to support urban development.

Recently, companies have shown interest in mining the high-quality quartzite used in road construction and as railroad ballast. In an effort to block mining, DNR considered buying about 445 hectares (1,100 acres) adjacent to

Devil's Lake State Park from a group of Sauk County land owners. Funding would come from special DNR funds for real estate purchases and the new Stewardship Fund established by the legislature to protect wildlife, endangered species, and recreation.

EXPLORATION ACTIVITIES

Exploratory drilling for metallic minerals in Wisconsin surpassed last year's alltime record. The record number, 128 drill holes completed during the year, included 111 holes that were considered as development drilling designed to establish the quantity of ore in deposits. Two centers of drilling activity included Noranda's Lynne deposit in Oneida County and Jump River Joint Venture's Bend deposit in Taylor County. Four companies, including BHP-Utah International, E. K. Lehmann & Associates of Wisconsin Inc., Placer Dome U.S. Inc., and Noranda Exploration Inc., were involved in drilling programs during the year. Total footage drilled in 1991, 28,750 meters (94,321 feet), included 22,940 meters (75,261 feet) in Oneida County, 2,360 meters (7,748 feet) in Taylor County, 170 meters (3,835 feet) in Price County, 923 meters (3,029 feet) in Lincoln County, and 824 meters (2,704 feet) in Marathon County.

For the fourth year in a row, the number of new acres leased for mineral exploration increased significantly, rising 46% above the 1990 level. Metallic mineral leasing activity in 1991 was undertaken by six companies: BHP-Utah International Inc., 7,740 hectares (19,127 acres); Great Lakes Exploration, 1,666 hectares (4,118 acres); E. K. Lehmann & Associates of Wisconsin Inc., 483 hectares (1,194 acres); Jump River Joint Venture, 1,570 hectares (3,880 acres); Noranda Exploration Inc., 9,320 hectares (23,030 acres); and Phelps Dodge Exploration East, 746 hectares (1,844 acres). Leasing occurred in nine northern Wisconsin counties. Most of the 19,860 hectares (49,075 acres) acreage leased was in Marinette County [7,270 hectares (17,965 acres)] followed by Price County [4,757 hectares (11,754 acres)], Oneida County [1,960 hectares (4,847 acres)], Taylor County [1,878 hectares (4,641 acres)], Forest County [1,647 hectares (4,071 acres)], and Florence County [1,478 hectares (3,652 acres)]. The remaining metallic mineral leases were in Langlade, Lincoln, and Marathon Counties.

Leasing activities of note included the leasing of more than 6,070 hectares (15,000 acres) of county forest land by Marinette County to BPH-Utah International, the termination of large acreage leased previously by Noranda Exploration on land held by Lake Superior Land Co. in northern Wisconsin, and the termination by default of more than 1,619 hectares (4,000 acres) in Oneida County that had been leased under competitive sale of mineral leases held in 1989. At the end of 1991, Cominco American Resources, using information obtained under agreements with Kerr-McGee Resources, was actively negotiating a lease with Iron County on land last evaluated in the mid-1980's.

Lease terms were similar to those of previous years. Acreage rentals ranged from $5 to more than $10 per 0.4 hectare (1 acre) per year. Purchase options were generally at about $1,000 per 0.4 hectare (1 acre). Most leases were from 5 to 10 years, although shorter lease lengths were not uncommon.

Oil and gas leasing activity centered on Bayfield County. Typical leases included $1 per 0.4-hectare (1-acre) rentals; production royalties were up to one-eighth of the value of the oil and gas produced.

LEGISLATION AND GOVERNMENT PROGRAMS

The current high level of mineral exploration activity, potential mineral development, and opposition to possible mining developments in the State by environmental interests led to the introduction of several bills dealing with metallic mineral regulation and oil and gas production. Assembly bill (A.B.) 701, introduced late in the year, proposed imposing a severance tax on oil and gas and provided authority to DNR to adopt rules to regulate oil and gas production; a decision was pending at yearend.

Metallic mineral legislation considered in 1991 covered activity on State-owned land, past environmental compliance records of mining companies, and expanded environmental regulation. A.B. 27 [and companion Senate bill (S.B.) 132], vetoed by the Governor, would have prohibited metallic mineral activity on lands managed by DNR. S.B. 224, which sought to limit lands suitable for mineral development, failed to gain support in the legislature.

A.B. 81, which passed the assembly but did not receive favorable consideration in the Senate, would have expanded the scope of the State's environmental protection activity by (1) prohibiting the issuance of a mining or prospecting permit in any shoreland or wetlands; (2) prohibiting mineral activity on land managed by DNR; (3) prohibiting uranium mining; (4) expanding mining-company liability; (5) mandating the preparation of environmental impact statements for all mining projects, requiring consideration of cumulative impacts of the proposed mine, existing mines, and potential mining projects; (6) expanding consideration of net substantial adverse impact to include any area in the State; and (7) eliminating agreements between mining companies and local units of government.

A.B. 661 focused on Wisconsin's local agreement statute (S. 144.839, WI stats.) as well as provided funds for early involvement by local governments. Final consideration on this bill as well as S.B. 240, which would expand the scope of the DNR mining-permit review process to include the collection of information on the mining-permit applicant's previous record of environmental compliance, is expected next year.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Gemstones.—No commercial gemstone operations were reported in Wisconsin in 1991. No precise value is known for gem material that rock hounds, mineral collectors, and other hobbyists collected. Lapidary materials found in the State included quartzite, granite, chalcedony, catlinite, moonstone, and Lake Superior agates in addition to a variety of mineral and fossil specimens. Diamonds have been found in the glacial deposits of northern Wisconsin.

Lime.—In 1991, the quantity of lime produced in the State increased by 16%, surpassing the record high reached during 1990. However, value decreased by 6% compared with that of the previous year. Three companies continued to report production of both hydrated lime and quicklime at four plants in Brown, Dodge, Fond du Lac, and Manitowoc Counties. The average unit value of all lime produced in the State was $43.33 per short ton, a $10.0 per short ton decrease in average value from that of 1990.

Peat.—Peat was harvested by four companies from bogs in Kewaunee and Waukesha Counties. Most of the peat produced was the reed-sedge type with the remainder principally sphagnum and small amounts of humus and hypnum. Peat was mainly used for general soil improvement and as a seed inoculant.

Peat production decreased approximately 25% in quantity and 11% in value compared with 1990 figures. The average unit value for all types of peat produced in the State increased about $3.89 per short ton to $25.22 per short ton from the 1990 average.

Sand and Gravel.—Construction.—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This annual report contains estimates for 1989 and 1991 and actual data for 1990.

A record-high output of construction sand and gravel was estimated in 1991. Tonnage was estimated slightly above last year's record high, while estimated value increased about 5%. Average estimated unit value of the material mined in the State increased about $0.18 per short ton, to $2.61 per short ton during the year. In terms of value, construction sand and gravel was Wisconsin's second leading mineral commodity.

Industrial.—Industrial sand production continued to slide from its 10-year high established in 1989. Although production decreased from 1990 levels, the average unit price increased to $16.15 ($2.70 per short ton above the previous year's average), accounting for an increase in the State's overall value.

Three companies, with operations in Columbia, Green Lake, Jackson, and Waupaca Counties, reported industrial sand production. The largest use of the sand produced was in foundry moldings,

TABLE 2
WISCONSIN: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch):			
Macadam	W	W	$4.58
Riprap and jetty stone	78	360	4.62
Filter stone	362	1,457	4.02
Other coarse aggregate	1	1	1.00
Coarse aggregate, graded:			
Concrete aggregate, coarse	1,506	5,620	3.73
Bituminous aggregate, coarse	863	3,027	3.51
Bituminous surface-treatment aggregate	689	2,423	3.52
Railroad ballast	W	W	4.33
Fine aggregate (-3/8 inch):			
Stone sand, concrete	25	101	4.04
Stone sand, bituminous mix or seal	W	W	4.88
Screening, undesignated	683	1,627	2.38
Coarse and fine aggregate:			
Graded road base or subbase	6,764	23,908	3.53
Unpaved road surfacing	1,209	2,538	2.10
Crusher run or fill or waste	114	314	2.75
Other construction materials[2]	137	627	4.58
Agricultural:			
Agricultural limestone	666	3,536	5.31
Chemical and metallurgical:			
Lime manufacture	148	502	3.39
Other miscellanous uses[3]	56	192	3.43
Unspecified:[4]			
Actual	5,358	18,336	3.42
Estimated	5,017	15,907	3.17
Total	23,676	80,475	3.40

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes dolomite, granite, limestone, and sandstone, excludes a minor amount of miscellaneous stone and traprock; withheld to avoid disclosing company proprietary data.
[2]Includes withheld amounts for coarse aggregate (+1 inch), coarse aggregate, graded, and fine aggregate (-3/8 inch).
[3]Includes chemicals and refractory stone(including ganister).
[4]Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 3

WISCONSIN:[1] CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1991, BY DISTRICT AND USE

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregates (+1 1/2 inch)[2]	82	294	271	1,148	W	W	W	W
Coarse aggregates, graded[3]	203	679	W	W	454	1,211	—	—
Fine aggregates (-3/8 inch)[4]	64	217	W	W	315	776	W	W
Coarse and fine aggregates[5]	3,495	13,795	2,702	9,105	581	1,247	974	1,399
Other construction materials	—	—	2,544	9,688	23	75	151	204
Agricultural[6]	(7)	(7)	139	1,329	(7)	(7)	—	—
Chemical and metallurgical[8]	(7)	(7)	W	63	(7)	(7)	—	—
Other miscellaneou	278	1,133	—	—	326	1,083	—	—
Unspecified:[9]								
Actual	1,128	4,138	—	—	200	400	1,380	4,548
Estimated	570	2,144	2,223	5,792	1,000	3,176	228	1,214
Total[10]	5,820	22,400	7,880	27,125	2,899	7,968	2,733	7,365

	District 5		District 6		District 7		District 8	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregates (+1 1/2 inch)[2]	W	W	W	W	—	—	—	
Coarse aggregates, graded[3]	W	W	—	—	—	—	—	—
Fine aggregates (-3/8 inch)[4]	1	W	—	—	—	—	—	—
Coarse and fine aggregates[5]	221	817	W	W	—	—	—	—
Other construction materials	241	914	125	434	—	—	—	—
Agricultural[6]	52	309	(7)	(7)	—	—	23	157
Chemical and metallurgical[8]	—	—	(7)	(7)	—	—	—	—
Other miscellanious uses	—	—	35	157	—	—	—	—
Unspecified:[9]								
Actual	2,281	7,969	338	1,168	—	—	32	111
Estimated	634	2,398	360	1,183	—	—	—	—
Total[10]	3,430	12,407	858	2,942	—	—	55	268

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Excludes miscellaneous stone and traprock; withheld to avoid disclosing company proprietary data.
[2]Includes macadam, riprap and jetty stone, filter stone, and other coarse aggregate.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, and railroad ballast.
[4]Includes stone sand (concrete), stone sand (bituminous mix or seal), and fine aggregate (screening-undesignated).
[5]Includes graded road base or subbase, unpaved road surfacing, crusher run or fill or waste, and other construction and maintenance uses.
[6]Includes agricultural limestone.
[7]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."
[8]Includes chemicals, lime manufacture, and refractory stone (including ganister).
[9]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[10]Data may not add to totals shown because of independent rounding.

followed by use for hydraulic fracturing and glass containers.

A $475,000 Wisconsin Department of Transportation grant was designated to help build a 4-kilometer (2.5-mile) rail spur in the village of Taylor. The rail spur is expected to save 83 jobs at the Badger Mining Corp. (BMC) and create 12 additional jobs. Completion of the rail spur will allow BMC to market additional sizes of its sand product profitably.

DNR issued an air quality permit to allow sand mining to resume at the Maiden Rock mine site. More than 24 kilometers (15 miles) of tunnels was mined for sand between 1920 and the early 1960's. These tunnels are used in the winter months by about 200,000 hibernating bats; it is believed that the sand mining will not disturb these bats. Expected annual sand production is 125,000 short tons. Mainly used to rejuvenate oil and gas wells, the sand is expected to be shipped throughout the United States.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual

TABLE 4
WISCONSIN: CRUSHED STONE SOLD OR USED, BY KIND

Kind	1989				1991[1]			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	220	20,049	$64,827	$3.23	220	20,476	$71,179	$3.48
Dolomite	2	W	W	1.83	3	190	813	4.28
Granite	13	2,185	6,395	2.93	12	1,466	3,239	2.21
Traprock	2	W	W	2.97	—	—	—	—
Sandstone	4	2,337	7,732	3.31	3	1,544	5,244	3.40
Total[2]	XX	26,520	83,664	3.15	XX	23,676	80,475	3.40

W Withheld to avoid disclosing company proprietary data; included with "Total." XX Not applicable.
[1]Excludes miscellaneous stone and traprock; withheld to avoid disclosing company proprietary data.
[2]Data may not add to totals shown because of independent rounding.

company estimates. This annual report contains actual data for 1989 and 1991 and estimates for 1990.

Crushed.—Crushed stone output, excluding certain stones such as traprock, decreased in production and value by 11% and 12%, respectively. The average unit value of the mined material was estimated at $3.40 per short ton. Approximately 85 companies using 180 operators produced crushed rock from 180 quarries. Production was reported in 42 of the State's 72 counties. Limestone was produced in the largest quantities. Other types of crushed stone produced included dolomite, granite, sandstone, and traprock.

The Lannon Village Board approved plans of operation for two area quarries. Lannon Stone Products Inc. and Halquist Stone Co. Inc.'s plans of operation, which included the option to quarry deeper, were approved in May. Approval requires close monitoring of area water wells.

A conditional use permit was approved by the Rib Mountain Town Board allowing 3M Corp. to extract 1,600 metric tons of rock from its quarry next to Rib Mountain State Park before yearend. 3M's mining plan originally requested approval to mine 387,000 cubic yards (3,000 pounds per cubic yard) of rock. This will be considered by board members later. Mining at this site began in 1934 when the company purchased the 113-hectare (280-acre) property. 3M originally crushed the 1.8-billion-year-old quartzite material to make the abrasive used on sandpaper. Today, the crushed rock is colored and used to coat the sides of swimming pools.

Dimension.—Dimension stone production increased 20% over the estimated 1990 amount and 5% over the quantity reported in 1989. Value increased 14% over 1990's estimate, but decreased 7% compared with that reported in 1989. Nine companies operated 12 quarries in 7 counties and produced 7 varieties of finished product. Monumental stone commanded the highest unit value; rough blocks the lowest. Irregular-shaped stone was produced in the largest quantity. Granite, limestone, and dolomite were the principal types of dimension stone quarried.

Other Industrial Minerals.—Raw materials for producing iron oxide pigments, expanded perlite, exfoliated vermiculite, and sulfur produced in Wisconsin were obtained from out-of-State sources. DCS Color & Supply Co. Inc. of Milwaukee processed black magnetite, red iron oxide, and burnt red sienna varieties of iron oxide pigments. Perlite was expanded by Midwest Perlite Co. at its plant in Outagamie County and was used as concrete aggregate, in acoustic tile, for cavity fill insulation, and as a horticultural aggregate. Vermiculite was exfoliated by Koos Inc. at its Kenosha plant. The exfoliated material, which increased significantly in quantity and value compared with 1990 figures, was used for concrete and plaster aggregates, insulation, horticultural purposes, and numerous other uses. Sulfur was recovered by Murphy Oil USA Inc. at its refinery in Superior, Douglas County.

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[1]State Mineral Officer, U.S. Bureau of Mines, Denver, CO. He has 15 years of mineral-related work with the government. Assistance in the preparation of this chapter was given by Pat La Tour, editorial assistant.

[2]Associate professor, Mineral Information, Wisconsin Geological and Natural History Survey, Madison, WI.

WISCONSIN

LEGEND

- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Abr	Abrasives
Cem	Cement plant
CS	Crushed Stone
D-G	Dimension Granite
D-L	Dimension Limestone
IS	Industrial Sand
Lime	Lime plant
Peat	Peat
SG	Sand and Gravel

Principal Mineral-Producing Localities

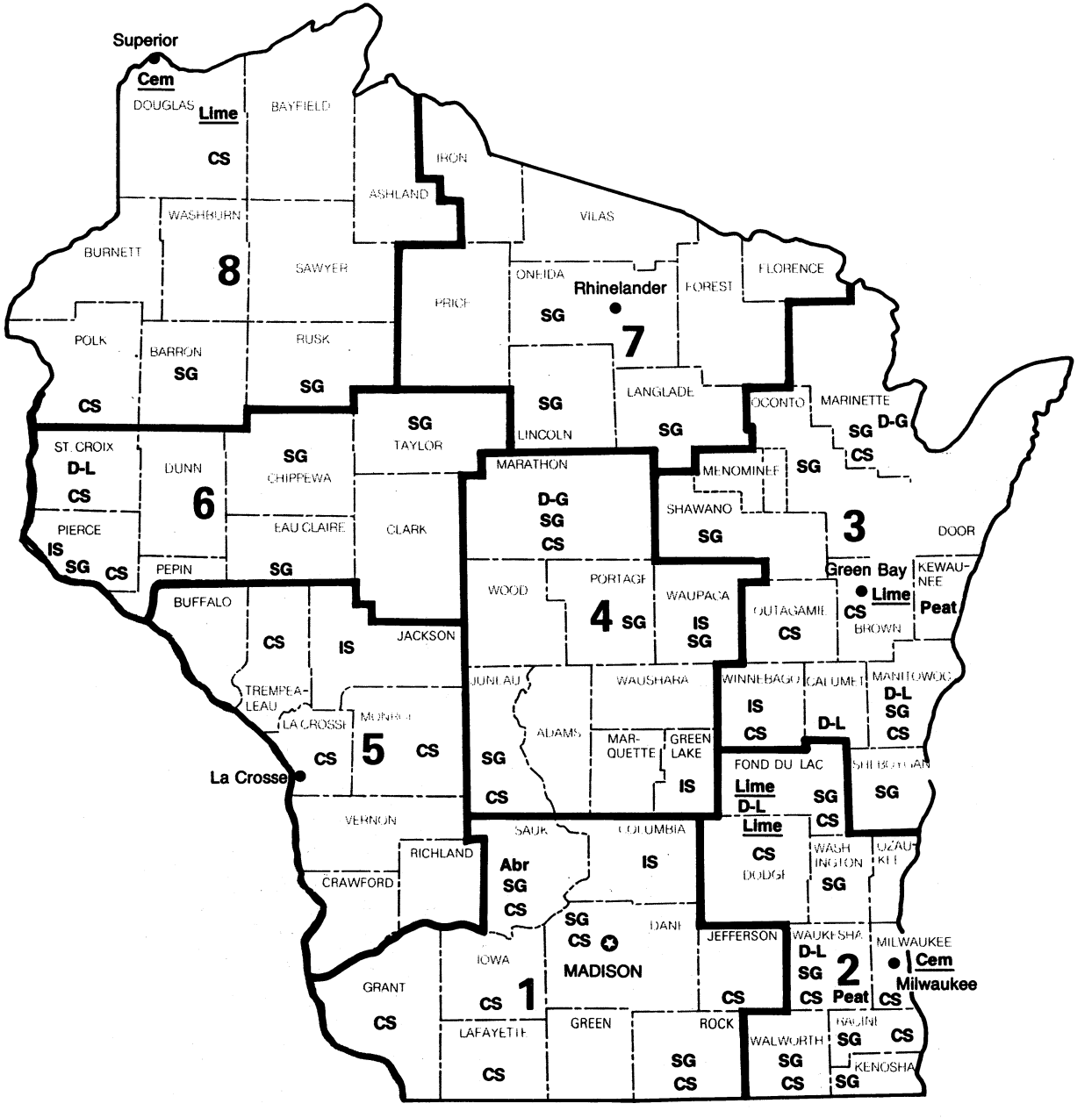

TABLE 5
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Abrasives (natural):			
Edward Kraemer & Sons Inc.	1 Plainview Rd. Plain, WI 53577	Quarry and plant	Sauk.
Iron oxide pigments (finished):			
DCS Color & Supply Co. Inc.	2011 South Allis St. Milwaukee, WI 53207	Plant	Milwaukee.
Lime:			
CLM Corp.	Box 16807 Duluth, MN 55816	do.	Douglas.
Rockwell Lime Co.	4223 Rockwood Rd. Manitowoc, WI 54220	do.	Manitowoc.
Western Lime & Cement Co.	Box 57 West Bend, WI 53095	Plants	Brown and Fond du Lac.
Peat:			
Bogda's Top Soil & Excavating Co.	12600 West Cleveland Ave. New Berlin, WI 53151	Bog and plant	Waukesha.
Certified Peat & Sod Inc.	19000 West Lincoln Ave. New Berlin, WI 53151	do.	Do.
Liphatech Inc.	3101 West Custer Ave. Milwaukee, WI 53209	do.	Do.
Zellner Enterprises Inc.	North 8548 Highway M Algoma, WI 54201	Bog	Kewaunee.
Perlite (expanded):			
Midwest Perlite Co.	4280 Parkway Blvd. Appleton, WI 54915	Plant	Outagamie.
Sand and gravel:			
Construction:			
B. R. Amon & Sons Co.	Route 3 Elkhorn, WI 53121	Pits and plants	Various.
Janesville Sand & Gravel Co., Lycon Inc.	Box 427 Janesville, WI 53545	do.	Columbia, Dane, Rock.
Mann Bros. Inc.	Box 48 Elkhorn, WI 53121	do.	Dane, Kenosha, Racine, Rock, Walworth, Waukesha, Waushara.
Mathy Construction Co., Patterson Quarries Div.	Box 18 Onalaska, WI 54650	do.	Adams and Juneau.
Tews Co. Inc.	Box 64 Colgate, WI 53017	do.	Various.
Wissota Sand & Gravel Co.	Box 1268 Eau Claire, WI 54701	do.	Barron, Trempealeau, Washington.
Industrial:			
Badger Mining Corp.	Box 97 Fairwater, WI 53931	do.	Green Lake and Jackson.
A. F. Gelhar Co. Inc.	Box 209 Berlin, WI 54923	do.	Green Lake and Waupaca.
Unimin Corp.	258 Elm St. New Canaan, CT 06840	Pit and plant	Columbia.
Stone:			
Crushed:			
Granite:			
Roehl Granite Inc.	220 South Highway 107 Mosinee, WI 54445	Quarry and plant	Marathon.
Wimmer Granite & Supply Co.	1204 Starling Lane Wausau, WI 54401	Quarries and plant	Do.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone—Continued:			
Crushed—Continued:			
Limestone and dolomite:			
C. C. Linck Inc.	1226 North Center St. Beaver Dam, WI 53916	Quarries and plant	Various.
Mathy Construction Co., Patterson Quarries Div.	Box 18 Onalaska, WI 54650	Quarries and plants	Do.
Vulcan Materials Co., Midwest Div.	Box 6 Countryside, IL 60525	do.	Milwaukee, Racine, Waukesha, Winnebago.
Wilber Lime Products Inc.	544 East 6th St. Trempealeau, WI 54661	do.	Buffalo, Pepin, Trempealeau.
Sandstone and quartzite:			
Martin Marietta Aggregates, Central Div.	Box 30013 Raleigh, NC 27622	Quarry and plant	Sauk.
Minnesota Mining & Manufacturing Co.	3M Center St. Paul, MN 55101	do.	Marathon.
Traprock (basalt):			
Dresser Traprock Inc.	Box 517 Dresser, WI 54009	do.	Polk.
GAF Chemicals Corp.	Box 630 Pembine, WI 54156	do.	Marinette.
Dimension:			
Granite:			
Anderson Bros. & Johnson Co.	Box 26 Wausau, WI 54401	Quarries and plant	Marathon, Wausau, Marinette.
Cold Spring Granite Co.	202 South 3d Ave. Cold Spring, MN 56320	Quarry	Marathon.
Lake Wausau Granite Co.	Box 397 Wausau, WI 54401	Quarry and plant	Do.
Limestone and dolomite:			
Buechel Stone Corp.	West 3639 Highway H Chilton, WI 53014	Quarries and plant	Calumet and Fond du Lac.
Fond du Lac Stone Co. Inc.	Box 148 Fond du Lac, WI 54935	Quarry and plant	Fond du Lac.
R. & T. Quality Stone Inc.	Box 182 Lannon, WI 53046	do.	Waukesha.
Valders Stone & Marble Inc.	Box 35 Valders, WI 54245	Quarries and plant	Manitowoc.
Sulfur (recovered):			
Murphy Oil USA Inc.	Box 2066 Superior, WI 54880	Byproduct sulfur recovery plant	Douglas.
Vermiculite (exfoliated):			
Koos Inc.	4500 13th Court Kenosha, WI 53140	Plant	Kenosha.

THE MINERAL INDUSTRY OF WYOMING

This chapter has been prepared under a Memorandum of Understanding between the U.S. Bureau of Mines, U.S. Department of the Interior, and the Geological Survey of Wyoming for collecting information on all nonfuel minerals.

By Eileen K. Peterson,[1] W. D. Hausel,[2] and R. E. Harris[3]

In 1991, nonfuel mineral production in Wyoming was valued at $929 million, a 2% increase from that of 1990. Increases in the value for production of clays, cement, Grade-A helium, and lime barely offset decreases in the production value of gemstones, natural sodium carbonate (soda ash), sand and gravel, and stone. Clays, crushed stone, sand and gravel, and soda ash were the leading contributors to the State's nonfuel mineral production value. No metal production was reported.

Nonfuel minerals production came from 19 of the State's 23 counties. Sweetwater County was the leading county in terms of value, followed by Lincoln and Crook Counties.

Nationally, Wyoming ranked 11th in nonfuel mineral production value, accounting for more than 3% of the U.S. total. Wyoming continued to be the Nation's leading producer of bentonite clay and soda ash, the second largest producer of Grade-A helium, and ranked third for total clay produced.

In addition to nonfuel mineral production, Wyoming ranked first in the Nation in coal production and third in total coal reserves. In 1991, there was also production of petroleum, natural gas, methane, carbon dioxide, and uranium.

TRENDS AND DEVELOPMENTS

According to the Wyoming Department of Commerce, Economic & Community Development Division, the minerals industry in Wyoming continued to be the single largest contributor to the economy of Wyoming. The 1991 valuation on minerals produced represented 71% of the State's total assessed valuation, up from 62% in 1990.

Wyoming's five soda ash producers continued with plans to expand and modernize operations, and several other companies were looking at starting soda ash operations in the State. Although 1991 production of soda ash was down slightly from 1990 figures, producers expected a recovery in 1992 because of expanding markets for soda ash products.

In 1991, bentonite producers worked at diversifying markets away from a dependence on oil drilling muds. Wyoming producers have been operating at less than one-half of rated plant capacities since 1982 when oil and gas drilling declined dramatically. Production in 1991 was down from the slight recovery seen in 1990, but producers were hopeful of a recovery in 1992 based on expanding markets for bentonite for environmental uses.

Decreased spending for highway projects in Wyoming was cited as a reason for decreased production of sand and gravel. The Wyoming Department of Transportation projected spending in 1992 and 1993 would be less than that in 1991; however, late in 1991, the U.S. Congress passed a highway appropriations bill that included funding for highway projects in

TABLE 1
NONFUEL MINERAL PRODUCTION IN WYOMING[1]

Mineral		1989		1990		1991	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	metric tons	2,166,497	$74,697	2,523,573	$76,082	2,496,361	$81,573
Gemstones		NA	157	NA	151	NA	61
Lime	thousand short tons	W	W	W	W	37	2,729
Sand and gravel (construction)	do.	e4,500	e15,400	4,329	14,446	e3,500	e11,900
Stone (crushed)	do.	2,990	12,120	e2,200	e14,000	2,946	12,645
Combined value of cement [masonry (1989-90), portland], clays (common), gypsum (crude), helium (Grade-A), soda ash, and values indicated by symbol W		XX	724,987	XX	806,169	XX	820,268
Total		XX	827,361	XX	910,848	XX	929,176

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; kind and value included with "Combined value" figure.

Wyoming. Production of construction aggregate is expected to closely reflect trends in highway construction.

Dimension stone production in Wyoming was boosted with the quarrying of black granite blocks in Albany County and rough quarried slabs of brown marble in Washakie County. A study completed by the Geological Survey of Wyoming (GSW) on decorative stone in Wyoming is expected to increase interest in decorative and dimension stones in the future.

EMPLOYMENT

Mining employment in Wyoming continued to be an important sector of the total employment in the State, accounting for about 8% of total nonagricultural employment and salaries. Statewide, nonfuel mining employment climbed to about 4,400. Coal mines employed about 4,660 people in 1991 with a total annual payroll topping $200 million. Oil and gas extraction accounted for about 9,300 employees. The Research & Planning Division of the Wyoming Department of Employment reported average weekly earnings in mining in July were $693.64, up almost 3% from July 1990. U.S. average mining earnings in July of 1991 were $618.25, while U.S. Department of Labor statistics indicated the average annual mining pay in Wyoming rose to $38,841 in 1991, up 3.8% from that of 1990, and average weekly hours worked was 45.1, down slightly from that of 1990. Average annual pay for all State employment sectors in 1991 was $20,049.

According to the U.S. Department of Labor, injuries reported from Wyoming nonfuel surface and undeground mines totaled 149 injuries resulting in lost workdays and 110 injuries with no lost workdays during almost 8 million employee-hours worked. Coal mines reported 55 injuries with lost work days and 83 injuries with no work days lost during 8.7 million employee-hours worked. During the 4.3 million employee-hours worked at all surface mills and preparation plants, one fatality was reported. An additional 93 injuries occurred to workers resulting in lost workdays and 67 injuries occurred with no workdays lost.

REGULATORY ISSUES

Late in the year, a Fremont County District Court judge ordered the owner of the abandoned Atlantic City Iron Ore Mine to post a $4 million bond for reclamation work at the site. Universal Equipment Co., of Ohio, purchased the mine site and buildings from U.S. Steel in 1985. Universal has been fighting an order to demolish or remove all buildings from the site, hoping to find a use or a buyer for the mill buildings. Universal is a defendant in a lawsuit over payment for services rendered by consultants and equipment companies to Universal for reclamation work already completed at the site. The company reportedly has spent about $2 million for reclamation at the mine site.

Earlier in the year, a Ninth Judicial District judge issued a decision making the State of Wyoming responsible for reclamation of about 230 hectares (570 acres) of the 283 hectares (700 acres) not yet reclaimed at the Atlantic City Iron Ore Mine. Funds from the Abandoned Mine Lands (AML) program will be used for the reclamation; costs are expected to run from $2 million to $2.5 million. The same court decision declared Universal was responsible for reclaiming the remaining 55 hectares (136 acres) at the site. Approximately 50% of the 566-hectare (1,400-acre) mine site has been reclaimed by Universal.

A proposal to reclaim a placer gold property on Rock Creek, south of the Atlantic City mine, included a plan to use spoil piles from the placer operation as cover material at the Atlantic City mine. Nugget Exploration Co. has control of the surface rights at the Rock Creek site and has proposed to give the site to the State for use as a public recreation area once reclamation is completed. Reclamation at the placer site would also be completed with AML funds. The Wyoming Environmental Quality Council endorsed the "concept" of the plan.

EXPLORATION ACTIVITIES

Exploration for precious metals and industrial minerals was reported throughout the State in 1991. Major areas of interest included the Bear Lodge Mountains, Hartville Uplift, Arlington and Cooper Hill areas in the Medicine Bow Mountains, Encampment district of the Sierra Madre Mountains, the greenstone belt in the Seminoe Mountains, Rattlesnake Hills in the Granite Mountains, the South Pass region of the Wind River Range, and the Kirwin and Sunlight Basin areas of the Absaroka Mountains.

During 1991, GSW conducted exploration in southern Wyoming on a number of atypical geological environments for gold and other metals under a $20,000 grant provided by Union Pacific Resources. Environments examined included gold, copper, lead, and silver mineralization in the Cooper Hill mining district. Gold also was looked for in titaniferous sandstone in the Rock Springs Uplift, in a large silicified alunite zone south of Rock Springs, and in numerous sand and gravel deposits in southern Wyoming. Coal and clinker deposits in the Rock Springs area and coal deposits near Walcott Junction also were examined for gold.

The GSW also continued exploration for diamonds under a grant from the University of Wyoming's Mining and Mineral Resource Research Institute (the Institute is funded in part by the U.S. Bureau of Mines). The investigations identified more than 100 heavy-mineral anomalies in the Laramie Mountains of southeastern Wyoming. GSW also explored for diamonds in lamproites in the Leucite Hills near Rock Springs, southwestern Wyoming. GSW reports have apparently attracted exploration activity by diamond exploration firms. A major international diamond mining company reportedly explored both the Bighorn and Gros Ventre Mountains, in north-central and west-central Wyoming, respectively.

Exploration work by CoCa Mines Inc. in the Bear Lodge Mountains,

northeastern Wyoming, resulted in a revised gold resources estimate for the Sundance property. Estimated resources were placed at 7.4 million metric tons (8.2 million short tons) of ore averaging 0.56 gram per metric ton (0.02 troy ounce per short ton). Metallurgical testing on the ore reportedly showed only a 70% gold recovery.

A claim-staking rush in the Hartville Uplift, eastern Wyoming, saw at least four mining companies competing for claims. The area of interest, south of Lusk, was being explored for massive sulfide deposits of zinc as well as gold and other precious metals. The Hartville Uplift was initially mined for copper and yielded at least 711,245 kilograms (1.57 million pounds) of copper and 70.9 kilograms (2,280 troy ounces) of silver. Iron ore was produced in the area from 1898 until the last iron mine closed in 1981. At least 40.8 million metric tons (45 million short tons) of hematite ore was recovered from the uplift area.

More than one company conducted extensive exploration work for copper, gold, silver, and zinc in the Encampment district of the southern Sierra Madre Mountains, along the southern border of Wyoming. Geochemical sampling and aerial magnetic surveys were conducted. Exploration work by GSW found both primary and secondary copper minerals south of Encampment.

Goldstake Exploration Inc. and Sawatch Gold Placers continued gold exploration work on their property in the South Pass greenstone belt. The joint venture did exploration drilling on previously untested paleoplacer deposits south of Atlantic City. The 10.5-kilometer-long (6.5-mile-long) placer deposit ranges from 12 to 21 meters (40 to 70 feet) in depth and may contain more than 31,100 kilograms (1 million troy ounces) of gold.

In the Kirwin and Sunlight Basin areas in the Absaroka Mountains of northern Wyoming, several companies have been exploring for gold and copper. These areas are south of the planned New World gold mine in Montana. Crown Butte Mines (a subsidiary of Noranda Exploration) reportedly has an estimated 68,420 kilograms (2.2 million troy ounces) of gold at the New World property, about 4.8 kilometers (3 miles) north of the Wyoming border. The Kirwin area was explored by AMAX Inc. for several years. AMAX identified a geologic reserve of 178 million metric tons (196 million short tons) averaging 0.505% copper in a porphyry with additional credits in molybdenum, lead, zinc, silver, and gold. The Kirwin property was recently donated to the U.S. Forest Service by the Mellon Foundation. The property has been taken into acquired land status and could possibly be leased for exploration in the future.

Several companies continued exploration activities for decorative and dimension stone sites in the State. A report prepared by GSW, with the financial assistance of the Wyoming Department of Commerce, Economic & Community Development Division, on decorative stone occurrences in the State generated much interest in Wyoming stone deposits. The report, "Decorative Stones of Wyoming," contains full color pictures and descriptions of 64 potential decorative stones and 16 examples of decorative aggregates in the State.

BWAB Inc., a Colorado company, received the necessary U.S. Bureau of Land Management (BLM) permits to conduct test drilling for black trona water in southwestern Wyoming. Black trona water is ground water containing organic materials and saturated with trona. If exploration is successful, the company plans to produce soda ash from trona recovered from the black trona water. They also may produce organic-based fungicides, pesticides, and pigments from byproducts.

LEGISLATION AND GOVERNMENT PROGRAMS

During the 1991 session, the Wyoming Legislature extended the 2% severance tax break for the uranium industry for 2 more years. Production in the State did not improve following passage of the extension.

The Wyoming 1991 legislature failed to pass a bill that would have tightened requirements associated with the mining permit exemption given to 4-hectare (10-acre) mining operations. The proposed legislation also would have increased bonding requirements for small operators. It is expected that similar legislation will be proposed during the 1992 legislative secession.

The State legislature also failed to pass legislation that would have redistributed mineral tax revenues equally among all Wyoming counties. Distribution of mineral tax revenues will continue to be based on the proportion of mineral taxes collected for minerals produced in each county.

After 6 months of negotiations between the State and bentonite producers, the Wyoming Board of Land Commissioners approved a plan for determining bentonite royalties on State lands. Royalties will be determined by calculating the average sale prices for bentonite products instead of on volumes of bentonite removed. The new royalty rate will start at 49.90 cents per metric ton (55 cents per short ton) for sale prices of $13.61 to $19.04 per metric ton ($15 to $20.99 per short ton) and increase with increasing sales prices for processed bentonite.

The Wyoming Legislative Joint Revenue Committee monitored the impact from changes in the law on captive coal mines coal valuation formulas. The new method of calculating coal taxes reportedly cost the State about $20 million in 1990. Late in 1991, the Governor recommended that the 1.5% capital facilities tax on coal and trona be extended. The tax is scheduled to end on June 30, 1992.

Following passage of the Wyoming 1990 mineral tax reform law on valuation of minerals, State officials worked on new rules for determining mineral valuation rates. The new valuation methods would affect bentonite, coal, sand and gravel, uranium, and other solid minerals.

In April, seven counties and the State were named in a lawsuit filed by Union Pacific Resources Co. concerning taxation of minerals in Wyoming. Major issues

were independent audits of oil and mineral companies by independent auditors hired by counties or the State and the statute of limitations on the audits. Currently, there is no statute of limitations for mineral audits in Wyoming. The 1991 Wyoming Legislature passed and the Governor signed a bill that would, on March 1, 1994, place a 5-year statute of limitation of audits and would require audits to be completed within 2 years, except in cases of gross negligence by the taxpayer. The State law, however, would not apply to audits commissioned by counties.

A Wyoming Supreme Court decision issued in 1991 required repayment of $2.8 million in sales taxes collected on the 1986 sale of a soda ash mine in Sweetwater County. The State and municipalities in Sweetwater County each had received one-half of the $2.8 million. The court decision declared that excessive sales tax collections were made related to the sale of the mine and plant. Allied-Signal Inc. sold the operation to General Chemical Co. and paid the $2.8 million in sales taxes for the 1986 sale under protest.

GSW completed work on the 6-year study of the South Pass greenstone belt and published its report, "Economic Geology of the South Pass Granite-Greenstone Belt, Southern Wind River Mountains, Western Wyoming." The report identified several arsenic, chromium, copper, gold, silver, tin, and tungsten anomalies. Gold values as high as 28 to 85 grams per metric ton (1 to 3 ounces per short ton) were found in channel and chip samples. A copper-silver stockwork and a hidden auriferous shear zone were identified as well as broad zones of low-grade gold mineralization. The report concluded that the South Pass area contained several small, high-grade gold deposits; some large, low-grade gold deposits; extensive banded iron deposits; small gold placers; and some giant low-grade gold paleoplacers.

GSW also published updated maps of coal and oil and gas resources in Wyoming. Open-file reports were completed on the Seminoe Mountains iron and gold mining district and carbon dioxide resources in the State. A public information circular, "Decorative Stones of Wyoming," was published, and several companies started exploration and development programs on decorative stone deposits described in the publication.

In mid-January, the Wyoming BLM office reported the office had recommended more than 97,000 hectares (240,091 acres) for wilderness designation in the State. BLM also found 136,440 hectares (337,140 acres) of the 7.4 million hectares (18.4 million acres) of land it manages in Wyoming nonsuitable for wilderness designation. The findings angered citizens on both sides of the wilderness issue.

The Forest Service withdrew about 8,756 hectares (21,636 acres) in the Snowy Range, southeastern Wyoming, from further mineral development. The order does not affect valid existing rights and only applies to minerals that are "locatable" under the Mining Law of 1872. GSW investigations suggest the area may contain "Witwatersrand type" and shear zone gold deposits. Significant gold anomalies and decorative stone occurrences were identified by GSW and the Forest Service in the area slated for withdrawal. In western Wyoming, the Forest Service was considering the possibility of restricting access to the Lake Alice district in the Overthrust Belt. A 1986 GSW report identified a large, red-bed, copper-silver-zinc-lead deposit of potentially large tonnage in the district, possibly a 90.7-million-metric-ton (100-million-short-ton) resource of copper and silver.

The U.S. Bureau of Mines participated in an interagency examination of the Greater Yellowstone Area (GYA), a 4.7-million-hectare (11.7-million-acre) area contiguous to Yellowstone National Park. Mineral examinations of the Shoshone and Bridger/Teton National Forests were started in late 1991. Both forests are within the GYA study area.

During the summer of 1991, the Wyoming Department of Environmental Quality, through its AML program, issued a $488,888 contract for capping about 70,000 exploration drill holes in the Red Desert and Gas Hills in Fremont and adjacent counties.

An allotment grant of $148,000 from the U.S. Bureau of Mines was received by the Mining and Mineral Resources Research Institute at the University of Wyoming in Laramie under provisions of Public Laws 98-409 and 100-483. The purpose of the institute is to coordinate and administer training and research in mining, mineral resources, minerals development, and mineral processing.

Wyoming received $196 million in Federal royalties in 1991 for minerals produced on Federal lands within the State borders. The money represented the State's share of bonuses, rents, and royalties collected by the U.S. Department of the Interior's Minerals Management Service (MMS). Approximately 48% of the land area in Wyoming is public land. In June, the U.S. House of Representatives removed a provision from the House Interior spending bill that would have cost Wyoming about $27 million in Federal mineral royalties in 1992. The pending legislation would have required States to pay 50% of the administrative cost of MMS's royalty collection program. In 1991, States paid 25% of the administration costs.

Wyoming mineral severance tax collections for 1991 amounted to $265 million and an additional $273 million was collected in 1991 for production in previous years. Sales and use taxes on minerals generated another $21 million for the State during the year. The Wyoming Department of Commerce, 1991 Wyoming Mineral and Energy Yearbook, showed the total mineral income to the State for 1991 to be more than $821 million.

FUELS

Wyoming was the Nation's leading coal producer in 1991 with a historic high production rate of 175.9 million metric tons (193.9 million short tons), about 20% of the Nation's total production. Coal was produced in seven counties; about 85% came from Campbell County

with Sweetwater and Converse Counties being the other major production centers. About 87% of the coal was shipped out of the State. Wyoming coal was used in 32 States and 4 foreign countries, primarily for power generation. Eight of the 10 largest producing surface coal mines in the Nation are in Wyoming. Only 4 of the State's 32 coal mines are underground operations.

Wyoming has 63 billion metric tons (69.5 billion short tons) of proven coal reserves, 24.5 billion metric tons (27 billion short tons) of which can be surface mined. About 13.6 billion metric tons (15 billion short tons) is "compliance coal," meeting the Clean Air Act mandate of 0.54 kilogram (1.2 pounds) of sulfur dioxide per million British thermal unit (Btu). At current production rates, Wyoming miners can produce "compliance coal" from surface operations for another 77 years.

Cordero Mining Co., a subsidiary of Sun Co. Inc., was awarded a $17.1 million Federal grant to develop a clean "synfuels" process designed to reduce pollution emissions from powerplants. The demonstration plant will be designed to produce about 226,800 metric tons (250,000 short tons) of dried coal per year from coal supplied by the company's Cordero Mine, about 35 kilometers (22 miles) southeast of Gillette, Campbell County. The upgraded coal can be burned at powerplants designed to burn higher Btu coals than Wyoming coal and still be a lower sulfur coal than most eastern coals. The Cordero project is the second Wyoming synfuel project to receive Federal funding under the Clean Air Program. The first was the En-Coal project, now under construction at the Buckskin Mine north of Gillette.

FMC Corp.'s Kemmerer Coke Plant is the world's largest commercial form (briquette) coke plant and, in 1991, it operated 24 hours per day to produce 108,860 metric tons (120,000 short tons) annually. The coke plant used coal produced at FMC's nearby Skull Point Mine and supplied coke to FMC's Phosphorus Chemicals Div. Plant near Pocatello, ID.

About 100 million barrels of oil, 24 billion cubic meters (860 billion cubic feet) of natural gas, and 3.7 billion cubic meters (131 billion cubic feet) of carbon dioxide were produced in the State in 1991. Oil and gas well completions in 1991 were down about 20% from those in 1990, with a total of 566 wells completed and a 60% success rate.

Uranium production in Wyoming is limited to surface operations in the Shirley Basin, northern Carbon County, by Pathfinder Mines, a subsidiary of French-owned COGEMA, Inc., and in situ solution mining from the Highland property and adjoining areas in the southern Powder River Basin by Power Resources, wholly owned by Nuclear Electric Ltd., a British company.

The Pathfinder Mine and mill were closed during part of 1990 while a new ore body was uncovered; the mine and mill were fully operational in 1991.

Power Resources produced yellowcake from the Highland Mine area in Converse County and recently constructed a new solution mining field at the site of the North Morton Ranch deposit, northwest of the Highland deposit. In May, Power Resources purchased property with proven uranium resources in the Gas Hills, in southeastern Fremont County.

Rio Algom, a Canadian company, was testing solution mining possibilities at the Bill Smith property in the southern Powder River Basin.

U.S. Energy-Crested Corp. (USE-CC) announced plans to purchase the Sweetwater uranium mill in the Red Desert area of eastern Sweetwater County from Union Minerals. The mill, Wyoming's largest in 1982, closed in 1983. USE-CC proposed to use the mill for processing uranium from the proposed underground uranium mines near Green Mountain, south of Jeffrey City, Fremont County.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Mountain Cement Co. produced cement at a plant south of Laramie, Albany County. Major ingredients in the cement were limestone, gypsum, and silicic shale. Iron ore is used in certain types of cement produced at the plant. Tailings from an abandoned titaniferous magnetite mine at Iron Mountain, Laramie County, have been used in the cement in the past. Because of the titanium in the iron ore, the plant is now using mill fines from an abandoned steel plant at Pueblo, CO. Ironically, most of the Colorado mill fines originally came from the Sunrise Mine near Hartville, Platte County, Wyoming.

Clays.—Wyoming continued to rank first in the Nation in bentonite production. Because of a steep decline in domestic oil well drilling in the 1980's, production of bentonite in the State fell from almost 4.5 million metric tons (5 million short tons) in 1981 to less that 1.8 million metric tons (2 million short tons) in 1986. Since 1986, bentonite production has recovered slowly, with new uses for the clay taking up more of the production tonnage. In 1991, slightly less than 2.5 million metric tons (2.75 million short tons) of bentonite was produced, down about 1% from that in 1990. The value of production, however, rose about 7%. Unit values for the bentonite ranged from $24.44 to $31.13 per metric ton ($26.94 to $36.52 per short ton); average unit value was $26.89 per metric ton ($29.64 per short ton).

Bentonite was produced by five companies in seven counties. American Colloid Co. was the State's largest producer; other producers included Baroid Drilling Fluids Inc. (a subsidiary of NL Industries), Black Hills Bentonite, M-I Drilling Fluids Inc., and Wyo-Ben Inc. Most of the bentonite production came from Crook, Big Horn, Weston, and Johnson Counties; other counties

where bentonite was mined included Hot Springs, Natrona, and Washakie.

Bentonite is now finding more use in barriers to isolate wastes, in containment structures, and as cleaning and adsorbing agents for industrial chemicals. In 1991, major uses of Wyoming bentonite were as pet waste absorbent, drilling mud, pelletizing iron ore, in foundry sand, and as a waterproof sealant.

Common clay was mined in Albany and Uinta Counties for use in cement and brick manufacturing, respectively. Mountain Cement produced clay in Albany County for use at its cement plant near Laramie and Interstate Brick Co. produced clay in Uinta County.

Gemstones.—The value of gemstone production fell about 60% from the 1990 value. Gemstones collected in Wyoming include nephrite (commonly called Wyoming jade), diamonds, peridot, sapphire, and some rubies and aquamarine. A recent GSW report on diamonds reported that more than 100,000 diamonds have been recovered from the Colorado-Wyoming State Line district, ranging in size from microdiamonds to 2.4 carats.

Gypsum.—Both Celotex Corp., at Cody, and Georgia-Pacific Corp., south of Lovell, operated their gypsum mines at near capacity in 1991. The gypsum produced at the mines was pressed into wallboard at nearby plants operated by the two companies. Mountain Cement mined gypsum south of Laramie for use in the manufacture of cement at the company's Laramie cement plant.

Helium (Grade-A).—Exxon Co. U.S.A. has produced helium in Wyoming since 1986. Helium was extracted from natural gas produced at Shute Creek in the Riley Ridge gasfield, Lincoln County. Wyoming continued to be the Nation's second largest producer of Grade-A helium with an increase in production of more than 10% from 1990 to 1991. Helium has been Wyoming's third most important nonfuel mineral commodity, in terms of value, since 1987.

Leonardite.—Black Hills Lignite, a division of Black Hills Bentonite, produced leonardite near Glenrock, Converse County, and refined it at Casper, Natrona County, for use in drilling fluids and wood stains. Leonardite is produced by the oxidation of coal or lignite.

Greenbelt Earth Sciences Inc., a Texas company, explored for and found a source of leonardite in the State and established a processing and packaging facility in Casper. Greenbelt plans to sell the leonardite as a soil conditioner-fertilizer.

Lime.—Early in 1991, Wyoming Lime Producers, a division of Dakota Coal Co. (a subsidiary of Basin Electric Power Cooperative) was looking at several locations in Wyoming for a site to locate a lime plant. By yearend, Wyoming Lime Producers and Basin Electric had decided to build Wyoming's first lime plant in many years at Frannie, in Park County. The $9 million facility will use up to 272,160 metric tons (300,000 short tons) of limestone and about 31,750 metric tons (35,000 short tons) of coal to produce from 54,430 to 63,500 metric tons (60,000 to 70,000 short tons) of lime annually at a rate of 363 metric tons (400 short tons) per day. Pete Lien & Sons Inc., of South Dakota, will operate the plant. Initially, limestone from the Montana Limestone Quarry in Montana, about 18 kilometers (11 miles) north of Frannie, will supply the lime plant. Plans call for a limestone quarry east of the plant site, in Wyoming, sometime in the future. Basin Electric will use lime produced at the Frannie plant as a reagent to remove sulfur dioxide from exhaust gases at the company's coal-fired powerplants in Wyoming and North Dakota. The lime plant was expected to be operating in late 1992 or early 1993.

Pete Lien & Sons examined two proposed limestone quarry sites near Laramie, Albany County. The company had proposed to build a lime plant in the area and wanted a close source of limestone. Both quarry locations were protested by environmental and citizen groups. At yearend, all plans were on hold pending development of a market for the finished product.

Perlite (Expanded).—The Harborlite perlite plant west of Green River in Sweetwater County expanded perlite mined in Arizona. The product was sold to soda ash plants in the county for use as a filter aid. Planned expansions at the soda ash mines were expected to be reflected in increased expanded perlite production in coming years.

Phosphate.—Although no phosphate was mined in Wyoming, it was slurried into the State from Chevron Chemical Co.'s mine in Utah for use at the company's fertilizer plant at Rock Springs, Sweetwater County. During the year, Chevron Chemical announced plans to sell its Utah phosphate mine, a 154-kilometer-long (96-mile-long) slurry pipeline, and the fertilizer plant at Rock Springs to a joint venture between J.R. Simplot Co. of Boise, ID, and Farmland Industries of Kansas City, MO.

The Rock Springs fertilizer plant produced phosphoric acid and diammonium phosphate from phosphate mined in Utah and sulfur recovered from natural gas produced in western Wyoming. The plant employed about 190 people and produced from 317,520 to 362,880 metric tons (350,000 to 400,000 short tons) of fertilizer annually.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1990 and estimates for 1989 and 1991.

Estimated sand and gravel production for 1991 decreased about 17% from surveyed production data for 1990, and value fell about 19%. Sand and gravel was produced in 22 of the State's 23 counties; Fremont, Johnson, Laramie, Natrona, and Washakie were the leading counties.

At yearend, Rocky Mountain Pre-Mix Concrete of Lander was waiting for Wyoming Department of Environmental Quality approval to expand an existing sand and gravel pit near Riverton, Fremont County. The proposed expansion drew environmental and public objections because of the proximity to the 1838 Rendezvous Site for trappers near the confluence of the Big Wind and Little Wind Rivers. The Riverton City Council approved a conditional use permit for the expansion late in the year.

In Park County, the Board of Commissioners denied a land use change that would have allowed expansion of the Park County Materials sand and gravel pit north of Cody. The board cited the owners inability to maintain acceptable environmental conditions at the site as the primary reason for denying the zoning change.

The U.S. Bureau of Reclamation and Midvale Irrigation District may end up paying the Shoshone and Arapaho Indian tribes more than $1 million for sand and gravel taken out of the Midvale district since 1973. Court cases in 1983 and 1990 led to the determination that sand and gravel are minerals, and although the irrigation project is on reclamation or withdrawn land, the minerals were reserved to the tribes of the Wind River Indian Reservation. As such, the tribes are owed money for sand and gravel removed from the land. About 413,340 cubic meters (540,600 cubic yards) of sand and gravel has been removed since 1973.

Because the Wind River Indian Reservation Tribes have placed a moratorium on renewing previous gravel leases and opening new pits on the reservation, Fremont County was experiencing a lack of adequate supplies of sand and gravel in some portions of the county. The tribes were charging $0.74 per cubic meter ($1 per cubic yard) for gravel, nearly double the local market value. The county was investigating alternate sources of sand and gravel, including the possibility of obtaining sand from the Atlantic City iron mine for use on icy streets during the winter.

A study by GSW indicated some sand and gravel deposits in southern Wyoming may contain sufficient quantities of gold to recover as a byproduct. To date, no operators have taken advantage of the possible gold credit.

Sodium Carbonate.—Wyoming continued to lead the Nation in soda ash production from the world's largest known resource of trona, a natural sodium carbonate-bicarbonate. Trona mined in Wyoming was used to produce soda ash, caustic soda, sodium sulfite, sodium bicarbonate, sodium cyanide, and calcined trona. All trona production comes from the Green River Trona District in the southwestern part of the State. Five of the Nation's six major mines and soda ash processing facilities are located within a few miles of Green River in Sweetwater County.

In 1991, soda ash production fell about 3% from 1990 figures. The decrease was attributed to falling exports of soda ash to China, formerly a major export market.

Despite a 13-day labor strike, FMC mined its 90.7-millionth metric ton (100 million short tons) of trona in May. The mine, the largest producer and oldest trona mine in Wyoming, has been operating since 1948. FMC's 58,970-metric-ton-per-year (65,000-short-ton-per-year) caustic soda plant, the first in the Green River Basin, and its 54,430-metric-ton-per-year (60,000-short-ton-per-year) sodium bicarbonate plant and 27,200-metric-ton-per-year (30,000-short-ton-per-year) sodium cyanide plant began operating in 1990 and were fully operational in 1991.

General Chemical Co., the State's second largest producer of soda ash, produced soda ash primarily for Church & Dwight Co. for its line of Arm and Hammer products.

Rhône-Poulenc of Wyoming Co., a joint venture of Rhône-Poulenc Basic Chemicals Co. and Union Pacific Resources Co., has been conducting safety training for all employees and streamlining operations.

Tenneco Minerals Co. dedicated its 68,000-metric-ton-per-year (75,000-short-ton-per-year) caustic soda plant and 45,360-metric-ton-per-year (50,000-short-ton-per-year) sodium sulfite plant. Caustic soda is used in the pulp and paper industries, chemical manufacturing, and other industrial applications. Sodium sulfite is used in pulp processing, for water treatment in boilers, and as a scrubbing agent in textile manufacturing. The company was also in the process of expanding capacity for an additional 544,320 metric tons per year (600,000 short tons per year) of soda ash production. The soda ash production expansion project, scheduled for completion in 1992, was a joint-venture project with Asahi Glass of Tokyo. Tenneco also was trying to sell 907,000 metric tons (1 million short tons) of relatively raw "calcined" trona for caustic soda production.

Tg Soda Ash Operations (a subsidiary of Societe National Elf Aquitaine Inc., a French company) set new sales and production records in 1991. According to company annual reports, production was up about 1% from that of 1990 and productivity rose 5% from the previous productivity record set in 1987. The shortwall used to mine the trona was shut down at midyear because of unfavorable geologic conditions for the miner. Late in the year, the shortwall miner was back in production and set a new monthly average production record.

In May, Tg Soda Ash announced plans for a 136,000-metric-ton-per-year (150,000-short-ton-per-year) chemical caustic soda plant near Granger. The plant will be a joint-venture project with ATOCHEM North America Inc. (also a subsidiary of Societe National Elf Aquitaine Inc.). Tg will not mine additional trona to supply the plant but will extract trona remaining in solution from other company-owned processing plants in the area that would normally be deposited in tailings ponds.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimated data for 1990 and actual data for 1989 and 1991.

TABLE 2
WYOMING: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1991, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value	Unit value
Coarse aggregate (+1 inch): Riprap and jetty stone	51	292	$5.73
Coarse aggregate, graded[2]	1,360	6,503	4.78
Fine aggregate (-3/8 inch): Stone sand, bituminous mix or seal	W	W	4.88
Coarse and fine aggregate:			
Graded road base or subbase	149	427	2.87
Unpaved road surfacing	50	50	1.00
Other construction materials[3]	824	3,977	4.83
Agricultural: Poultry grit and mineral food	W	W	4.85
Unspecified:[4]			
Actual	510	1,397	2.74
Total[5]	2,946	12,645	4.29

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."
[1]Includes dolomite, granite, limestone, marble, miscellaneous stone, quartzite, traprock, and volcanic cinder and scoria.
[2]Includes concrete aggregate, coarse, bituminous aggregate, coarse, and surface-treatment aggregate, and railroad ballast.
[3]Includes terrazzo and exposed aggregate and crusher run or fill or waste.
[4]Includes production reported without a breakdown by use and estimates for nonrespondents.
[5]Data may not add to totals shown because of independent rounding.

Crushed.—Although the quantity of crushed stone produced dropped slightly, the value increased by almost 27% from that surveyed in 1989. Production primarily came from Albany, Laramie, and Platte Counties. Major producers were Meridian Aggregate Co., Centex Corp., Peter Kiewit & Sons, and Frost Construction Co. Most of the crushed rock produced was granite, followed by limestone and quartzite.

Meridian Minerals, a division of Burlington Northern Inc., operated a railroad ballast quarry west of Cheyenne, Laramie County. During the year, the quarry was sold to Meridian Aggregates, a joint venture between Meridian Minerals and a private individual. Ballast from the quarry was sold to the Burlington Northern Railroad and Union Pacific Railroad, and construction aggregate was sold locally. Some rock was being shipped to Colorado for use at the new Denver International Airport, now under construction.

Lamb Construction of Torrington, Goshen County, reopened the Bald Butte ballast quarry south of Lusk, Niobrara County. Ballast was sold to Chicago North Western Transportation Co. to upgrade a portion of its trackage in the area.

Georgia Marble operated a marble aggregate quarry west of Wheatland and processed white marble at a plant in Wheatland, Platte County. The aggregate was used for roofing granules, landscape rock, coloring agents, and as aggregate for white, precast, concrete products. Georgia Marble has developed a new product line at its coloring shop where several colors of aggregate were produced by dying the white marble.

Wyoming Red Rock, of Gillette, produced and sold decorative aggregate, including red clinker and green serpentine. Most of the aggregate was used for landscaping.

Bessemer Mountain area residents failed in their attempt to stop issuance of a 4-hectare (10-acre) mining permit for a limestone quarry on Bessemer Mountain. The Eighth Judicial District Court ruled that Rissler and McMurry Co. could proceed with opening the quarry. Under Wyoming's eminent domain statutes, the company has been allowed to condemn private lands for "roads or mine haul truck roads required in the course of their business." The controversial quarry is located on State land southwest of Laramie. State law exempts mining operations affecting less than 4 hectares (10 acres), including the proposed Bessemer Mountain quarry, from the Department of Environmental Quality's normal land quality permitting process.

Late in the year, Rissler and McMurry offered to sell a scenic easement of outcrops of limestone visible from a State highway and relinquish its mining permit on a small portion of its 259-hectare (640-acre) limestone mining lease. The company has a mining permit for only 4 hectares within the 259-hectare lease area. At yearend, the State had not determined how much area might be included in a scenic easement nor what value would be placed on the acreage.

Due in part to public protests about the Bessemer Mountain quarry, the Wyoming Board of Land Commissioners adopted a measure that would ensure they are notified in the future of applications for State sand and gravel, or limestone, mining leases near residential areas.

Rissler and McMurry had proposed a quarry site near Jackson Canyon to replace the controversial quarry on Bessemer Mountain. The proposed Jackson Canyon site was rejected by BLM because of its proximity to an Area of Critical Environmental Concern.

The U.S. Army Corps of Engineers tried to find a replacement quarry site to provide stone needed for future repairs of the Snake River levee system. The Corps' current quarry was expected to be exhausted of good quality stone in the near future. Proposed quarry locations within the Bridger-Teton National Forest have been protested because they are in environmentally sensitive areas. No replacement quarry site had been identified by yearend.

Dimension.—As a result of extensive work and promotion by GSW, several companies were exploring for dimension stone in Wyoming during 1991.

About midyear, Sunrise Stone cut its first block of black granite (amphibolite) from the Kennedy Ranch quarry in northern Albany County. Sunrise quarried 1.5- by 1.5- by 3-meter (5- by

TABLE 3
WYOMING: CRUSHED STONE SOLD OR USED BY, BY KIND

Kind	1989				1991			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	10	1,371	$5,643	$4.12	8	514	$1,402	$2.73
Dolomite	1	W	W	3.81	1	W	W	3.82
Marble	1	61	261	4.28	1	W	W	4.44
Granite	1	W	W	4.62	1	W	W	4.85
Traprock	—	—	—	—	1	W	W	3.63
Quartzite	—	—	—	—	1	W	W	5.71
Volcanic cinder and scoria	7	293	W	W	1	W	W	5.68
Miscellaneous stone	1	28	91	3.25	4	W	W	2.69
Total[1]	XX	2,990	12,120	4.05	XX	2,946	12,645	4.29

W Withheld to avoid disclosing company proprietary data, included in "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

5- by 10-foot) blocks of granite for shipment to a stone-cutting plant in Arkansas to be cut into slabs for decorative facing. By yearend, the company had a permanent crew cutting stone at the quarry. The black granite, marketed as "Wyoming Raven," was reportedly the blackest stone produced in the United States at the present time. Sunrise supplied domestic, European, and Japanese markets.

Rustic West Stone Co. of Powell, Park County, quarried and sold thin, rough-quarried slabs of brown marble from a quarry near Ten Sleep, Washakie County. The slabs were suitable for interior or exterior walls, flooring, and other decorative uses. The stone was marketed throughout the United States but primarily in the New York City area. Rustic West Stone also tested brown, pink, and yellow marble from other localities in Washakie County.

Sulfur.—In Wyoming, all sulfur production was as a byproduct of natural gas and petroleum processing. Six companies produced sulfur in seven southwestern Wyoming counties. Amoco Production Co., Chevron U.S.A. Inc., and Exxon Co. U.S.A. were the largest producers.

Zeolites.—U.S. Zeolite, in partnership with Colorado Lien, tested their clinoptilolite deposit near Fort LaClede, in Sweetwater County. Zeolites act as molecular sieves and can remove selected ions, including toxic ions, from water. The Wyoming Department of Commerce's Division of Economic and Community Development was financially assisting the research and testing of clinoptilolite.

Other Industrial Minerals.—In late 1991, a private company and GSW sent samples of iron oxides, colored clay, and colored marble to Swansea Minerals, in Arizona, for testing as mineral pigments. Georgia Marble sold finely ground white marble from its quarry for use as pigment. During past years, Red Dog Minerals shipped small amounts of iron oxide pigment from the former Sunrise iron mine near Hartville. When CF&I Steel Co., the former owner of the mine, forfeited its bond and abandoned the Sunrise property, shipments of pigment were stopped, and there were no plans to resume shipments until ownership of the mine was established. Farmer's Union Insurance of San Diego, CA, is the present titleholder for the mine and has inquired of the Wyoming Department of Environmental Quality if complete removal of all structures and mine workings is necessary for reclamation. It seemed unlikely that any mining would take place at this site in the future.

Metals

Gyorvay Mining Co. received a State permit to operate the Mary Ellen gold mine at South Pass. The mine was originally developed in the South Pass-Atlantic City district about the turn of the century. Historic reports indicate the quartz vein, on which the mine is located, averaged 11 grams of gold per metric ton (0.4 troy ounce of gold per short ton) and may have produced as much as 194 kilograms (6,250 troy ounces) of gold prior to 1911.

Late in the year, it was reported that Hol-Lac Gold Mines had purchased the Carrisa Mine in the South Pass greenstone belt in the southern Wind River Range from Consolidated McKinney Resources Inc. of Canada. The Carrisa property was drilled by Consolidated McKinney in 1989 with reportedly favorable results.

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[1]Mining engineer, U.S. Bureau of Mines, Denver, CO. She has 16 years of mineral-related experience with the Government. Assistance in the preparation of the chapter was given by Pat LaTour, editorial assistant.

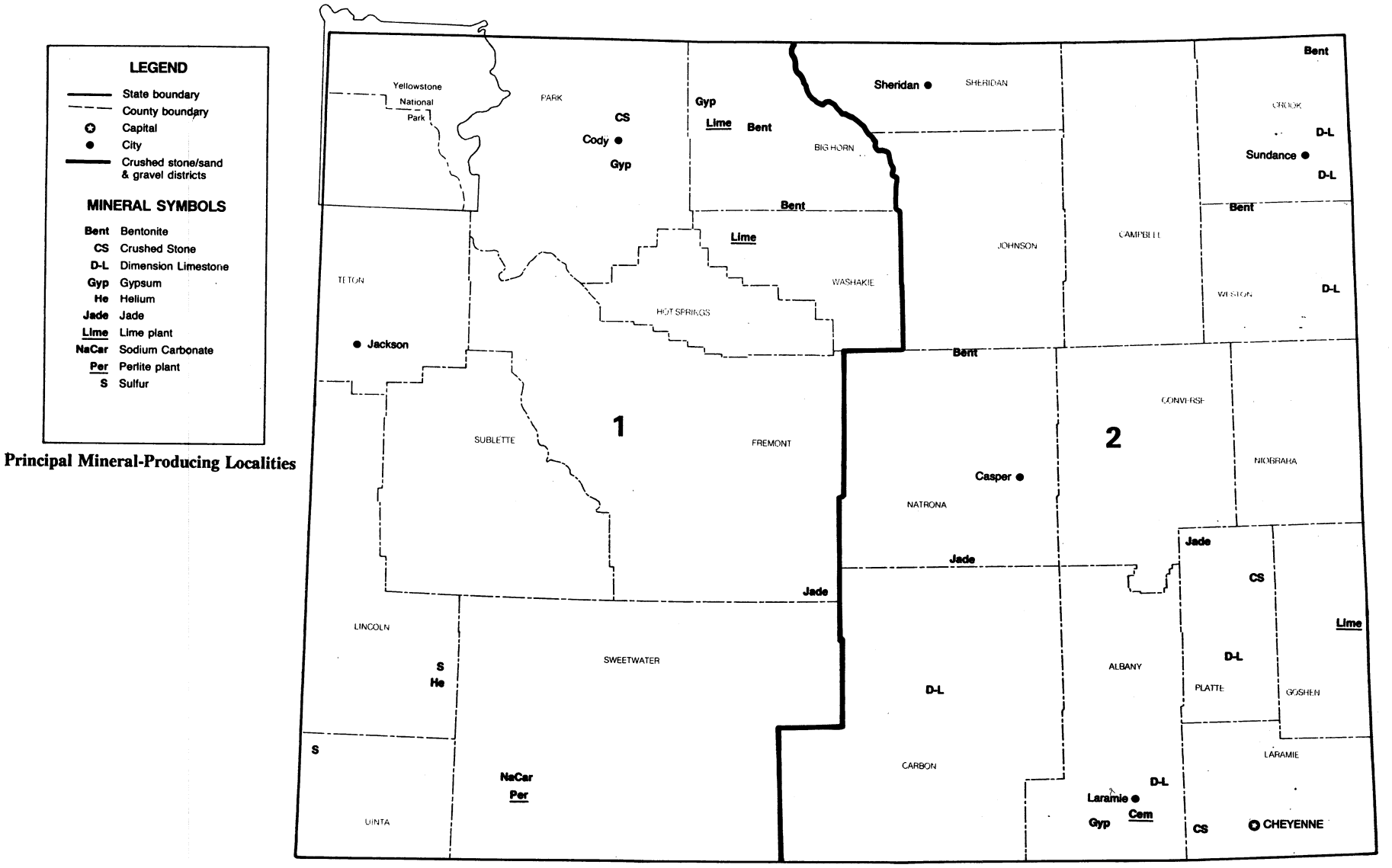
[2]Senior Economic Geologist, Metals and Precious Stones, Geological Survey of Wyoming, Laramie, WY.

[3]Geologist, Industrial Minerals and Uranium, Geological Survey of Wyoming, Laramie, WY.

[4]Rocky Mountain Construction. Mountain America Mining. Oct. 5, 1992, pp. 14-30, 46.

[5]Wyoming Geo-Notes, Wyoming Geological Society, Laramie, WY. Aug. 1992.

WYOMING


LEGEND
State boundary
County boundary
Capital
City
Crushed stone/sand & gravel districts
MINERAL SYMBOLS
Bent Bentonite
CS Crushed Stone
D-L Dimension Limestone
Gyp Gypsum
He Helium
Jade Jade
Lime Lime plant
NaCar Sodium Carbonate
Per Perlite plant
S Sulfur
Principal Mineral-Producing Localities
Yellowstone National Park
PARK
CS
Cody
Gyp
Gyp
Lime
Bent
Sheridan
SHERIDAN
BIG HORN
Bent
Lime
JOHNSON
CAMPBELL
Bent
CROOK
D-L
Sundance
D-L
Bent
D-L
TETON
WASHAKIE
HOT SPRINGS
Jackson
1
SUBLETTE
FREMONT
Bent
2
CONVERSE
NIOBRARA
Casper
NATRONA
Jade
Jade
Jade
CS
Lime
D-L
PLATTE
GOSHEN
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LARAMIE
D-L
Laramie
Gyp
Cem
CS
CHEYENNE
UINTA

TABLE 4
PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Mountain Cement Co.[1]	Box 40 Laramie, WY 82070	Plant	Albany.
Clays:			
American Colloid Co.	1500 West Shure Dr. Arlington Heights, IL 60004	Pits and plants	Big Horn, Crook, Weston.
Baroid Drilling Fluids Inc.	Box 1675 Houston, TX 77251	do.	Big Horn and Crook.
Black Hills Bentonite	Box 9 Mills, WY 82644	do.	Johnson, Natrona, Washakie.
M-I Drilling Fluids Co., Greybull Div.	Box 42842 Houston, TX 77242	Pits and plant	Big Horn.
Wyo-Ben Inc.	Box 1979 Billings, MT 59103	do.	Do.
Gypsum:			
Celotex Corp.	Box 590 Cody, WY 82414	Surface mine and plant	Park.
Georgia-Pacific Corp.	133 Peachtree St., NE Atlanta, GA 30303	do.	Big Horn.
Helium (Grade-A):			
Exxon Co. U.S.A.[2]	Box 98 Frontier, WY 83121	Plant	Lincoln.
Lime:			
The Great Western Sugar Co.	Box 5308 Denver, CO 80217	do.	Big Horn.
Holly Sugar Corp.	Holly Sugar Bldg. Colorado Springs, CO 80902	Plants	Goshen and Washakie.
Perlite (expanded):			
Harborlite Corp.	Box 1510 Green River, WY 82935	Plant	Sweetwater.
Sand and gravel:			
Casper Concrete Co.	Box 561 Casper, WY 82601	Pit	Natrona.
Gilpatrick Construction Co.	714 West Monroe Riverton, WY 82501	Pits	Fremont.
McGarvin-Moberty Construction Co.	Box 1166 Worland, WY 82401	Pit	Washakie.
Teton Construction Co.	Box 3243 Cheyenne, WY 82003	Pit	Laramie.
Western Mobile Pre-Mix Co.	Box 1230 Laramie, WY 82070	Pit	Do.
Sodium carbonate:			
FMC Wyoming Corp.	Box 872 Green River, WY 82935	Underground mine and plant	Sweetwater.
General Chemical Co.	Box 551 Green River, WY 82935	do.	Do.
Rhone-Poulenc of Wyoming	Box 513 Green River, WY 82935	do.	Do.
Tenneco Minerals Co.	Box 1167 Green River, WY 82935	do.	Do.
Tg Soda Ash Operations	Box 100 Granger, WY 82934	do.	Do.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sulfur (recovered):			
Amoco Production Co.	Box 2520 Casper, WY 82602	Plant	Unita.
Chevron USA Inc.	Box AA Evanston, WY 82930	do.	Do.

[1]Also gypsum and crushed stone.
[2]Also recovered sulfur.

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