Minerals yearbook 1989. Year 1989, Volume 2 1989

Bureau of Mines
Washington, D. C.: Bureau of Mines : United States Government Printing Office, 1989

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SURVEY METHODS AND STATISTICAL SUMMARY OF NONFUEL MINERALS

By Jeffrey B. Osmint and Stephen D. Smith

Mr. Osmint, a statistician with 13 years of Government experience in surveys, has been with the Bureau of Mines Branch of Statistics and Methods Development since 1983.

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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.

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FIGURE 1

A TYPICAL SURVEY FORM

Form 6-1066-M
Fer. (6-88)

A03

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

IRON ORE (Usable ore)

O.M.B.No. 1032-0006.
Approval Expires: 3/31/91

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.

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, Office of Statistical Standards, 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

Minerals Yearbook

U.S.
DEPARTMENT
OF THE
INTERIOR

BUREAU OF
MINES

1989

UNITED STATES DEPARTMENT OF THE INTERIOR • Manuel Lujan, Jr., Secretary

BUREAU OF MINES • T S Ary, Director

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.

U.S. GOVERNMENT PRINTING OFFICE

WASHINGTON : 1991

For sale by the U.S. Government Printing Office
Superintendent of Documents, Mail Stop: SSOP, Washington, DC 20402-9328
ISBN 0-16-035931-7

Foreword

This edition of the Minerals Yearbook discusses the performance of the worldwide minerals industry during 1989 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. 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 and 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, International Area Reports, 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 the U.S.S.R., and Minerals in the World Economy. This year's reports incorporate location maps, industry structure tables, and an outlook section previously incorporated in our Minerals Perspectives Series quinquennial regional books, which are being discontinued. The Bureau of Mines continually strives to improve the value of its publications to users. Constructive comments and suggestions by readers of the Yearbook will be welcomed.

T S Ary, *Director*

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 Office of State Activities, Division of Mineral Commodities.

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 Mineral Commodities.

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 of 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: Mineral Resources Research Center, University of Minnesota.
Mississippi: Bureau of Geology and Energy Resources, Mississippi Department of Natural Resources.
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 and Mineral 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.

Donald S. Colby, *Chief, Office of State Activities*

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Name of person to be contacted regarding this report	Tel. area code	No.	Ext.

Address No. Street	City	State	Zip

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Signature	Title	Date

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 hopes 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 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 that 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 "Minerals Yearbook" tables. However, if a company gives permission in writing, the Bureau may release data otherwise withheld because of proprietary considerations if the data from other producers in an aggregated cell are protected from disclosure.

International Data

International data are collected by country specialists in the 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 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, International Review. Chapters in these volumes are issued separately as preprints before the bound volumes are available.

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 160 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" provides 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.

"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 chapters of the "Minerals Yearbook," the "Mineral Industry Surveys," the "Mineral Commodity Summaries," the "State Mineral Summaries," and "Information Circulars," contact Publications Distribution, Bureau of Mines, Cochrans Mill Road, P.O. Box 18070, Pittsburgh, PA 15236.

Electronic Data Dissemination

In addition to the Bureau's printed publications, current "Mineral Industry Surveys" for several commodities and selected chapters 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) 634-4637 using a modem set to 1200 or 2400 baud, 8 data bits, no parity, and one stop bit. Further information on how to use the MINES-DATA system may be obtained from the system operator by calling (202) 634-9632.

STATISTICAL SUMMARY

This chapter 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 commodity chapters of Volume I and in the State chapters 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 chapter 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		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
METALS							
Bauxite metric tons, dried equivalent		575,574	$10,916	587,889	$10,566	W	W
Beryllium concentrates	metric tons	W	W	5,308	6	4,592	$5
Copper[2]	do.	1,243,638	2,261,833	r1,416,928	r3,764,353	1,497,458	4,322,922
Gold[2]	kilograms	153,870	2,216,027	200,914	2,831,281	265,541	3,266,210
Iron ore (includes byproduct material)	thousand metric tons	47,983	1,503,087	57,113	1,716,661	58,299	1,901,722
Iron oxide pigments (crude)	metric tons	38,803	3,598	39,711	3,815	45,575	3,645
Lead[2]	do.	311,381	246,720	384,983	315,222	410,915	356,477
Magnesium metal	do.	124,307	381,914	141,983	469,767	152,066	508,668
Molybdenum[3]	thousand pounds	69,868	179,286	r101,283	r271,039	139,124	421,427
Nickel[3]	short tons	—	—	—	—	382	2,600
Platinum-group metals[e]	kilograms	3,110	44,686	4,970	67,622	6,280	85,318
Silver[2]	metric tons	1,241	279,675	1,661	349,339	2,007	354,973
Zinc[2]	do.	216,327	199,924	244,314	324,249	275,883	499,103
Combined value of antimony, 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	110,422	XX	116,954	XX	222,944
Total metals[4]		XX	7,438,000	XX	10,241,000	XX	11,946,000
INDUSTRIAL MINERALS (EXCEPT FUELS)							
Abrasives[5]	metric tons	11,587	$957	13,313	$1,183	1,257	$189
Asbestos	do.	50,600	17,198	W	W	17,427	W
Barite	thousand metric tons	406	15,810	404	15,512	290	12,625

See footnotes at end of table.

TABLE 1—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Boron minerals	metric tons	1,256,452	$475,092	1,149,404	$429,667	1,114,007	$429,806
Bromine[e]	thousand kilograms	151,954	107,000	163,293	144,000	175,000	188,650
Cement:							
Masonry	thousand short tons	3,680	259,926	3,574	243,941	3,329	229,441
Portland	do.	74,868	3,646,561	74,074	3,575,906	74,202	3,592,255
Clays	metric tons	43,234,014	1,202,284	44,515,041	1,400,820	42,254,269	1,515,300
Diatomite	do.	596,928	134,239	628,680	143,774	617,164	136,754
Emery	short tons	1,945	W	W	W	—	—
Feldspar	do.	720,000	26,100	715,484	28,082	721,256	28,029
Fluorspar	metric tons	[e]63,500	W	[e]63,500	W	[e]66,000	W
Garnet (abrasive)	do.	38,353	4,350	42,506	4,707	42,604	4,408
Gem stones		NA	21,389	NA	43,580	NA	42,901
Gypsum	thousand short tons	15,612	106,977	16,390	109,205	17,624	128,448
Helium:							
Crude	million cubic feet	730	16,068	W	W	W	W
Grade-A	do.	2,230	82,540	2,574	95,238	2,879	106,523
Iodine	kilograms	W	W	[r]998,000	W	1,508,000	23,947
Lime	thousand short tons	15,733	786,125	[r]17,052	[r]817,893	17,152	852,113
Mica (scrap)	thousand metric tons	146	8,201	130	6,793	119	6,273
Peat	thousand short tons	958	21,020	[r]908	[r]20,320	769	17,636
Perlite	do.	533	16,494	[r]645	17,652	601	16,301
Phosphate rock	thousand metric tons	40,954	793,280	45,389	887,809	49,817	1,082,797
Potash (K_2O equivalent)	do.	1,262	195,700	1,521	240,300	1,595	271,515
Pumice	do.	356	4,493	353	4,129	424	8,213
Salt	thousand short tons	36,493	684,170	37,997	680,174	38,356	776,846
Sand and gravel:							
Construction	do.	[e]895,200	[e]3,002,500	923,400	3,126,000	[e]897,300	[e]3,249,000
Industrial	do.	28,010	364,100	28,480	388,000	29,205	410,200
Sodium compounds:							
Soda ash	do.	8,891	593,685	9,632	644,973	9,915	764,146
Sodium sulfate (natural)	do.	382	33,086	398	31,377	375	31,104
Stone:[6]							
Crushed	thousand short tons	1,200,100	5,248,600	[e]1,247,800	[e]5,558,000	1,213,400	5,325,800
Dimension	short tons	1,183,849	190,153	[e]1,189,333	[e]196,289	1,206,995	208,311
Sulfur (Frasch)	thousand metric tons	3,610	386,834	4,341	430,814	3,780	378,712
Talc and pyrophillite	thousand short tons	1,281,789	28,872	[r]1,359,937	[r]31,185	1,381,335	W
Tripoli	metric tons	104,259	975	99,928	864	105,229	2,537
Vermiculite	short tons	302,926	33,105	303,544	33,948	293,320	32,550
Combined value of aplite, calcium chloride (natural), graphite (natural, 1988-89), kyanite, lithium minerals, magnesite, magnesium compounds, marl (green-sand), olivine, pyrites, staurolite, wollastonite, and values indicated by symbol W		XX	[r]395,795	XX	[r]452,436	XX	496,445
Total industrial minerals[4]		XX	18,904,000	XX	19,805,000	XX	20,370,000
Grand total[4]		XX	26,342,000	XX	30,045,000	XX	32,316,000

[e]Estimated. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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 may not add to totals shown because of independent rounding.

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

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

TABLE 2

NONFUEL MINERALS PRODUCED IN THE UNITED STATES AND PRINCIPAL PRODUCING STATES IN 1989

Mineral	Principal producing States, in order of quantity	Other producing States
Abrasives[1]	AR, IN, OH.	
Antimony (content of ores, etc.)	MT.	
Aplite	VA.	
Asbestos	CA and VT.	
Barite	GA, NV, MO, TN.	IL, MT.
Bauxite	AR, AL, GA.	
Beryllium concentrate	UT.	
Boron minerals	CA.	
Bromine	AR.	
Calcium chloride (natural)	MI and CA.	
Cement:		
Masonry	FL, PA, IN, MI.	All other States except AK, CT, DE, LA, MA, MN, NV, NH, NJ, NC, ND, RI, VT, WI.
Portland	CA, PA, TX, MI.	All other States except CT, DE, LA, MA, MN, NH, NJ, NC, ND, RI, VT, WI.
Clays	GA, WY, FL, TN.	All other States except AK, DE, HI, RI, VT, WI.
Copper (content of ores, etc.)	AZ, NM, UT, MT.	CA, CO, ID, IL, MI, MO, NV, TN.
Diatomite	CA, NV, WA, OR.	AZ.
Emery	(2)	
Feldspar	NC, CA, CT, GA.	ID, OK, SD.
Fluorspar	IL and NV.	
Garnet (abrasive)	ID and NY.	
Gold (content of ores, etc.)	NV, CA, UT, SD.	AK, AZ, CO, ID, MI, MT, NM, OR, SC, WA.
Graphite (natural)	MT.	
Gypsum	TX, IA, MI, OK.	AR, AZ, CA, CO, IN, KS, LA, MT, NM, NV, NY, OH, SD, UT, VA, WA, WY.
Helium	KS, WY, TX, NM.	
Iodine	OK.	
Iron ore (includes byproduct)	MN, MI, MO, UT.	CA, MT, NM, NY, SD, TX.
Iron oxide pigments (crude)	GA, VA, MI, MO.	AZ.
Kyanite	VA.	
Lead (content of ores, etc.)	MO, ID, CO, AK.	AZ, IL, MY, NM, NY, SD, TN.
Lime	MO, OH, PA, AL.	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, DE.	TX, UT.
Magnesium metal	TX, WA, UT.	
Manganiferous ore	SC.	
Marl (greensand)	NJ.	
Mercury	NV, CA, UT.	
Mica (scrap)	NC, GA, SC, SC.	CO, PA, SD.
Molybdenum	CO, AZ, NV, ID.	CA, MY, NM, UT.
Nickel	OR.	
Olivine	NC AND WA.	
Peat	MI, FL, MN, IL.	CO, GA, IA, IN, MA, MD, ME, MT, NC, ND, NJ, NY, OH, PA, SC, WA, WI.
Perlite	NM, AZ, ID, CA.	CO, NV.
Phosphate rock	FL, NC, ID, UT.	MT, TN.
Platinum-group metals	MT.	

See footnotes at end of table.

TABLE 2—Continued

NONFUEL MINERALS PRODUCED IN THE UNITED STATES AND PRINCIPAL PRODUCING STATES IN 1989

Mineral	Principal producing States, in order of quantity	Other producing States
Potassium salts	NM, UT, CA, MI.	
Pumice	CA, OR, NM, ID.	HI, KS.
Pyrites (ore and concentrate)	AZ.	
Rare-earth metal concentrate	CA and FL.	
Salt	NY, OH, LA, MI.	AL, AZ, CA, KS, NM, NV, TX, UT, WV.
Sand and gravel:		
Construction	CA, TX, OH, AZ.	All other States.
Industrial	IL, CA, TX, NJ.	All other States except AK, DE, HI, IA, ME, NH, NM, ND, OR, SD, VT, WY.
Silver (content of ores, etc.)	NV, ID, MT, UT.	AK, AZ, CA, CO, IL, MI, MO, NM, NY, OR, SC, SD, TN, WA.
Sodium carbonate (natural)	WY and CA.	
Sodium sulfate (natural)	CA, TX, UT.	
Staurolite	FL.	
Stone:		
Crushed	PA, FL, VA, GA.	All other States except DE, ND.
Dimension	VT, IN, GA, SD.	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, VT, TX, NC.	AL, AR, CA, GA, NY, OR, VA.
Tin	AK and AZ.	
Titanium concentrates	FL and CA.	
Tripoli	IL, OK, AR, PA.	
Tungsten (content of ores, etc.)	CA.	
Vanadium (content of ores, etc.)	CO, ID, AR, UT.	
Vermiculite (crude)	SC, MT, VA.	
Wollastonite	NY.	
Zinc (content of ores, etc.)	TN, MO, NY, CO.	AK, ID, IL, MT, NM.
Zircon concentrate	FL, NJ, AL.	

[1]Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.
[2]No production reported.

TABLE 3

VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1989

State	Value (thousands)	Rank	Percent U.S. total	Principal minerals, in order of value
Alabama	$462,752	22	1.43	Stone (crushed), cement (portland), lime, and sand and gravel (construction).
Alaska	213,352	36	.66	Gold, sand and gravel (construction), zinc, and silver.
Arizona	3,040,368	1	9.41	Copper, sand and gravel (construction), molybdenum, cement (portland).
Arkansas	381,909	26	1.18	Bromine, stone (crushed), cement (portland), sand and gravel (construction).
California	2,854,116	2	8.83	Sand and gravel (construction), cement (portland), boron, gold.
Colorado	453,990	23	1.40	Molybdenum, sand and gravel (construction), cement (portland), gold.
Connecticut	113,217	41	.35	Stone (crushed), sand and gravel (construction), feldspar, sand and gravel (industrial).
Delaware[1]	6,201	50	.02	Magnesium compounds, sand and gravel (construction), gem stones.
Florida	1,608,263	4	4.98	Phosphate rock, stone (crushed), cement (portland), sand and gravel (construction).
Georgia	1,387,295	8	4.29	Clays, stone (crushed), cement (portland), stone (dimension).
Hawaii[1]	92,051	44	.28	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry).
Idaho	366,310	28	1.13	Phosphate rock, silver, molybdenum, gold.
Illinois	633,361	17	1.96	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial).
Indiana	434,115	24	1.34	Stone (crushed), cement (portland), sand and gravel (construction), stone (dimension).
Iowa	282,702	33	.87	Stone (crushed), cement (portland), sand and gravel (construction), gypsum (crude).
Kansas	318,131	31	.98	Salt, cement (portland), stone (crushed), helium (Grade-A).
Kentucky	330,659	30	1.02	Stone (crushed), lime, cement (portland), sand and gravel (construction).
Louisiana	379,722	27	1.18	Sulfur (Frasch), salt, sand and gravel (construction), stone (crushed).
Maine	64,654	46	.20	Sand and gravel (construction), cement (portland), stone (crushed), stone (dimension).
Maryland	342,050	29	1.06	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry).
Massachusetts	144,126	39	.45	Stone (crushed), sand and gravel (construction), stone (dimension), lime.
Michigan	1,598,971	5	4.95	Iron ore (includes byproduct material), cement (portland), sand and gravel (construction), stone crushed).
Minnesota	1,438,135	7	4.45	Iron ore (includes byproduct material), sand and gravel (construction), stone (crushed), stone (dimension).
Mississippi	107,610	42	.33	Sand and gravel (construction), clays, cement (portland), stone (crushed).
Missouri	1,050,056	11	3.25	Lead, cement (portland), stone (crushed), lime.
Montana	599,239	18	1.85	Copper, gold, platinum-group metals, molybdenum.
Nebraska	103,817	43	.32	Sand and gravel (construction), cement (portland), stone (crushed), lime.
Nevada	2,319,068	3	7.18	Gold, silver, sand and gravel (construction), molybdenum.
New Hampshire[1]	33,240	47	.10	Sand and gravel (construction), stone (dimension), stone (crushed), clays.
New Jersey	248,883	34	.77	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), zircon concentrates.
New Mexico	1,124,592	10	3.48	Copper, potassium salts, sand and gravel (construction), silver.
New York	745,168	14	2.31	Stone (crushed), salt, cement (portland), sand and gravel (construction).
North Carolina	581,568	19	1.80	Stone (crushed), phosphate rock, lithium minerals, sand and gravel (construction).
North Dakota	13,660	48	.04	Sand and gravel (construction), lime, clays, peat.
Ohio	699,156	15	2.16	Stone (crushed), sand and gravel (construction),salt, lime.
Oklahoma	219,031	35	.68	Stone (crushed), cement (portland), iodine, sand and gravel (construction).
Oregon	185,556	37	.57	Stone (crushed), sand and gravel (construction), cement (portland), lime.
Pennsylvania	1,000,669	12	3.10	Stone (crushed), cement (portland), sand and gravel (construction), lime.
Rhode Island[1]	11,072	49	.03	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), gem stones.
South Carolina	425,297	25	1.32	Stone (crushed), gold, cement (portland), clays.
South Dakota	284,358	32	.88	Gold, cement (portland), sand and gravel (construction), stone (dimension).
Tennessee	638,407	16	1.98	Stone (crushed), zinc, cement (portland), clays.
Texas	1,462,453	6	4.53	Cement (portland), magnesium metal, stone (crushed), sulfer (Frasch).
Utah	1,290,450	9	3.99	Copper, gold, magnesium metal, cement (portland).
Vermont	88,902	45	.28	Stone (crushed), stone (dimension), sand and gravel (construction), talc and pyrophyllite.
Virginia	509,130	20	1.58	Stone (crushed), sand and gravel (construction), lime, cement (portland).
Washington	480,879	21	1.49	Sand and gravel (construction), magnesium metal, gold, stone (crushed).
West Virginia	125,498	40	.39	Stone (crushed), cement (portland), salt, sand and gravel (industrial).
Wisconsin[1]	185,277	38	.57	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), lime.
Wyoming	827,361	13	2.56	Sodium carbonate (natural), clays, helium (Grade-A), sand and gravel (construction).
Undistributed	9,043	—	—	
Total[2]	32,316,000	XX	100.00	

XX Not applicable.

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

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

TABLE 4

VALUE OF NONFUEL MINERAL PRODUCTION PER CAPITA AND PER SQUARE MILE IN 1989, BY STATE

State	Area (square miles)	Population (thousands)	Total (thousands)	Per square mile		Per capita	
				Dollars	Rank	Dollars	Rank
Alabama	51,705	4,118	$462,752	8,950	27	112	21
Alaska	591,004	527	213,352	361	49	405	7
Arizona	114,000	3,556	3,040,368	26,670	5	855	3
Arkansas	53,187	2,406	381,909	7,180	31	159	14
California	158,706	29,063	2,854,116	17,984	10	98	24
Colorado	104,091	3,317	453,990	4,361	37	137	16
Connecticut	5,018	3,239	113,217	22,562	7	35	44
Delaware	2,044	673	[1]6,201	3,034	44	9	50
Florida	58,664	12,671	1,608,263	27,415	3	127	18
Georgia	58,910	6,436	1,387,295	23,549	6	216	11
Hawaii	6,471	1,112	[1]92,051	14,225	18	83	31
Idaho	83,564	1,014	366,310	4,384	36	361	9
Illinois	56,345	11,658	633,361	11,241	22	54	39
Indiana	36,185	5,593	434,115	11,997	21	78	32
Iowa	56,275	2,840	282,702	5,024	35	100	23
Kansas	82,277	2,513	318,131	3,867	39	127	19
Kentucky	40,409	3,727	330,659	8,183	29	89	25
Louisiana	47,751	4,382	379,722	7,952	30	87	27
Maine	33,265	1,222	64,654	1,944	46	53	40
Maryland	10,460	4,694	342,050	32,701	1	73	33
Massachusetts	8,284	5,913	144,126	17,398	11	24	47
Michigan	58,527	9,273	1,598,971	27,320	4	172	13
Minnesota	84,402	4,353	1,438,135	17,039	12	330	10
Mississippi	47,689	2,621	107,610	2,256	45	41	42
Missouri	69,697	5,159	1,050,056	15,066	17	204	12
Montana	147,046	806	599,239	4,075	38	743	5
Nebraska	77,355	1,611	103,817	1,342	48	64	37
Nevada	110,561	1,111	2,319,068	20,975	9	2,087	1
New Hampshire	9,279	1,107	[1]33,240	3,582	41	30	46
New Jersey	7,787	7,736	248,883	31,961	2	32	45
New Mexico	121,593	1,528	1,124,592	9,249	24	736	6
New York	49,107	17,950	745,168	15,174	15	42	41
North Carolina	52,669	6,571	581,568	11,042	23	89	26
North Dakota	70,703	660	13,660	193	50	21	48
Ohio	41,330	10,907	699,156	16,916	13	64	38
Oklahoma	69,956	3,224	219,031	3,131	43	68	34
Oregon	97,073	2,820	185,556	1,912	47	66	36
Pennsylvania	45,308	12,040	1,000,669	22,086	8	83	30
Rhode Island	1,212	998	[1]11,072	9,135	26	11	49
South Carolina	31,113	3,512	425,297	13,669	19	121	20
South Dakota	77,116	715	284,358	3,687	40	398	8
Tennessee	42,144	4,940	638,407	15,148	16	129	17
Texas	266,807	16,991	1,462,453	5,481	33	86	28
Utah	84,899	1,707	1,290,450	15,200	14	756	4
Vermont	9,614	567	88,902	9,247	25	157	15
Virginia	40,767	6,098	509,130	12,489	20	83	29
Washington	68,138	4,761	480,879	7,057	32	101	22
West Virginia	24,231	1,857	125,498	5,179	34	68	35
Wisconsin	56,153	4,867	[1]185,277	3,300	42	38	43
Wyoming	97,809	475	827,361	8,459	28	1,742	2
Undistributed	XX	XX	9,043	XX	XX	XX	XX
Total[2] or average	3,618,700	247,639	[3]32,316,000	8,930	XX	130	XX

XX Not applicable.

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

[2]Excludes Washington, DC (which has no mineral production), with an area of 69 square miles and a population of 604,000.

[3]Data do not add to total shown because of independent rounding.

Sources: Bureau of Mines and Bureau of the Census.

TABLE 5

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
ALABAMA							
Cement:							
Masonry	thousand short tons	291	$17,626	273	$16,457	252	$13,852
Portland	do.	3,600	160,878	3,524	157,214	3,169	130,590
Clays[2]	metric tons	2,031,163	16,217	2,282,670	16,039	1,878,070	18,537
Gem stones		NA	7	NA	5	NA	W
Lime	thousand short tons	1,232	52,200	1,450	66,576	1,481	70,361
Sand and gravel:							
Construction	do.	e10,300	e35,600	11,742	41,417	e10,400	e36,500
Industrial	do.	580	5,025	871	8,507	805	8,092
Stone (crushed)	do.	30,018	146,247	e29,700	e140,100	31,737	167,332
Combined value of bauxite, clays (bentonite), salt, stone (crushed granite 1989, dimension), talc and pyrophyllite (1988-89), zircon concentrates, (1988-89), and value indicated by symbol W		XX	12,843	XX	13,180	XX	17,487
Total		XX	446,643	XX	459,495	XX	462,751
ALASKA							
Gem stones		NA	$86	NA	$50	NA	W
Gold[4]	kilograms	3,812	r54,895	4,210	59,320	5,756	$70,800
Sand and gravel (construction)	thousand short tons	e27,200	e73,400	17,200	48,749	e17,000	e48,500
Silver[4]	metric tons	(5)	111	1	135	W	W
Stone (crushed)	thousand short tons	2,033	8,945	e1,800	e8,400	2,900	20,300
Combined value of cement (portland), lead (1989), tin, zinc (1989), and values indicated by symbol W		XX	4,010	XX	2,040	XX	73,752
Total		XX	141,447	XX	118,694	XX	213,352
ARIZONA							
Clays	short tons	218,151	$1,905	185,620	$1,590	188,211	$2,506
Copper[4]	metric tons	751,073	1,365,994	r842,728	r2,238,875	898,315	2,593,292
Diatomite	do.	7,257	1,208	W	W		
Gem stones		NA	3,000	NA	3,300	NA	2,821
Gold[4]	kilograms	1,791	25,798	4,549	64,106	2,810	34,564
Lime	do.	546	21,932	674	29,637	W	W
Perlite	thousand short tons	49	1,361	W	W	W	W
Pumice	thousand metric tons	907	7	907	7	—	—
Sand and gravel:							
Construction	do.	e38,100	e141,300	32,399	123,854	e33,900	e133,900
Industrial	do.	W	W	119	3,045	W	W
Silver[4]	metric tons	114	25,666	152	31,974	171	30,186
Stone:							
Crushed	thousand short tons	7,712	33,999	e7,400	e33,000	6,649	28,552
Dimension	short tons	W	e1	W	W		
Combined value of cement, gypsum, iron oxide pigments (crude, 1989), lead (1988-89), molybdenum, pyrites, salt, tin (1988-89), and values indicated by symbol W		XX	129,398	XX	235,596	XX	214,546
Total		XX	1,750,360	XX	2,766,193	XX	3,040,367

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ARKANSAS							
Abrasives[6]	metric tons	W	W	1,120	$429	W	W
Clays	do.	824,082	$8,651	844,466	15,376	901,308	$17,391
Gem stones		NA	1,800	NA	2,300	NA	4,041
Sand and gravel:							
Construction	thousand short tons	e7,200	e23,900	7,722	26,201	e7,500	e25,500
Industrial	do.	505	5,147	669	6,784	545	5,507
Stone:							
Crushed	do.	15,234	63,847	e17,100	e70,100	3 18,791	3 76,419
Dimension	short tons	10,541	629	e10,541	e629	W	W
Combined value of bauxite, bromine,[e] cement, gypsum, lime, stone (crushed slate and dolomite, 1989), talc and pyrophyllite, tripoli, vanadium (1989), and values indicated by symbol W		XX	160,188	XX	184,970	XX	253,051
Total		XX	264,162	XX	306,789	XX	381,909
CALIFORNIA							
Boron minerals[7]	metric tons	625,051	$475,092	577,877	$429,667	1,114,007	$429,806
Cement:							
Masonry	thousand short tons	W	W	8	730	W	W
Portland	do.	9,937	593,859	10,423	601,152	10,911	642,020
Clays	metric tons	2,083,200	33,045	2,015,488	31,620	2,195,830	39,243
Gem stones		NA	3,367	NA	3,365	NA	2,982
Gold[4]	kilograms	18,743	269,937	22,442	316,246	29,804	366,595
Gypsum	thousand short tons	1,468	11,719	1,490	11,222	1,734	13,066
Lime	do.	465	25,745	r458	r20,242	395	24,503
Mercury	metric tons	(5)	(5)	W	W	W	W
Peat	thousand short tons	W	W	2	119	—	—
Pumice	short tons	42,000	1,539	35,000	1,245	79	4,612
Sand and gravel:							
Construction	thousand short tons	e141,600	e561,300	141,946	622,074	e138,300	e670,800
Industrial	do.	2,241	41,472	2,444	42,078	2,426	43,863
Silver[4]	metric tons	4	854	15	3,148	21	3,650
Stone:							
Crushed	thousand short tons	44,315	186,504	e49,100	e275,000	54,887	238,034
Dimension	short tons	33,335	4,554	e42,048	e5,991	28,829	5,564
Combined value of asbestos, barite (1987-88), calcium chloride (natural), copper (1988-89), diatomite, feldspar, diatomite, feldspar, iron ore (includes byproduct material, 1988-89), magnesium compounds, molybdenum, perlite, potassium salts, rare-earth metal concentrates, salt, sodium carbonate (natural), sodium sulfate (natural), talc and prophyllite, titanium concentrates ilmenite, 1989), tungsten ore concentrates, wollastonite (1987), and values indicated by symbol W		XX	342,298	XX	334,755	XX	369,378
Total		XX	2,551,285	XX	2,698,654	XX	2,854,116

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
COLORADO							
Clays	metric tons	264,944	$1,763	247,471	$1,890	265,435	$2,064
Copper[4]	do.	W	W	898	2,386	W	W
Gem stones		NA	100	NA	100	NA	240
Gold[4]	kilograms	5,561	80,091	5,126	72,237	3,448	42,411
Peat	thousand short tons	W	W	W	W	W	412
Sand and gravel (construction)	do.	e22,800	e84,300	21,566	69,882	e25,300	e104,000
Silver[4]	metric tons	27	6,033	27	5,588	W	W
Stone:							
Crushed	thousand short tons	8,045	33,465	e10,600	e42,400	3 7,261	3 32,435
Dimension	short tons	3,000	133	e3,450	e143	5,310	398
Combined value of cement, gypsum, lead, lime, mica (crude, 1989), molybdenum, perlite, pyrites (1987), sand and gravel (industrial), stone (crushed traprock, 1989), vanadium, zinc, and values indicated by symbol W		XX	167,104	XX	169,379	XX	272,030
Total		XX	372,989	XX	364,005	XX	453,990
CONNECTICUT							
Gem stones		NA	$2	NA	$2	NA	$2
Sand and gravel (construction)	thousand short tons	e8,400	e37,000	8,275	32,102	e5,800	e24,700
Stone:							
Crushed	do.	11,412	76,668	e11,400	e76,900	3 11,480	3 78,734
Dimension	short tons	18,140	1,646	e19,718	e1,914	W	W
Combined value of clays (common), feldspar, mica (scrap, 1987-88), sand and gravel (industrial), stone (crushed granite, 1989), and value indicated by symbol W		XX	6,959	XX	7,198	XX	9,780
Total		XX	122,275	XX	118,116	XX	113,216
DELAWARE							
Gem stones		NA	$1	NA	$1	NA	$1
Marl (greensand)	short tons	W	W	750	10	—	—
Sand and gravel (construction)	thousand short tons	e2,300	e6,400	1,933	5,988	e1,900	e6,200
Total[8]		XX	6,401	XX	5,999	XX	6,201
FLORIDA							
Cement:							
Masonry	thousand short tons	390	$24,069	411	$25,892	477	$31,231
Portland	do.	3,565	165,944	3,682	168,719	4,357	207,857
Clays	metric tons	541,760	39,496	536,922	44,423	2 563,687	2 46,941
Peat	thousand short tons	363	6,068	266	5,091	235	4,515
Sand and gravel:							
Construction	do.	e30,000	e74,900	18,654	53,083	e17,900	e55,500
Industrial	do.	1,884	19,713	636	6,928	681	7,768
Stone (crushed)	do.	3 78,992	3 350,537	e 3 83,200	e 3 374,400	83,995	341,397
Combined value of clays (common), gem stones, magnesium compounds (1988-89), phosphate rock, rare-earth metal concentrates, staurolite, stone (crushed marl 1987-88), titanium concentrates (ilmenite and rutile), and zircon concentrates		XX	665,510	XX	713,345	XX	913,054
Total		XX	1,346,237	XX	1,391,881	XX	1,608,263

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
GEORGIA							
Clays	metric tons	9,484,392	$756,093	10,274,358	$908,771	9,768,312	$1,004,954
Gem stones		NA	20	NA	20	NA	21
Sand and gravel:							
Construction	thousand short tons	e9,000	e26,900	9,526	30,185	e6,100	e18,900
Industrial	do.	W	W	W	W	537	7,013
Stone:							
Crushed	do.	60,834	318,903	e57,400	e317,200	50,417	262,805
Dimension	short tons	179,207	21,683	e190,472	e27,768	3145,545	312,087
Talc and pyrophyllite	do.	20,100	286	26,000	260	W	W
Combined value of barite, bauxite, cement, feldspar, iron oxide pigments (crude), mica (scrap), peat, stone (dimension marble, 1989), and values indicated by symbol W		XX	88,485	XX	89,621	XX	81,515
Total		XX	1,212,370	XX	1,373,825	XX	1,387,295
HAWAII							
Cement:							
Masonry	thousand short tons	10	$1,559	10	$1,531	10	$1,566
Portland	do.	324	26,550	354	28,880	493	40,495
Gem stones		NA	25	NA	W	NA	44
Lime	thousand short tons	3	W	W	W	—	—
Sand and gravel (construction)	do.	e700	e3,500	652	3,173	e600	e3,200
Stone (crushed)	do.	5,732	41,548	e5,700	e41,000	6,205	46,746
Combined value of other industrial minerals and values indicated by symbol W		XX	297	XX	348	XX	(9)
Total		XX	73,479	XX	74,932	XX	892,051
IDAHO							
Clays[2]	metric tons	8,114	W	8,519	W	W	W
Copper[4]	do.	W	W	2,269	$6,028	2,950	$8,516
Feldspar	short tons	—	—	—	—	12,800	720
Gem stones		NA	$507	NA	500	NA	500
Gold[4]	kilograms	3,041	43,797	3,218	45,349	3,057	37,602
Lime	thousand short tons	97	5,149	W	W	W	W
Phosphate rock	thousand metric tons	3,411	47,072	4,706	81,011	W	W
Sand and gravel:							
Construction	thousand short tons	e7,200	e28,000	6,914	19,897	e5,800	e18,900
Industrial	do.	W	W	483	5,089	459	5,037
Silver[4]	metric tons	W	W	340	71,512	439	77,651
Stone (crushed)	thousand short tons	3,852	15,346	e3,400	e13,100	3,298	12,609
Combined value of antimony (1988-89), cement, clays, (bentonite, common, kaolin), garnet (abrasive), lead, molybdenum (1987, 1989), perlite, pumice, stone (dimension), vanadium, zinc, and values indicated by symbol W		XX	r129,502	XX	48,130	XX	204,775
Total		XX	269,373	XX	290,616	XX	366,310
ILLINOIS							
Cement (portland)	thousand short tons	2,119	$86,210	2,307	$101,760	2,776	$117,224
Clays[2]	metric tons	211,328	977	163,571	704	142,207	641
Gem stones		NA	15	NA	30	NA	W

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
ILLINOIS—Continued							
Sand and gravel:							
Construction	thousand short tons	e28,300	e$93,300	30,098	$93,504	e33,000	e$108,900
Industrial	do.	4,346	45,547	4,328	56,142	4,582	52,935
Stone:							
Crushed	do.	52,102	216,212	e57,900	e251,200	3 60,829	3 256,832
Dimension	short tons	W	W	e1,175	e129	W	W
Combined value of barite (1989), cement (masonry), clays (fuller's earth), copper, fluorspar, lead, lime, peat, silver, stone (crushed sandstone, 1989), tripoli, zinc, and values indicated by symbol W		XX	74,945	XX	84,157	XX	96,829
Total		XX	517,206	XX	587,626	XX	633,361
INDIANA							
Cement:							
Masonry	thousand short tons	422	$32,299	405	$27,442	357	$24,054
Portland	do.	2,320	103,177	2,315	107,179	2,364	108,297
Clays	metric tons	2 940,451	2 4,056	1,035,837	4,630	871,179	3,836
Gem stones		NA	10	NA	10	NA	W
Peat	thousand short tons	44	W	54	W	34	607
Sand and gravel:							
Construction	do.	e18,900	e65,200	25,923	79,985	e29,600	e99,200
Industrial	do.	230	1,357	362	1,829	W	W
Stone:							
Crushed	do.	31,067	106,770	e36,600	e130,000	3 36,188	3 136,252
Dimension	short tons	183,609	23,115	e195,444	e24,956	3 198,531	3 27,212
Combined value of abrasives, clays (fire clay 1987), gypsum, lime, stone (crushed marl and miscellaneous, 1989, dimension sandstone, 1989), and values indicated by symbol W		XX	27,881	XX	30,358	XX	34,657
Total		XX	363,865	XX	406,389	XX	434,115
IOWA							
Cement:							
Masonry	thousand short tons	W	W	W	W	47	$4,450
Portland	do.	2,139	$104,457	2,029	$98,930	2,072	102,387
Clays	metric tons	428,907	1,495	403,923	1,588	439,323	1,773
Gem stones		NA	W	NA	W	NA	10
Gypsum	thousand short tons	1,874	12,887	2,047	13,710	2,273	16,884
Peat	do.	24	W	r15	433	W	W
Sand and gravel (construction)	do.	e19,000	e63,800	11,880	36,087	e12,800	e37,800
Stone:							
Crushed	do.	25,991	110,106	e29,200	e128,500	28,049	111,182
Dimension	short tons	W	W	W	e588	15,151	613
Combined value of other industrial minerals and values indicated by symbol W		XX	12,332	XX	10,420	XX	7,603
Total		XX	305,077	XX	290,256	XX	282,702
KANSAS							
Cement:							
Masonry	thousand short tons	52	$3,150	50	$2,988	42	$2,514
Portland	do.	1,697	81,045	1,569	72,805	1,505	69,390
Clays[2]	metric tons	547,650	2,576	555,739	2,632	533,099	2,700
Gem stones		NA	3	NA	3	NA	W
Salt[10]	thousand short tons	1,689	70,148	1,284	55,753	1,948	82,212

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
KANSAS—Continued							
Sand and gravel:							
Construction	thousand short tons	e15,600	e$37,800	10,760	$25,329	e13,000	e$33,200
Industrial	do.	127	1,400	W	W	230	2,690
Stone:							
Crushed	do.	19,319	69,628	e17,300	e72,700	315,850	356,976
Dimension	short tons	11,423	445	e6,889	e219	W	W
Combined value of clay (bentonite), gypsum, helium (crude and Grade-A), pumice, salt (brine), stone (crushed sandstone and quartzite, 1989), and values indicated by symbol W		XX	53,409	XX	59,284	XX	68,449
Total		XX	319,604	XX	291,713	XX	318,131
KENTUCKY							
Clays[2]	metric tons	801,287	$3,393	762,324	$3,217	716,990	$3,357
Gem stones		NA	3	NA	3	NA	W
Sand and gravel (construction)	thousand short tons	e7,100	e15,200	6,325	15,243	e5,500	e15,100
Stone (crushed)	do.	43,330	173,222	e50,700	e207,900	448,178	4187,849
Zinc[4]	metric tons	10	9	W	W	—	—
Combined value of cement, clays (ball clay, fire clay), lime, sand and gravel (industrial, 1987, 1989), stone (crushed dolomite, 1989), and values indicated by symbol W		XX	98,508	XX	118,616	XX	124,353
Total		XX	290,335	XX	344,979	XX	330,659
LOUISIANA							
Clays	metric tons	323,778	$9,192	340,900	$9,535	233,992	$6,115
Gem stones		NA	1	NA	3	NA	14
Salt	thousand short tons	12,498	108,999	14,274	108,982	13,218	115,203
Sand and gravel:							
Construction	do.	e12,200	e43,600	14,233	52,820	e13,600	e54,400
Industrial	do.	289	3,997	318	4,786	572	9,664
Stone (crushed)	do.	34,390	336,514	e 33,700	e 329,200	3,206	24,414
Sulfur (Frasch)	thousand metric tons	1,458	W	1,719	W	1,334	W
Combined value of cement [masonry (1987-88), portland, (1987-88)], gypsum, lime, stone (crushed miscellaneous, (1987-88), and values values indicated by symbol W		XX	221,918	XX	229,210	XX	169,912
Total		XX	424,221	XX	434,536	XX	379,722
MAINE							
Gem stones		NA	$1,172	NA	$150	NA	W
Sand and gravel (construction)	thousand short tons	e8,600	e22,100	10,183	33,007	e8,600	e$30,100
Stone:							
Crushed	do.	2,010	7,532	e1,400	e5,300	1,591	8,801
Dimension	short tons	7,512	5,924	e7,512	e5,924	W	W
Combined value of cement, clays (common), garnet (abrasive 1987-88), peat (1988-89), and values indicated by symbol W		XX	28,729	XX	23,379	XX	25,753
Total		XX	65,457	XX	67,760	XX	64,654

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
MARYLAND							
Cement (portland)	thousand short tons	1,829	$90,020	1,808	$89,083	1,871	$94,002
Clays	metric tons	347,501	1,940	357,833	2,016	351,464	1,882
Gem stones		NA	5	NA	5	NA	3
Lime	thousand short tons	9	486	6	329	—	—
Peat	do.	W	W	7	W	3	W
Sand and gravel (construction)	do.	e19,600	e92,900	19,266	95,169	e16,900	e84,500
Stone:							
Crushed	do.	30,136	151,579	e32,700	e167,000	30,841	153,375
Dimension	short tons	22,843	1,516	e20,729	e1,515	27,529	2,072
Combined value of other industrial minerals and values indicated by symbol W		XX	6,688	XX	7,804	XX	6,216
Total		XX	345,134	XX	362,921	XX	342,050
MASSACHUSETTS							
Gem stones		NA	$1	NA	$1	NA	$3
Sand and gravel:							
Construction	thousand short tons	e21,800	e75,300	22,168	79,364	e13,900	e57,000
Industrial	do.	56	922	W	W	34	601
Stone:							
Crushed	do.	14,907	78,969	e17,500	e91,900	11,880	67,768
Dimension	short tons	76,579	12,747	W	W	67,533	10,302
Combined value of clays (common), lime, peat, and values indicated by symbol W		XX	8,583	XX	20,973	XX	8,452
Total		XX	176,522	XX	192,238	XX	144,126
MICHIGAN							
Cement:							
Masonry	thousand short tons	263	$23,004	265	$22,915	255	$22,286
Portland	do.	4,755	207,332	5,253	231,141	5,449	253,324
Clays	metric tons	1,209,730	5,338	1,248,121	4,432	1,249,198	4,599
Gem stones		NA	25	NA	25	NA	10
Gypsum	thousand short tons	1,977	12,190	1,958	11,630	2,089	15,589
Iron ore	thousand metric tons	12,509	W	14,623	W	15,045	W
Lime	thousand short tons	569	30,320	714	36,088	621	32,479
Peat	do.	281	5,290	r322	6,256	286	6,082
Sand and gravel:							
Construction	do.	e42,800	e105,300	53,508	138,171	e48,000	e132,000
Industrial	do.	2,792	22,451	3,045	27,150	2,865	24,577
Stone (crushed)	do.	37,909	109,514	e38,800	e120,300	40,905	123,678
Combined value of bromine (1987-88), calcium chloride (natural), copper, gold, iron oxide pigments (crude), magnesium compounds, potassium salts (1989), salt, silver, stone (dimension), and values indicated by symbol W		XX	844,846	XX	989,453	XX	984,347
Total		XX	1,365,610	XX	1,587,561	XX	1,598,971
MINNESOTA							
Gem stones		NA	$40	NA	$40	NA	$42
Iron ore	thousand metric tons	34,274	1,012,788	40,735	1,134,539	41,044	1,285,807
Peat	thousand short tons	30	W	29	r1,414	27	1,415
Sand and gravel (construction)	do.	e25,200	e67,400	33,769	72,678	e33,700	e82,600

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
MINNESOTA—Continued							
Stone:							
Crushed	thousand short tons	8,995	$29,246	e8,300	e$28,200	8,760	$30,218
Dimension	short tons	41,354	12,967	e45,000	e13,000	44,605	16,031
Combined value of clays (common, kaolin), lime, sand and gravel (industrial) and value indicated by symbol W		XX	20,308	XX	18,015	XX	22,022
Total		XX	1,142,749	XX	1,267,886	XX	1,438,135
MISSISSIPPI							
Clays[2]	short tons	838,826	$13,044	1,093,316	$24,564	899,373	$23,573
Gem stones		NA	1	NA	1	NA	5
Sand and gravel (construction)	thousand short tons	e14,700	e47,000	13,314	38,806	e15,600	e51,500
Stone (crushed)	do.	1,492	9,621	e1,500	e9,000	1,069	3,994
Combined value of cement (masonry, portland), clays (ball clay, fuller's earth, 1987), and sand and gravel (industrial)		XX	40,413	XX	31,029	XX	28,539
Total		XX	110,079	XX	103,400	XX	107,611
MISSOURI							
Barite	thousand metric tons	24	$2,030	24	$1,930	W	W
Cement:							
Masonry	thousand short tons	167	10,027	153	6,310	W	W
Portland	do.	5,110	185,317	4,679	184,755	4,922	$182,005
Clays[2]	metric tons	1,338,858	10,414	1,435,045	12,171	1,479,898	14,665
Iron ore	thousand metric tons	756	W	816	W	1,060	W
Lead[4]	metric tons	W	W	353,194	289,194	366,931	318,320
Sand and gravel:							
Construction	thousand short tons	e10,900	e30,400	11,217	32,941	e10,000	e32,500
Industrial	do.	622	7,786	744	9,876	750	9,972
Silver[4]	metric tons	37	8,276	45	9,550	53	9,456
Stone:							
Crushed	thousand short tons	54,910	184,824	e52,100	e183,000	51,754	171,848
Dimension	short tons	3,212	454	e3,644	e547	W	W
Zinc[4]	metric tons	34,956	32,306	41,322	54,842	50,790	91,885
Combined value of clays (fuller's earth), copper, gem stones, iron oxide pigments (crude), lime, and values indicated by symbol W		XX	391,206	XX	182,833	XX	219,405
Total		XX	863,040	XX	967,949	XX	1,050,056
MONTANA							
Clays[2]	metric tons	26,199	$98	91,802	$1,416	95,743	$1,835
Gem stones		NA	1,302	NA	1,602	NA	2,500
Gold[4]	kilograms	234,365	104,984	294,976	129,291	11,623	142,965
Gypsum	thousand short tons	24	W	27	W	W	W
Lead[4]	metric tons	W	W	8,266	6,768	W	W
Platinum-group metals	do.	W	W	W	W	6,280	85,318
Sand and gravel (construction)	thousand short tons	e6,800	e18,800	7,984	20,225	e5,800	e13,900
Silver[4]	metric tons	185	41,619	192	40,457	194	34,367
Stone (crushed)	thousand short tons	1,463	3,585	e1,800	e4,500	2,846	9,718
Talc and pyrophyllite	do.	356,231	11,334	377,789	11,309	500,424	12,718
Zinc[4]	metric tons	W	W	18,935	25,130	W	W

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
MONTANA—Continued							
Combined value of barite (1987, 1989), cement, clay (fire clay), copper, graphite (natural 1988-89), iron ore, lime, molybdenum, peat, phosphate rock, sand and gravel (indistrial), stone (dimension), vermiculite, and values indicated by symbol W		XX	$186,456	XX	r$332,630	XX	$295,918
Total		XX	368,178	XX	573,328	XX	599,239
NEBRASKA							
Clays	metric tons	202,963	$721	215,419	$786	224,624	$880
Gem stones		NA	10	NA	10	NA	2
Sand and gravel (construction)	thousand short tons	e10,300	e26,300	11,229	28,928	e15,200	e41,800
Stone (crushed)	do.	4,316	19,461	e4,900	e22,000	3,978	20,050
Combined value of cement, lime, and sand and gravel (industrial)		XX	43,256	XX	39,468	XX	41,085
Total		XX	89,748	XX	91,192	XX	103,817
NEVADA							
Barite	thousand metric tons	279	$4,778	289	$5,053	209	$3,473
Clays[2]	metric tons	10,704	810	26,186	2,143	57,264	5,457
Gem stones		NA	280	NA	280	NA	1,402
Gold[4]	kilograms	83,341	1,200,269	114,322	1,611,020	154,573	1,901,280
Perlite	short tons	W	W	5,000	142	5	136
Sand and gravel:							
Construction	thousand short tons	e10,600	e30,700	15,729	50,928	e20,000	e70,000
Industrial	do.	578	W	602	W	718	W
Silver[4]	metric tons	379	85,429	608	127,760	625	110,442
Stone (crushed)	thousand short tons	31,264	35,700	e 31,300	e 35,700	1,560	4,638
Combined value of cement (portland), clays [fuller's earth (1987), kaolin], copper (1988), diatomite, fluorspar, gypsum, lead (1988), lime, lithium minerals, magnesite, mercury, molybdenum (1989), salt, stone (crushed dolomite), and values indicated by symbol W		XX	r128,063	XX	r151,356	XX	222,240
Total		XX	1,456,029	XX	1,954,382	XX	2,319,068
NEW HAMPSHIRE							
Gem stones		NA	$310	NA	$100	NA	$51
Sand and gravel (construction)	thousand short tons	e9,100	e33,300	9,089	32,614	e6,000	e20,400
Stone:							
Crushed	do.	2,479	10,386	e2,400	e9,800	771	4,020
Dimension	short tons	67,479	10,684	e73,393	e10,546	55,305	8,769
Total[8]		XX	54,680	XX	53,060	XX	33,240
NEW JERSEY							
Clays[2]	metric tons	5,430	$140	14,954	$368	18,492	$400
Gem stones		NA	3	NA	3	NA	3
Peat	thousand short tons	32	614	43	797	W	638
Sand and gravel:							
Construction	do.	e15,200	e61,200	18,318	74,183	e15,200	e68,400
Industrial	do.	2,112	27,872	1,860	25,437	1,797	26,138
Stone (crushed)	do.	317,576	3111,951	e 319,300	e 3123,500	20,799	140,998

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
NEW JERSEY—Continued							
Zircon concentrates	metric tons	W	W	W	W	W	$8,988
Combined value of clays (common), marl (greensand), stone (crushed limestone, 1987-88), and values indicated by symbol W		XX	$12,444	XX	$17,544	XX	$3,318
Total		XX	214,224	XX	241,832	XX	248,883
NEW MEXICO							
Clays	metric tons	46,491	$141	28,555	$83	31,012	$94
Copper[4]	do.	246,532	448,373	258,660	687,182	259,432	748,939
Gem stones		NA	200	NA	200	NA	279
Gold[4]	kilograms	W	W	W	W	1,076	13,231
Perlite	short tons	437,000	13,611	458,000	14,294	487	13,080
Potassium salts	thousand metric tons	1,323	174,200	1,271	213,800	1,365	242,619
Pumice	do.	79	991	76	852	77	795
Sand and gravel (construction)	thousand short tons	e8,600	e31,000	8,787	31,367	e11,800	e45,400
Stone:							
Crushed	do.	4,503	15,919	e3,500	e13,900	2,784	11,672
Dimension	short tons	21,893	626	e21,893	e626	W	W
Combined value of cement, gypsum, helium (Grade-A), iron ore (includes byproduct material), lead, mica (scrap), molybdenum, pyrites (1987), salt, silver, zinc (1989), and values indicated by symbol W		XX	52,783	XX	r60,368	XX	48,483
Total		XX	737,844	XX	1,022,672	XX	1,124,592
NEW YORK							
Cement:							
Masonry	thousand short tons	W	W	W	W	138	$7,971
Portland	do.	W	W	W	W	2,654	134,032
Clays	metric tons	610,205	$3,562	551,375	$3,654	531,559	3,429
Emery	short tons	1,945	W	W	W	—	—
Gem stones		NA	135	NA	200	NA	350
Peat	thousand short tons	1	34	W	W	W	10
Salt	do.	4,918	119,962	4,614	127,994	5,424	161,427
Sand and gravel:							
Construction	do.	e31,400	e112,900	33,884	124,341	e31,600	e118,500
Industrial	do.	58	651	53	625	53	633
Stone:							
Crushed	do.	38,103	188,694	e39,900	e193,500	39,851	201,749
Dimension	short tons	38,553	5,822	e30,751	e4,333	23,756	3,575
Combined value of garnet, gypsum, iron ore (includes byproduct material, 1988-89), lead, silver, talc and prophyllite, wollastonite, zinc, and values indicated by symbol W		XX	218,620	XX	241,053	XX	113,492
Total		XX	650,380	XX	695,700	XX	745,168
NORTH CAROLINA							
Clays	metric tons	2,929,351	$15,282	2,880,103	$16,349	2,270,384	$15,529
Feldspar	short tons	512,386	15,562	507,986	17,312	480,436	14,024
Gem stones		NA	550	NA	688	NA	784
Mica (scrap)	thousand metric tons	91	5,607	79	4,512	73	4,192
Peat	thousand short tons	W	W	21	W	W	W

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
NORTH CAROLINA—Continued							
Sand and gravel:							
Construction	thousand short tons	e8,600	e$30,100	11,076	$38,459	e11,200	e$43,700
Industrial	do.	1,184	15,329	1,246	15,953	1,627	19,902
Stone:							
Crushed	do.	48,847	237,181	e50,500	e250,000	51,519	257,976
Dimension	short tons	32,669	5,128	e31,977	e5,026	62,665	10,477
Combined value of lithium minerals, olivine, phosphate rock, talc and pyrophyllite, and values indicated symbol W		XX	152,178	XX	181,135	XX	214,984
Total		XX	476,917	XX	529,434	XX	581,568
NORTH DAKOTA							
Clays	metric tons	45,451	$100	76,918	$147	47,903	W
Gem stones		NA	2	NA	2	NA	$10
Lime	thousand short tons	127	11,912	108	7,094	107	5,439
Sand and gravel (construction)	do.	e4,900	e10,200	3,772	8,079	e3,600	e8,100
Combined value of peat, salt (1987-88), sand and gravel (industrial, 1987), stone (crushed miscellaneous, 1987-88) and value indicated by symbol W		XX	4,097	XX	3,485	XX	111
Total		XX	26,311	XX	18,807	XX	13,660
OHIO							
Cement:							
Masonry	thousand short tons	139	$11,964	129	$11,140	128	$11,233
Portland	do.	1,748	83,661	1,424	70,816	1,446	73,230
Clays	metric tons	2,891,446	12,714	3,365,164	14,423	3,519,668	14,983
Gem stones		NA	10	NA	10	NA	18
Lime	thousand short tons	1,926	93,108	2,065	87,431	1,888	94,157
Peat	do.	W	W	W	W	8	182
Salt	do.	3,276	104,099	3,795	115,860	W	W
Sand and gravel:							
Construction	do.	e36,400	e136,900	46,104	156,318	e44,400	e148,700
Industrial	do.	1,249	21,292	1,361	23,441	1,394	24,662
Stone:							
Crushed	do.	51,590	300,096	e48,000	e252,000	46,426	183,190
Dimension	short tons	47,816	2,427	e38,300	e3,137	59,923	3,455
Combined value of other industrial minerals and values indicated by symbol W		XX	2,510	XX	2,676	XX	145,346
Total		XX	768,781	XX	737,252	XX	699,156
OKLAHOMA							
Cement:							
Masonry	thousand short tons	41	$2,436	W	W	W	W
Portland	do.	1,415	54,870	1,432	$42,131	1,236	$39,360
Clays	metric tons	723,300	1,783	684,067	1,803	565,956	1,619
Gem stones		NA	8	NA	18	NA	W
Gypsum	thousand short tons	1,828	13,336	2,173	13,393	2,523	14,369
Iodine	kilograms	W	W	1,015,210	W	1,505,714	23,947
Sand and gravel:							
Construction	thousand short tons	e10,500	e24,200	9,273	22,654	e8,500	e20,000
Industrial	do.	1,243	17,078	1,268	17,381	1,216	18,310

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral	1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
OKLAHOMA—Continued						
Stone:						
Crushed[3] thousand short tons	25,155	$83,732	e26,300	e$92,000	23,598	$81,969
Dimension short tons	8,311	861	e7,746	e785	8,290	762
Combined value of feldspar, lime, salt (1987-88), stone (crushed dolomite, (1987-88), crushed granite, 1989), tripoli, and values indicated by symbol W	XX	24,915	XX	29,972	XX	18,695
Total	XX	223,219	XX	220,137	XX	219,031
OREGON						
Clays metric tons	242,966	$986	225,001	$1,049	210,893	$875
Gem stones	NA	350	NA	894	NA	1,304
Nickel (content of ores and concentrates) short tons	—	—	—	—	382	2,600
Sand and gravel (construction) thousand short tons	e13,000	e42,200	14,880	52,657	e14,400	e49,700
Stone (crushed) do.	20,663	73,902	e22,200	e77,600	3r18,407	3r81,204
Talc and pyrophyllite short tons	150	14	W	W	225	18
Combined value of cement, diatomite, gold, lime, pumice, silver, stone (crushed dolomite and quartzite, 1989), value indicated by symbol W	XX	43,544	XX	45,988	XX	49,854
Total	XX	160,996	XX	178,188	XX	185,555
PENNSYLVANIA						
Cement:						
Masonry thousand short tons	397	$30,464	391	$28,713	349	$26,473
Portland do.	6,325	334,709	6,309	329,634	5,757	301,980
Clays[2] metric tons	1,094,176	4,751	1,248,139	5,843	1,049,973	4,936
Gem stones	NA	5	NA	5	NA	5
Lime thousand short tons	1,574	93,430	1,641	91,214	1,660	92,139
Peat do.	18	513	21	736	20	746
Sand and gravel (construction) do.	e14,800	e72,900	19,826	91,966	e19,500	e94,600
Stone:						
Crushed do.	97,213	458,676	e104,600	e470,700	3r93,123	3r455,004
Dimension short tons	60,118	10,177	e59,022	e9,584	44,267	10,032
Combined value of clays (kaolin), mica (scrap), sand and gravel (industrial), stone (crushed granite, 1989), tripoli (1987-88), and value indicated by symbol W	XX	10,872	XX	14,098	XX	14,754
Total	XX	1,016,497	XX	1,042,493	XX	1,000,669
RHODE ISLAND						
Gem stones	NA	$1	NA	$1	NA	$2
Sand and gravel (construction) thousand short tons	e2,700	e10,900	1,853	7,847	1,100	3,900
Stone (crushed) do.	1,228	7,797	e1,500	e9,400	11r1,208	7,170
Total[8]	XX	18,698	XX	17,248	XX	11,072

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
SOUTH CAROLINA							
Cement (portland)	thousand short tons	2,567	$117,878	2,533	$118,670	2,188	$99,083
Clays	metric tons	[2]1,989,948	[2]38,244	1,867,829	40,541	1,596,153	39,075
Gem stones		NA	10	NA	10	NA	10
Sand and gravel:							
Construction	thousand short tons	[e]7,500	[e]19,500	7,529	20,751	[e]7,500	[e]23,300
Industrial	do.	844	15,188	859	15,271	842	16,635
Stone:							
Crushed[3]	do.	24,278	105,387	[e]23,500	[e]105,800	24,429	111,656
Dimension	short tons	2,319	312	[e]353	[e]31	W	W
Combined value of cement (masonry), clays (fuller's earth 1987), gold, manganiferous ore, mica (scrap), peat, silver, stone (crushed shell), vermiculite, and value indicated by symbol W		XX	44,806	XX	56,728	XX	135,538
Total		XX	341,325	XX	357,802	XX	425,297
SOUTH DAKOTA							
Cement:							
Masonry	thousand short tons	4	W	4	W	W	W
Portland	do.	519	W	490	W	W	W
Gem stones		NA	$100	NA	$100	NA	$150
Gold[4]	kilograms	W	W	13,981	197,026	16,123	198,318
Lead[4]	metric tons	—	—	—	—	4	3
Sand and gravel (construction)	thousand short tons	[e]9,600	[e]19,100	7,929	18,681	[e]6,400	[e]20,800
Silver[4]	metric tons	W	W	3	552	4	705
Stone:							
Crushed	thousand short tons	5,070	18,515	[e]5,500	[e]20,600	3,833	14,303
Dimension	short tons	50,718	18,209	[e]43,297	[e]16,472	54,623	17,738
Combined value of beryllium concentrates (1987), clays (common), feldspar, gypsum, iron ore (1988-89), lime, mica (scrap), and values indicated by symbol W		XX	206,968	XX	32,288	XX	32,341
Total		XX	262,892	XX	285,719	XX	284,358
TENNESSEE							
Clays[2]	metric tons	1,143,846	$25,480	1,165,736	$27,696	1,137,152	$26,292
Sand and gravel (construction)	thousand short tons	[e]7,900	[e]28,900	6,836	23,343	[e]6,100	[e]21,900
Stone:							
Crushed	do.	51,406	227,263	[e]52,200	[e]235,000	52,917	252,785
Dimension	short tons	3,360	573	[e]3,942	[e]567	4,888	437
Zinc[4]	metric tons	115,699	106,926	119,954	159,201	W	W
Combined value of barite, cement, clays (bentonite 1988, common 1989, fuller's earth), copper, gem stones, lead, lime, phosphate rock, pyrites, (1987), sand and gravel (industrial), silver, and value indicated by symbol W		XX	138,670	XX	139,842	XX	336,993
Total		XX	527,812	XX	585,649	XX	638,407

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
TEXAS							
Cement:							
Masonry	thousand short tons	172	$11,283	136	$10,800	133	$10,735
Portland	do.	7,318	319,996	7,000	292,256	7,200	286,236
Clays[2]	metric tons	3,007,706	14,825	2,714,451	17,468	2,276,629	15,962
Gem stones		NA	345	NA	340	NA	W
Gypsum	thousand short tons	1,874	14,254	1,943	15,790	1,993	17,044
Lime	do.	1,140	59,027	1,192	55,935	1,304	60,829
Salt	do.	7,810	60,857	7,802	62,925	7,856	69,934
Sand and gravel:							
Construction	do.	e48,200	e178,600	50,370	171,167	e43,900	e155,800
Industrial	do.	1,509	22,843	1,631	26,645	1,661	29,107
Stone:							
Crushed	do.	84,347	276,477	e82,000	e271,300	76,823	252,982
Dimension	short tons	75,426	10,030	e66,354	e8,310	81,268	12,449
Sulfur (Frasch)	thousand metric tons	2,152	W	2,622	W	2,446	W
Talc and pyrophyllite	short tons	255,039	4,380	260,950	4,466	266,513	4,564
Combined value of clays [ball clay, fuller's earth (1987), kaolin], helium (crude and Grade-A), iron ore, magnesium compounds, magnesium metal, sodium sulfate (natural), and values indicated by symbol W		XX	457,814	XX	531,416	XX	546,812
Total		XX	1,430,731	XX	1,468,818	XX	1,462,454
UTAH							
Beryllium concentrates	metric tons	5,499	$6	5,308	$6	1,592	$5
Cement (portland)	thousand short tons	935	50,565	772	39,664	W	W
Clays	metric tons	285,903	1,959	308,585	2,469	321,949	2,633
Gem stones		NA	105	NA	370	NA	659
Lime	thousand short tons	562	17,894	365	17,252	373	17,974
Salt	do.	1,108	34,264	1,006	35,294	1,183	40,421
Sand and gravel:							
Construction	do.	e21,000	e56,700	17,843	49,796	e14,300	e41,500
Industrial	do.	6	11	3	60	3	60
Stone:							
Crushed	do.	7,989	23,606	e7,300	e20,600	4,683	19,176
Dimension	short tons	2,004	93	e2,004	e93	—	—
Combined value of cement (masonry), copper, gold, gypsum, iron ore, magnesium compounds, magnesium metal, mercury, molybdenum, phosphate rock, potassium salts, silver, sodium sulfate (natural, 1988-89), vanadium, and value indicated by symbol W		XX	514,661	XX	849,243	XX	1,168,022
Total		XX	699,864	XX	1,014,847	XX	1,290,450

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral	1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
VERMONT						
Gem stones	NA	$10	NA	$10	NA	$10
Sand and gravel (construction) thousand short tons	e4,700	e10,800	6,047	17,478	e6,900	e20,400
Stone:						
Crushed do.	32,159	320,400	e 32,000	e 318,000	3,119	28,110
Dimension short tons	103,923	30,074	e105,000	e30,500	100,698	31,413
Combined value of other industrial minerals	XX	12,160	XX	10,957	XX	8,969
Total	XX	73,444	XX	76,945	XX	88,902
VIRGINIA						
Clays[2] metric tons	1,065,437	$6,291	1,010,114	$6,614	1,001,394	$6,302
Gem stones	NA	20	NA	20	NA	27
Lime thousand short tons	699	29,435	741	33,875	821	38,353
Sand and gravel (construction) do.	e12,100	e43,400	12,551	42,573	e12,900	e49,700
Stone:						
Crushed do.	60,376	295,903	e66,000	e326,700	64,061	328,050
Dimension short tons	9,077	2,720	e10,000	e2,900	W	W
Combined value of aplite, cement, clays (fuller's earth), gypsum, iron oxide pigments (crude), kyanite, sand and gravel (industrial), talc and pyrophyllite, vermiculite, and value indicated by symbol W	XX	83,673	XX	81,830	XX	86,698
Total	XX	461,442	XX	494,512	XX	509,130
WASHINGTON						
Cement (portland) thousand short tons	1,282	$63,600	979	$48,233	W	W
Clays metric tons	377,020	2,356	376,924	2,235	233,267	$1,591
Gem stones	NA	200	NA	200	NA	208
Peat thousand short tons	7	191	5	142	W	W
Sand and gravel:						
Construction do.	e25,300	e78,900	31,170	94,402	e37,800	e124,700
Industrial do.	294	5,186	W	W	W	W
Stone:						
Crushed do.	14,754	49,618	e13,900	e48,700	13,259	55,624
Dimension short tons	297	42	e697	e60	W	W
Combined value of calcium chloride (natural, 1987-88), cement (masonry), copper (1987), diatomite, gold, gypsum, lime, magnesium metal, olivine, silver, and values indicated by symbol W	XX	238,341	XX	265,362	XX	298,756
Total	XX	438,434	XX	459,334	XX	480,879
WEST VIRGINIA						
Clays metric tons	241,345	$565	239,473	$586	251,385	$553
Gem stones	NA	1	NA	1	NA	1
Sand and gravel (construction) thousand short tons	e1,000	e3,200	1,653	6,099	e2,300	e6,700
Stone (crushed) do.	12,458	50,947	e11,600	e47,600	310,904	342,538
Combined value of cement, lime, peat (1987-88), salt, sand and gravel (industrial), and stone (crushed granite, 1989)	XX	89,308	XX	73,169	XX	75,706
Total	XX	144,021	XX	127,455	XX	125,498

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION[1] IN THE UNITED STATES, BY STATE

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
WISCONSIN							
Gem stones		NA	$15	NA	$15	NA	W
Lime	thousand short tons	393	21,733	452	23,986	437	$18,129
Peat	do.	9	237	11	270	13	309
Sand and gravel:							
Construction	do.	e23,900	e57,000	25,048	60,080	e21,700	e56,400
Industrial	do.	1,314	15,168	1,351	15,458	1,514	22,399
Stone:							
Crushed	do.	322,757	371,776	e 328,500	e 398,300	26,520	83,664
Dimension	short tons	36,903	3,697	e49,900	e6,200	35,587	4,376
Combined value of other industrial minerals and value indicated by by symbol W		XX	16,846	XX	564	XX	(9)
Total		XX	186,472	XX	204,873	XX	8185,277
WYOMING							
Clays[2]	metric tons	1,930,169	$62,031	2,138,796	$72,174	2,166,497	$74,697
Gem stones		NA	150	NA	150	NA	157
Lime	thousand short tons	29	1,560	26	1,640	W	W
Sand and gravel (construction)	do.	e2,600	e9,000	3,413	11,351	e4,500	e15,400
Stone (crushed)	do.	3,171	15,049	e2,500	e11,400	2,990	12,120
Combined value of cement, clays (common), gypsum, helium (Grade-A), sodium carbonate (natural), and value indicated by symbol W		XX	557,265	XX	613,097	XX	724,987
Total		XX	645,055	XX	709,812	XX	827,361
UNDISTRIBUTED							
Delaware, Hawaii, Hew Hampshire, Rhode Island, Wisconsin and Undistributed		XX	$6,553	XX	$7,812	XX	$9,043

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data, value included with "Combined value" figure. 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.

[4]Recoverable content of ores, etc.

[5]Less than 1/2 unit.

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

[7]Beginning with 1989 data reported in B_2O_3, 1987-88 data converted.

[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]Value excluded to avoid disclosing company proprietary data.

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

[11]Excludes traprock.

TABLE 6

NONFUEL MINERAL PRODUCTION[1] IN THE ISLANDS ADMINISTERED BY THE UNITED STATES

Mineral	1987		1988		1989	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
American Samoa: Stone (crushed) thousand short tons	W	W	—	—	48	$476
Guam: Stone (crushed) do.	354	$2,289	—	—	1,063	11,133
Virgin Islands: Stone (crushed) do.	345	2,741	—	—	312	3,159
Total	XX	5,030	XX	—	XX	14,768

W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

TABLE 7

NONFUEL MINERAL[1] PRODUCTION IN THE COMMONWEALTH OF PUERTO RICO

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	1,296	$106,185	1,397	$113,966	1,374	$112,318
Clays	metric tons	134,290	318	148,218	365	136,873	311
Lime	thousand short tons	25	3,558	25	3,802	26	3,800
Salt	do.	40	900	40	900	—	—
Sand and gravel (industrial)	do.	67	W	31	624	30	600
Stone (crushed)	do.	8,480	41,299	e9,350	e47,400	8,389	46,648
Total[2]		XX	152,260	XX	167,057	XX	163,677

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.

TABLE 8

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

Mineral		1989	
		Quantity	Value (thousands)
METALS			
Aluminum:			
Metals and alloys, crude	metric tons	593,048	$1,260,638
Scrap	do.	574,170	767,573
Plates, sheets, bars, etc.	do.	425,609	1,250,090
Castings and forgings	do.	20,480	128,975
Aluminum sulfate	do.	941	1,208
Other aluminum compounds (fluorides and chlorides)	do.	34,317	23,997
Antimony:			
Metal, alloys, crude, waste and scrap	do.	293	694
Oxide	do.	2,229	6,106
Bauxite (dried and calcined)	thousand metric tons	44	9,830
Beryllium, alloys, waste and scrap	kilograms	34,261	3,847
Bismuth metal, alloys, waste, and scrap	do.	122,171	540
Cadmium metal, alloys, dross, flue dust, etc.	metric tons	369	857

TABLE 8—Continued

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

Mineral		1989 Quantity	1989 Value (thousands)
METALS—Continued			
Chromium (gross weight):			
Chromite ore and concentrate	metric tons	40,445	$5,014
Metal and alloys:			
Chromium metal	do.	196	4,097
Chromium ferroalloys	do.	9,464	11,037
Chemicals	do.	23,303	23,626
Pigments	do.	2,264	7,654
Cobalt:			
Metal (unwrought cobalt, powders, matte, waste and scrap) (estimated cobalt content)	do.	355	9,452
Oxides and hydroxides (est. cobalt content)	do.	434	6,073
Salts and compounds (est. cobalt content)	do.	101	1,724
Wrought cobalt and cobalt articles (gross weight)	do.	171	7,033
Cobalt ores and concentrates (gross weight)	do.	28	253
Copper:			
Ore and concentrate (copper content)	do.	266,831	539,325
Scrap (unalloyed scrap only)	do.	154,935	244,195
Refined copper	do.	130,189	303,013
Semimanufactures, copper and copper alloy	do.	179,028	807,257
Matte and blister (includes precipitates, ash, and residues)	do.	14,949	35,365
Ferroalloys not elsewhere listed:			
Ferrophosphorous	short tons	24,898	3,511
Ferroalloys, n.e.c.	do.	6,642	9,068
Gold:			
Ores and concentrates	kilograms	16	165
Wastes and scrap	do.	44,541	542,150
Dore and precipitates	do.	42,935	242,690
Bullion, refined	do.	123,599	1,490,151
Iron ore (gross weight):			
Nonagglomerated:			
Concentrates	thousand metric tons	353	13,887
Coarse ores	do.	—	—
Fine ores	do.	145	559
Agglomerated:			
Pellets	do.	4,852	177,980
Sinter, briquettes, and miscellaneous agglomerates	do.	14	139
Roasted pyrites	do.	1	117
Iron chemicals (gross weight):			
Chlorides	metric tons	172	202
Sulfates	do.	—	—
Iron and steel:			
Pig iron	short tons	11,747	1,334

See footnote at end of table.

TABLE 8—Continued

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

Mineral		1989 Quantity	1989 Value (thousands)
METALS—Continued			
Iron and steel products (major):			
Steel mill products	short tons	NA	NA
Other steel products	do.	NA	NA
Iron and steel scrap: Ferrous scrap including rerolling material and ships, boats, and other vessels for scrapping	thousand short tons	12,476	$1,776,738
Lead:			
Ore and concentrate (lead content)	metric tons	57,038	23,516
Pigs, bars, cathodes, sheets, etc. (lead content)	do.	33,877	44,204
Scrap (gross weight)	do.	59,909	26,165
Magnesium, metal and alloys, scrap, semimanufactured forms, n.e.c. (gross weight)	do.	56,631	170,374
Manganese:			
Ore and concentrate	short tons	57,191	5,014
Ferromanganese	do.	9,014	7,310
Silicomanganese	do.	5,858	4,068
Metal	do.	5,667	10,632
Mercury: metal	metric tons	221	1,874
Molybdenum:			
Ore and concentrate (molybdenum content)	thousand pounds	112,946	283,371
Molybdates (gross weight)	do.	3,067	16,947
Molybdenum, unwrought (gross weight)	do.	558	3,216
Molybdenum, wrought (gross weight)	do.	743	8,219
Wire (gross weight)	do.	751	10,868
Powder (gross weight)	do.	1,399	3,846
Ferromolybdenum (gross weight)	do.	165	615
Nickel:			
Primary (unwrought commercially pure, cathodes, ferronickel, pellets, briquettes, shot, powder and flakes)	short tons	2,327	XX
Wrought (bars, rods, angles, shapes, sections, plates, sheets, strip; tubes, pipes, blanks, fittings, hollow bar; wire)			
Stainless steel scrap (nickel content)	do.	21,871	XX
Compound catalysts and waste and scrap	do.	6,736	34,875
Platinum-group metals:			
Platinum	kilograms	8,414	135,469
Palladium	do.	13,005	72,849
Rhodium	do.	1,156	28,519
Iridium, ruthenium, and osmium	do.	507	4,232
Waste and scrap	do.	15,046	157,040
Rare-earth metals:			
Rare-earth metals, including scandium and yttrium	do.	424,837	4,801
Ores and concentrates	metric tons	776	560
Cerium compounds	kilograms	1,432,672	7,026
Selenium	do.	372,126	3,429
Silicon:			
Silicon metal	short tons	5,561	84,074
Ferrosilicon	do.	54,056	40,842

See footnotes at end of table.

TABLE 8—Continued

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

Mineral		1989 Quantity	1989 Value (thousands)
METALS—Continued			
Silver:			
Ores and concentrates	kilograms	607	$166
Waste and scrap	do.	770,788	145,340
Dore and precipitates	do.	78,664	15,478
Bullion, refined	do.	430,110	77,812
Tantalum:			
Ore, metal, other forms (gross weight)	thousand pounds	366	$26,315
Powder (tantalum content)	do.	211	21,451
Tin:			
Ingots, pigs, bars, etc.	metric tons	904	8,915
Tinplate and terneplate	do.	178,884	101,279
Titanium:			
Ore and concentrates	do.	19,832	5,900
Sponge	do.	136	910
Scrap	do.	5,474	22,909
Ingot, slab, sheet bar, etc.	do.	3,875	63,772
Other articles of titanium	do.	3,857	110,511
Pigments and oxides	do.	212,197	437,645
Tungsten (tungsten content):			
Ore and concentrate	do.	203	1,539
Carbide powder	do.	1,360	27,209
Metal powder	do.	762	15,554
Vanadium:			
Pentoxide, anhydride (gross weight)	thousand pounds	8,248	35,204
Ferrovanadium (gross weight)	do.	1,087	5,299
Zinc:			
Slabs, pigs, or blocks	metric tons	7,955	14,433
Waste and scrap (zinc content)	do.	108,086	75,947
Powders and flakes (zinc content)	do.	8,137	13,861
Ore and concentrate (zinc content)	do.	78,877	64,224
Zirconium:			
Ore and concentrates	do.	48,176	33,159
Metal and scrap	do.	242	5,997
INDUSTRIAL MINERALS			
Abrasives (includes reexports):			
Industrial diamond, natural or synthetic:			
Powder or dust	thousand carats	78,235	124,180
Other	do.	2,755	33,248
Diamond grinding wheels	thousand wheels	761	9,896
Other natural and artificial metallic abrasives and products		XX	126,810
Asbestos:			
Exports (includes reexports):			
Unmanufactured	metric tons	27,004	7,690
Products		NA	153,081
Barite: Natural barium sulfate	metric tons	9,709	1,622
Boron:			
Boric acid	thousand metric tons	42	32,613
Sodium borates	do.	646	$361,000

See footnotes at end of table.

TABLE 8—Continued

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

Mineral		1989	
		Quantity	Value (thousands)
INDUSTRIAL MINERALS—Continued			
Bromine:			
Compounds (contained bromine)	thousand kilograms	28,998	$24,093
Elemental	do.	3,557	3,165
Calcium chloride	metric tons	20,316	5,695
Cement: Hydraulic and clinker	thousand short tons	512	25,561
Clays:			
Kaolin and china clay	thousand metric tons	2,337	370,919
Bentonite	do.	671	52,946
Other	do.	748	126,478
Diatomite	do.	137	41,290
Feldspar, leucite, nepheline syenite	short tons	10,283	829
Fluorspar	metric tons	5,134	694
Gem stones (including reexports):			
Diamonds	thousand carats	1,050	1,243,700
Pearls		NA	7,300
Other		NA	222,200
Graphite, natural	metric tons	11,452	7,421
Gypsum:			
Crude	thousand short tons	108	2,286
Plasters	do.	106	15,914
Boards	do.	97	25,140
Other	do.	NA	16,972
Helium	million cubic feet	796	33,830
Lime	short tons	32,241	3,893
Lithium compounds:			
Lithium carbonate	kilograms	9,045,732	28,214
Lithium hydroxide	do.	4,691,991	17,914
Lithium metal	do.	537,557	NA
Magnesium compounds:			
Caustic-calcined and unspecified magnesia	metric tons	20,218	11,476
Compounds, includes magnesium hydroxide, magnesium peroxide, magnesium chloride, and magnesium sulfate	do.	14,851	6,100
Crude magnesite	do.	10,380	8,299
Refractory and fused magnesia	do.	22,525	10,685
Mica:			
Powder	do.	3,628	1,634
Waste	do.	1,224	555
Unworked	do.	60	156
Worked	do.	415	7,227
Mineral-earth pigments, iron oxide, natuural, and synthetic	do.	9,966	15,700
Nitrogen compounds (major):			
Fertilizer materials	thousand short tons	13,569	NA
Industrial chemicals	do.	192	150,813
Phosphate rock (ground and unground)	thousand metric tons	8,323	288,990

See footnote at end of table.

TABLE 8—Continued

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

Mineral		1989 Quantity	1989 Value (thousands)
INDUSTRIAL MINERALS—Continued			
Phosphatic fertilizers:			
Phosphoric acid	thousand metric tons	703	$124,074
Superphosphates	do.	534	151,861
Diammonium and monoammonium phosphates	do.	9,102	1,608,264
Elemental phosphorous	metric tons	19,934	28,294
Pigments and compounds: Zinc oxide (metal content)	do.	13,989	19,946
Potash:			
Potassium chloride	metric tons	496,575	NA
Potassium sulfate, all grades	do.	448,880	NA
Quartz crystal:			
Cultured	thousand kilograms	57	2,600
Natural	do.	NA	NA
Salt, crude and refined	thousand short tons	1,567	20,211
Sand and gravel:			
Construction:			
Sand	do.	273	5,888
Gravel	do.	852	7,703
Industrial sand	do.	2,060	78,308
Sodium compounds:			
Soda ash	do.	2,919	365,469
Sodium sulfate	do.	68	6,241
Stone:			
Crushed	do.	3,900	23,345
Dimension		NA	34,610
Sulfur, elemental	thousand metric tons	1,024	107,126
Talc, crude and ground	do.	319	28,949
Total		XX	18,496,017

NA Not available. XX Not applicable.

TABLE 9

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

Mineral		1989 Quantity	1989 Value (thousands)
METALS			
Aluminum:			
Metals and alloys, crude	metric tons	923,030	$1,898,132
Scrap	do.	206,610	309,122
Plates, sheets, bars, etc.	do.	340,384	950,916
Aluminium oxide (alumina)	thousand metric tons	4,311	1,228,123
Antimony:			
Ore and concentrate (antimony content)	metric tons	4,550	8,462

TABLE 9—Continued

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

Mineral		1989	
		Quantity	Value (thousands)
METALS—Continued			
Antimony—Continued			
Antimony and articles thereof, including waste and scrap	metric tons	10,621	$21,143
Antimony oxides	do.	12,041	19,770
Arsenic:			
Arsenic trioxide	do.	28,348	13,526
Acid	do.	48	67
Sulfides	do.	2	19
Metallic	do.	928	2,150
Bauxite, crude	thousand metric tons	10,666	NA
Beryllium ore	metric tons	601	$655
Bismuth, metals and alloys (gross weight)	kilograms	1,880,321	21,586
Cadmium metal	metric tons	2,787	30,161
Chromium (gross weight):			
Chromite ore and concentrate	do.	525,044	43,949
Metals and alloys:			
Chromium metal	do.	4,202	27,590
Chromium ferroalloys	do.	343,732	330,427
Chemicals	do.	12,895	23,677
Pigments	do.	5,963	13,355
Cobalt:			
Metal (estimated cobalt content)	do.	5,444	91,960
Oxide and hydroxides (estimated cobalt content)	do.	273	6,598
Salts and compounds (estimated cobalt content)	do.	75	1,426
Unwrought cobalt alloys (gross weight)	do.	90	3,301
Other cobalt: Matte, waste, and scrap (gross weight)	do.	364	5,054
Wrought cobalt and cobalt articles (gross weight)	do.	84	3,627
Columbium ore (gross weight)	thousand pounds	4,891	7,649
Copper (copper content):			
Ore and concentrate	metric tons	46,515	50,744
Matte	do.	2,252	5,232
Blister	do.	77,217	236,129
Refined copper	do.	300,110	846,609
Semimanufactures, copper and copper alloy	do.	100,254	398,605
Scrap	do.	31,578	87,253
Ferroalloys not elsewhere listed, including spiegeleisen	short tons	2,578	7,737
Gallium	kilograms	15,284	5,665
Germanium	do.	40,105	23,789
Gold:			
Ore and concentrates	do.	2,426	7,103
Wastes and scrap	do.	39,952	115,685
Dore and precipitates	do.	13,159	157,952
Bullion, refined	do.	96,967	1,198,734
Hafnium: Waste and scrap	metric tons	4	976

See footnote at end of table.

TABLE 9—Continued

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

Mineral		1989 Quantity	1989 Value (thousands)
METALS—Continued			
Indium	kilograms	26,813	$8,944
Iron ore (gross weight):			
Nonagglomerated:			
Concentrates	thousand metric tons	371	7,760
Coarse ores	do.	662	15,566
Fine ores	do.	11,629	297,913
Agglomerated:			
Pellets	do.	5,628	175,728
Sinter, briquettes, and miscellaneous agglomerates	do.	1,186	23,251
Roasted iron pyrites	do.	121	2,045
Iron chemicals (gross weight):			
Chlorides	metric tons	1,116	494
Sulfates	do.	7,554	1,429
Iron and steel:			
Direct reduced iron	short tons	188,038	22,621
Pig iron	do.	488,175	73,184
Iron and steel products (major):			
Steel mill products	thousands	17,333	7,590,841
Other products	do.	2,378	2,884,328
Scrap, including tinplate and terneplate	thousand short tons	1,120	149,109
Lead:			
Ore and concentrates (lead content)	metric tons	5,122	1,975
Base bullion (lead content)	do.	5,782	4,538
Pigs and bars (lead content)	do.	115,681	79,863
Reclaimed scrap, including ash and residues (lead content)	do.	677	286
Wrought lead, all forms, including wire and powders (gross weight)	do.	6,068	9,076
Magnesium:			
Metal and scrap	do.	7,652	20,229
Alloys (magnesium content)	do.	3,829	14,702
Sheets, tubing, ribbons, wire, other forms (magnesium content)	do.	808	2,928
Manganese:			
Ore (20% or more contained manganese)	do.	638,524	43,794
Ferromanganese	do.	476,063	246,540
Ferrosilicon-manganese	do.	255,391	151,241
Metal	do.	16,147	22,283
Mercury: Metal, waste and scrap	do.	131	1,247
Molybdenum:			
Ore and concentrate (molybdenum content)	thousand pounds	—	—
Waste and scrap (gross weight)	do.	386	1,701
Metal:			
Unwrought (molybdenum content)	do.	102	2,391
Wrought (gross weight)	do.	111	3,311
Ferromolybdenum (gross weight)	do.	3,108	9,062

TABLE 9—Continued

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

Mineral		1989 Quantity	1989 Value (thousands)
METALS—Continued			
Material in chief value molybdenum (molybdenum content)	thousand pounds	524	$1,791
Compounds (gross weight)	do.	4,976	12,106
Nickel:			
Cathodes, pellets, briquets, and shot	short tons	100,448	114,861
Plates, bars, etc.	do.	911	16,511
Powder and flakes	do.	11,572	127,118
Ferronickel	do.	12,650	117,630
Oxide	do.	5,550	3,052
Platinum-group metals:			
Platinum	kilograms	49,238	801,728
Palladium	do.	51,135	263,790
Rhodium	do.	7,105	270,466
Ruthenium	do.	2,883	7,512
Iridium	do.	688	6,565
Osmium	do.	58	605
Waste and scrap	do.	2,159	30,944
Ores	do.	12	83
Rare-earth metals:			
Monazite	metric tons	974	674
Metals, intermixed or interalloyed	kilograms	294,236	4,181
Cerium compounds	do.	250,806	1,940
Rare-earth oxides, except cerium oxide	do.	501,898	6,986
Other rare-earth compounds or mixtures	do.	1,402,448	8,086
Other rare-earth oxides or other rare-earth chlorides	do.	7,390,689	30,709
Ferrocerium and other pyrophoric alloys	do.	244,271	1,690
Rhenium:			
Metal including scrap	pounds	8,345	4,197
Ammonium perrhenate (rhenium content)	do.	2,089	949
Selenium and selenium dioxide (selenium content)	kilograms	417,095	8,934
Silicon:			
Silicon metal	short tons	47,615	80,388
Ferrosilicon	do.	196,096	131,631
Silver:			
Ore and concentrates	kilograms	7,013	2,301
Waste and scrap	do.	90,753	96,254
Dore and precipitates	do.	142,739	27,943
Bullion,refined	do.	3,061,548	578,781
Tantalum ore (gross weight)	thousand pounds	3,850	52,762
Tellurium (gross weight)	kilograms	42,871	3,249
Thallium	do.	1,173	123
Tin:			
Tin ores and concentrates, containing by weight less than 5% lead (tin content)	metric tons	216	1,938
Metal	do.	33,988	288,118

TABLE 9—Continued

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

Mineral		1989 Quantity	1989 Value (thousands)
METALS—Continued			
Dross, skimmings, scrap,residues, tin alloys, n.s.p.f.	metric tons	10,270	$34,695
Tinfoil, powder, flitters, etc.	do.	XX	4,570
Tin compounds	do.	314	2,720
Titanium:			
Ilmenite[1]	do.	797,897	110,611
Rutile, natural and synthetic	do.	264,895	119,928
Sponge	do.	903	8,181
Scrap	do.	5,308	41,898
Other unwrought	do.	309	8,336
Other articles of titanium	do.	1,250	34,085
Pigments	do.	166,346	277,140
Tungsten ore and concentrate (tungsten content)	do.	7,896	45,077
Vanadium:			
Ferrovanadium (vanadium content)	thousand pounds	1,073	13,493
Pentoxide (vanadium content)	do.	203	1,911
Vanadium-bearing materials (slags and dross) (pentoxide content)	do.	8,979	18,762
Vanadim-bearing ash and residues (pentoxide content)	do.	3,157	5,035
Zinc:			
Ore and concentrates (zinc content)	metric tons	40,974	23,047
Blocks, pigs, slabs	do.	711,554	1,183,523
Sheets, etc.	do.	3,066	5,436
Dross, ashes, and fume (zinc content)	do.	9,031	7,856
Waste and scrap	do.	9,367	6,674
Dust, powder, flakes	do.	7,253	15,123
Zirconium:			
Ore and concentrates	do.	73,196	33,958
Metal, and scrap	do.	268	2,110
INDUSTRIAL MINERALS			
Abrasives:			
Diamond (industrial)	thousand carats	70,343	105,295
Other		XX	315,689
Asbestos	metric tons	55,306	14,031
Barite:			
Crude and ground	thousand metric tons	1,034	44,679
Witherite	metric tons	76	30
Chemicals	do.	32,637	24,041
Boron (contained boric oxide):			
Boric acid	thousand metric tons	3	2,197
Colemanite	do.	15	4,202
Ulexite	do.	27	1,552
Bromine:			
Elemental	thousand kilograms	460	293
Compounds	do.	30,524	55,602
Calcium metal	kilograms	679,603	3,210

See footnote at end of table.

TABLE 9—Continued

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

Mineral		1989 Quantity	1989 Value (thousands)
INDUSTRIAL MINERALS—Continued			
Calcium chloride:			
Crude	metric tons	119,296	$20,856
Other	do.	279	587
Cement: Hydraulic and clinker	thousand short tons	15,741	489,523
Clays	metric tons	27,794	10,928
Cryolite, natural and synthetic	do.	8,429	7,647
Diatomite	thousand short tons	187	41,290
Feldspar, crude, ground and crushed	metric tons	334,000	12,273
Fluorspar	do.	655,590	79,875
Hydrofluoric acid	do.	114,676	117,920
Gem stones:			
Diamond	thousand carats	10,689	4,358,147
Emeralds	do.	3,402	207,546
Rubies and sapphires	do.	6,666	183,344
Pearls (natural, cultured, and imitation)	do.	NA	154,173
Other		NA	211,339
Graphite, natural and synthetic	metric tons	99,374	83,218
Gypsum:			
Crude	thousand short tons	9,304	59,107
Plasters	do.	3	270
Boards	do.	355	29,355
Other	do.	NA	22,280
Iodine (includes crude, potassium iodide, and resublimed iodine)	thousand kilograms	3,326	58,980
Lime:			
Hydrated	short tons	36,952	2,219
Other lime	do.	180,704	9,749
Lithium:			
Carbonate	metric tons	3,326	6,629
Hydroxide	do.	23	164
Ores	do.	31,660	3,049
Compounds	do.	7,191	7,108
Salt	do.	14	14
Metal	do.	15	31
Magnesium compounds:			
Caustic-calcined and unspecified magnesia	do.	81,458	22,851
Compounds, includes magnesium hydroxide, magnesium peroxide, magnesium chloride, and magnesium sulfate	do.	29,002	6,942
Crude magnesite	do.	8,372	1,354
Refractory and fused magnesia	do.	202,790	38,555
Mica:			
Powder	do.	8,902	4,971
Waste	do.	4,185	1,259
Unworked	do.	1,616	2,054
Worked	do.	1,129	6,711
Mineral-earth pigments, iron oxide:			
Natural earth colors, crude and refined	do.	2,135	999

See footnote at end of table.

TABLE 9—Continued

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

Mineral		1989 Quantity	1989 Value (thousands)
INDUSTRIAL MINERALS—Continued			
Mineral-earth pigments, iron oxide—Continued			
Natural micaceous, crude and refined	metric tons	2,826	$355
Synthetic	do.	31,708	29,186
Nepheline syenite, crude, ground, crushed, etc.	short tons	—	—
Nitrogen compounds (major):			
Fertilizer materials	thousand short tons	8,325	920,785
Industrial chemicals	do.	138	108,392
Peat moss (poultry and fertilizer grade)	short tons	529,706	69,931
Phosphate rock and phosphatic materials	thousand metric tons	814	80,284
Pigments and salts:			
Lead pigments and compounds	metric tons	20,770	27,030
Zinc pigments and compounds	do.	71,825	105,089
Potash (includes potassium chloride, postassium sulfate, potassium nitrate, and sodium nitrate)	do.	5,618,300	501,300
Pumice:			
Crude or crushed	do.	273,464	12,483
Wholly or partially manufactured	do.	23,691	3,649
Salt	thousand short tons	6,084	74,474
Sand and gravel:			
Industrial sand	do.	35	2,057
Other sand and gravel	do.	427	6,618
Sodium compounds:			
Soda ash	do.	141,967	17,396
Sodium sulfate	do.	190	13,900
Stone:			
Crushed	do.	4,352	35,631
Dimension		NA	525,052
Calcium carbonate fines	thousand short tons	4	1,234
Strontium:			
Celestite (strontium sulfate)	metric tons	25,640	1,956
Compounds and metal	do.	19,129	11,072
Sulfur, crude, other, colloidal-precipitated or sublimed	thousand metric tons	2,260	209,465
Talc, unmanufactured	thousand short tons	77,716	12,128
Total[2]		XX	34,787,000

NA Not available. XX Not applicable.

[1]Includes titanium slag averaging about 70% TiO_2. For details, see "Titanium" chapter.

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

TABLE 10

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

Mineral		1988			1989[p]		
		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	67,992	W	NA	68,362	W	NA
Arsenic trioxide[3]	do.	52,047	—	—	52,390	—	—
Bauxite[4]	thousand metric tons	97,946	588	1	105,029	W	NA
Beryllium concentrates (gross weight)	metric tons	8,302	[5]5,313	64	7,586	[5]4,592	61
Bismuth	do.	3,567	W	NA	3,595	W	NA
Chromite	thousand metric tons	12,167	—	—	11,901	—	—
Cobalt[2]	metric tons	47,205	—	—	47,360	—	—
Columbium-tantalum concentrates (gross weight)	thousand pounds	88,641	—	—	73,306	—	—
Copper[2]	thousand metric tons	8,536	1,420	17	8,887	1,497	17
Gold[2]	kilograms	1,847,840	200,914	11	1,971,004	265,541	13
Iron ore (gross weight)	thousand metric tons	906,293	57,515	6	923,632	59,032	6
Lead[2]	do.	3,414	394	12	3,395	419	12
Manganese ore (gross weight)	thousand short tons	26,300	—	—	26,483	—	—
Mercury	metric tons	5,890	W	NA	5,840	W	NA
Molybdenum[2]	thousand pounds	208,209	94,911	46	256,658	139,123	54
Nickel[2]	thousand short tons	961	—	—	1,027	—	—
Platinum-group metals[3]	kilograms	281,854	[e]4,970	2	283,643	[e]6,280	2
Silver[2]	metric tons	14,167	1,661	12	14,452	2,007	14
Tin[2]	do.	200,150	W	NA	216,457	W	NA
Titanium concentrates (gross weight):							
Ilmenite	thousand metric tons	4,002	W	NA	4,213	W	NA
Rutile	do.	434	W	NA	476	W	NA
Tungsten[2]	metric tons	42,604	W	NA	43,280	W	NA
Vanadium[2]	short tons	33,660	W	NA	33,800	W	NA
Zinc[2]	thousand metric tons	7,015	256	4	7,062	288	4
METALS, SMELTER BASIS							
Aluminum (primary)	do.	17,608	3,944	22	17,980	4,030	22
Cadmium	metric tons	21,899	1,885	9	21,002	1,550	7
Cobalt	do.	27,166	—	—	26,319	—	—
Copper (primary and secondary)[6]	thousand metric tons	9,285	1,363	15	9,535	1,480	16
Iron, pig	thousand short tons	606,030	55,745	9	617,300	55,873	9
Lead (primary and secondary)[7]	thousand metric tons	5,810	1,129	19	5,866	1,205	21
Magnesium (primary)	metric tons	334,372	141,983	42	343,548	152,066	44
Nickel[8]	short tons	947,662	—	—	952,834	382	([9])
Selenium[10]	kilograms	1,540,381	285,600	19	1,553,285	253,427	16
Steel, raw	thousand short tons	857,941	99,924	12	863,064	97,943	11
Tellurium[10]	kilograms	78,259	W	NA	65,031	W	NA
Tin (primary and secondary)	metric tons	234,624	[11]2,045	1	241,828	[11]1,569	1
Zinc (primary and secondary)	thousand metric tons	7,115	330	5	7,186	358	5
INDUSTRIAL MINERALS							
Asbestos	do.	4,323	18	([8])	4,325	17	([8])
Barite	do.	5,481	[12]404	7	5,712	[12]290	5
Boron minerals	do.	2,880	1,149	40	2,989	1,114	37
Bromine	kilograms	408,792	[12]163,300	40	422,900	[12]174,600	41
Cement, hydraulic	thousand short tons	1,215,498	[13]78,252	6	1,235,613	[13]78,559	6

See footnotes at end of table.

TABLE 10—Continued

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

Mineral		1988			1989[p]		
		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	9,586	[12]2,871	30	9,794	[12]3,112	32
Fuller's earth[10]	do.	3,178	[12]1,973	62	3,079	[12]1,882	61
Kaolin[3]	do.	24,818	[12]8,973	36	25,669	[12]8,974	35
Diamond, natural	thousand carats	93,346	—	—	94,837	—	—
Diatomite	thousand metric tons	1,872	629	34	1,838	617	34
Feldspar	thousand short tons	5,150	715	14	5,155	720	14
Fluorspar	thousand metric tons	5,292	[e]64	1	5,731	[e]66	1
Graphite, natural	metric tons	643,938	W	NA	631,213	W	NA
Gypsum	thousand short tons	105,776	16,390	15	108,624	17,624	16
Iodine, crude	metric tons	14,994	998	7	15,622	1,508	10
Lime	thousand short tons	146,308	[12 13]17,077	12	149,184	[12 13]17,178	12
Magnesite, crude	thousand metric tons	11,936	W	NA	12,003	W	NA
Mica (including scrap and ground)	metric tons	274,585	129,900	47	265,387	119,142	45
Nitrogen (N content of ammonia)	thousand short tons	108,448	13,827	13	109,720	13,830	13
Peat	do.	214,864	844	([8])	213,931	755	([8])
Perlite	do.	2,062	[12]576	28	2,109	[12]601	28
Phosphate rock (gross weight)	thousand metric tons	160,375	45,389	28	162,268	48,866	30
Potash (K_2O equivalent)	do.	32,108	1,521	5	29,789	1,595	5
Pumice[10]	do.	12,636	[12]353	3	12,312	[e 12]424	3
Salt	thousand short tons	202,785	[12 13]38,368	19	209,988	[12 13]38,901	19
Sodium compounds, n.e.s. (natural and manufactured):							
Soda ash	do.	34,234	9,632	28	34,910	9,915	28
Sulfate	do.	5,182	788	15	5,217	777	15
Strontium[10]	metric tons	231,013	—	—	244,300	—	—
Sulfur, all forms	thousand metric tons	58,096	10,746	18	58,348	11,592	20
Talc and pyrophyllite	do.	7,991	1,237	15	7,980	1,253	16
Vermiculite[10]	short tons	599,834	[12]304,000	51	604,300	[e 12]290,000	48

[e]Estimated. [p]Preliminary. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in world total.

[1]For 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. percentage 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 equivalent basis, but for some countries available data are insufficient to permit this adjustment.

[5]Shipments.

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

[7]Includes bullion.

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

[9]Less than 0.5%.

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

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

[12]Quantity sold or used by producers.

[13]Includes Puerto Rico.

THE MINERAL INDUSTRY OF ALABAMA

This chapter has been prepared under a Memorandum of Understanding between the 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]

In 1989, Alabama's nonfuel mineral industry produced a State record of $463 million of nonfuel mineral commodities, an increase of $4 million over that reported by the State's mineral producers in 1988. The new record marked the fourth consecutive year in which mineral production increased over that of the previous year. Alabama ranked 22d among the States in total mineral value.

Cement, stone, and sand and gravel were the three leading mineral commodities produced, accounting for 77% of Alabama's total mineral value. During the year, there were several acquisitions by Alabama cement and stone companies, and the only tantalum mine in the United States completed its first full year of operation.

TRENDS AND DEVELOPMENTS

During the decade of the 1980's, Alabama's nonfuel mineral production contributed almost $4 billion to the economy of the State. Mineral value for the decade is summarized in the following table:

Year	Value (millions)
1989	$463
1988	459
1987	447
1986	405
1985	406
1984	409
1983	361
1982	299
1981	314
1980	328

In the early part of the decade, value plummeted $99 million because the

TABLE 1

NONFUEL MINERAL PRODUCTION IN ALABAMA[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Cement:							
Masonry	thousand short tons	291	$17,626	273	$16,457	252	$13,852
Portland	do.	3,600	160,878	3,524	157,214	3,169	130,590
Clays[2]	metric tons	2,031,163	16,217	2,282,670	16,039	1,878,070	18,537
Gem stones		NA	7	NA	5	NA	W
Lime	thousand short tons	1,232	52,200	1,450	66,576	1,481	70,361
Sand and gravel:							
Construction	do.	e10,300	e35,600	11,742	41,417	e10,400	e36,500
Industrial	do.	580	5,025	871	e8,507	805	8,092
Stone (crushed)	do.	30,018	146,247	e29,700	e140,100	3 31,737	3 167,332
Combined value of bauxite, clays (bentonite), salt, stone (crushed granite 1989, dimension), talc and pyrophyllite (1988-89), zircon concentrates, (1988-89), and value indicated by symbol W		XX	12,843	XX	13,180	XX	17,487
Total		XX	446,643	XX	459,495	XX	462,751

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

1980–82 recession had a devastating effect on the construction industry and sales of construction mineral commodities. In 1982, the State's sand and gravel industry sold 4 million tons less than in 1980, and stone production fell 22 million tons below the 1980 level. Clay output, used primarily in brick manufacture, fell from 2 million tons in 1980 to 1.3 million tons in 1982.

In 1983, the country recovered from the recession, and sales by Alabama's mineral industry established a new record high of $361 million. In the 1984–86 period, although sales exceeded $400 million for the first time, mineral value remained essentially stagnant. In 1987, however, a trend of increased output and sales began to emerge.

Several industrial mineral companies announced developments during 1989. Vulcan Materials Co., a leading United States crushed stone producer based in Birmingham, purchased several quarries, one in Alabama and others in the Southeast. The Ideal Basic Industries Inc. cement plant in Theodore received the first shipment of stone from the company's new quarry in Florida. Ideal Basic also purchased a Hoover cement firm.

Both the extractive and manufacturing sectors of the metals industry were in the news during the year. Coosa Mining Ltd. completed the first year of operation of the only tantalum mine in the United States. Reynolds Metals Co. began work on an aluminum casting facility at Listerhill, near Sheffield. Upon completion, annual capacity will exceed 1 billion pounds. Gulf States Steel Inc., Gadsden, completed blast furnace improvements, upping capacity from 2,500 to 3,000 short tons daily. Work was ongoing on continuous caster installation at yearend. American Cast Iron Pipe Co., Birmingham, completed construction of a second ductile steel pipe mill. With the increased capacity from the new mill, the company became the world's second largest.

The Geological Survey of Alabama reported capital investments for new or expanded facilities in the mineral-related field as follows: cement-concrete, $1.4 million; industrial minerals, $32 million; and primary metals, $238 million.

Alabama's coal output climbed to 26.6 million short tons, an increase of about 500,000 tons over the 1988 level. Natural gas recovery totaled 181,285 million cubic feet, an increase of 5 million cubic feet over that reported in 1988. Crude oil and condensate production, however, fell from 20.6 million barrels in 1988 to 19.6 million barrels in 1989.[3]

The State's coal industry operated 70 surface mines and washing plants and 15 underground mines. More than 3,000 of Alabama's coal miners struck for 28 days in support of striking miners in Kentucky, Virginia, and West Virginia.

The year was a banner one for the coalbed methane industry because 1,079 wells were permitted. From 1980 to 1988, 990 wells were permitted.[4]

The Geological Survey of Alabama estimated the value of the State's fuel production in 1989 at over $1.6 billion. Oil production was valued at $144.8 million, condensate at $176 million, gas at $207 million, and coal at $1.1 billion. Capital investments in new and/or expanding facilities in the oil and gas-petroleum and coal industries totaled over $11 million.[5]

EMPLOYMENT

Employment in the mining and quarrying sector increased from 11,200 in 1988 to 11,300 in 1989.[6]

REGULATORY ISSUES

The disposal of saline water collected during coalbed methane recovery has proved to be a major environmental concern for the methane industry, the Alabama Department of Environmental Management, and the environmental community. Most methane fields pump the water to discharge points at nearby waterways under department permit. The environmental community is opposed to this type of disposal. The saline water problem was the largest facing the coalbed methane industry as the decade ended.

Interstate Lead Co., Leeds, was fined more than $2 million for 154 alleged health and safety violations at its secondary lead smelter. The fines were levied by the U.S. Occupational Safety and Health Administration.[7]

American Brass Inc., Headland, was fined $242,000 by the U.S. Environmental Protection Agency. The fine was for storing toxic waste at its brass foundry.[8]

EXPLORATION ACTIVITIES

Gold exploration in Alabama included the reconnaisance evaluation of deposits and prospects in Tallapoosa County and a limited amount of drilling in Cleburne County. Exploration for heavy minerals in the Coastal Plain region was also reported.

LEGISLATION AND GOVERNMENT PROGRAMS

The State's 1989 legislative session resulted in no bills directly affecting Alabama's mineral industry.

The University of Alabama hosted the 1989 Coalbed Methane Symposium, which was attended by over 350 scientists and engineers from the United States and several foreign countries. The university also hosted the Southeastern Mining Institute, which emphasized scaling up of research methods to increase productivity in the mining industry.

During the year, the Geological Survey of Alabama, Tuscaloosa, published several reports of interest to the mineral industry. Among these were an annual minerals review and reports on marble and gold resources of the State. A new State geologic map compilation at a scale of 1:500,000 was published. The geology of two of the largest gold districts in Alabama, Hog Mountain and Goldville, was mapped (1:24,000) and published by the survey; the program of county mineral resource mapping was continued; and studies were completed on mineral filler and extender resources. Energy and water resource programs continued to collect data and samples for analysis of resource quality and use.

The Bureau of Mines again funded the Alabama Mining and Mineral Resources Institute (MMRI) at the University of Alabama to support mineral resource investigations. The MMRI continued work on recovering brass values from casting sands. An MMRI pilot plant to detoxify and recover metal values from the sand at a North Carolina foundry was successfully completed, and a second installation was constructed in another foundry. Another MMRI project involved zinc

foundries and the recovery of zinc oxide from fumes generated from burning insulation on scrap wiring.

Personnel of the Bureau of Mines Tuscaloosa Research Center worked with personnel from a Mobile-area ilmenite plant to resolve a complex drainage and liquid waste problem. A well-point dewatering system was installed at yearend, and data were being collected to evaluate the system's effectiveness.

Research was ongoing to identify materials to remove toxic metals from a wastewater stream at an Alabama foundry. Work continued to determine the flocculation response of coal and coal clay waste fines from Alabama mines.

The U.S. Department of Energy awarded the University of Alabama Geology Department and the Geological Survey of Alabama $1.3 million to "characterize the Smackover Formation in a comprehensive 3-year study." The Smackover is the most productive oil- and gas-producing formation in the State.

During 1989, the University of Alabama School of Mines and Energy Development began or continued work on several projects of interest to the minerals industry. Among these were (1) flotation of Eastern U.S. oil shales, (2) beneficiation of Southern U.S. tar sands, (3) flotation of phosphate rock, (4) removal of elemental phosphorous from electric-furnace sludge, and (5) Alabama clay use in chemical waste storage.

At midyear, a 145,000-square-foot Energy, Mineral and Material Science Research building on the University of Alabama campus, Tuscaloosa, was completed and dedicated. The building was equipped with 116 laboratories, including a 6,000-square-foot central analytical facility. One special feature was a mine ventilation test tunnel for mining engineering research. Among the academic departments housed in the new facility were geology and metallurgical and mineral engineering. The $17 million facility was funded, in part, by the U.S. Department of Energy.[9]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Alabama's mineral industry mined or manufactured 14 industrial minerals. With one exception, a dimension stone quarry, all extractive mineral production was from surface mines. As in past years, industrial mineral sales accounted for the bulk of the State's mineral value.

Cement.—Portland cement was the State's second leading mineral commodity in terms of sales and accounted for 28% of the 1989 mineral value. Alabama retained its seventh-place ranking among the 39 States with portland cement production; the State ranked fifth among 36 States in masonry cement output.

Portland cement production, 3.2 million tons valued at $131 million, was 300,000 tons and $26 million, respectively, below the 1988 levels, reflecting a downturn in Alabama's construction industry. The portland cement industry consisted of five plants operating seven kilns in the Birmingham, Demopolis, Mobile, and Montevallo areas. A sixth plant closed late in 1988. All five producers manufactured cement using the dry process. Three plants in Greystone, Roberta, and Theodore produced masonry cement. Output and value decreased from that reported in 1988.

Ideal Basic Industries Inc. began stone shipments to its reactivated cement plant at Theodore, near Mobile. The stone was shipped from the company's new quarry near Crystal River, Florida. Ideal Basic purchased a Birmingham-area cement company, Allied Products at Hoover. The purchase included cement storage and shipping facilities near Birmingham, in Atlanta, GA, and in Cowan, TN, and a masonry cement production facility in the Birmingham area.

Clays.—The State's clay industry continued to rank sixth among 44 clay-producing States, and clay value accounted for 4% of the State's mineral value. The Alabama clay industry mined bentonite, common clay, fire clay, and kaolin. Production was 1.9 million short tons, a decrease of approximately 400,000 tons. Value, $18.5 million, increased about $2.5 million above the 1988 level.

Bentonite.—American Colloid Co. mined bentonite, a clay with superior absorbent properties, from its Sandy Ridge mine in Lowndes County. The clay was dried, shredded, and sized and sold to the foundry and agricultural industries. Production and value decreased below that reported in 1988.

Common Clay and/or Shale.—Common clay and/or shale production accounted for approximately 85% of the clay tonnage produced in Alabama. Jefferson, Russell, and Sumter were again the top three counties in terms of tonnage and accounted for almost 50% of the State's common clay production. Most of the clay was manufactured into brick; other end uses reported included concrete block and highway surfacing.

Lightweight aggregate was produced using shale as a calciner feed by Vulcan Materials in Jefferson County and from a Tertiary clay by Livlite Corp. at Livingston.

Fire Clay.—Calhoun, St. Clair, and Shelby Counties were the hub of the State's fireclay industry. The clay is able to withstand elevated temperatures to 1,500 degrees Celsius and was sold to the refractory industry for fire and insulation brick manufacture. Four companies operated four mines to produce 108,000 metric tons of clay valued at $4 million. Output decreased, but value increased about $700,000 over that reported by the fireclay sector of the industry in 1988.

Kaolin.—Several companies produced kaolin, a light-colored clay containing the mineral kaolinite, from mines in Barbour and Henry Counties. Sales were to the refractory, heavy-clay products, and chemical materials industries. Production and value increased over that reported in 1988.

Lime.—The value of lime production ranked third among Alabama's industrial mineral commodities and accounted for 15% of the State's mineral value. Four companies mined and calcined limestone at facilities in Shelby County. Output and value increased about 30,000 tons and $3 million over that reported by the industry in 1988. Both quicklime and hydrated lime were produced.

Cheney Lime and Cement Co., a manufacturer of quick and hydrated lime and mortar mix, purchased 50 miles of CSX Transportation Co.'s rail line in northeastern Alabama. The line, which ran from northern Jefferson County to western Etowah County, was to be closed because of economics, and

Cheney operated two plants that would have been affected by the closure. Cheney spent $1.8 million on right-of-way and track structure and purchased a locomotive from a defunct West Virginia steel company. Maintenance costs, projected to be high for the first years of operation, would be offset if other firms along the line, shippers of coal, lubricants, fabricated steel, and pulpwood and other forest products, use the road.

In July, Allied Products Co. sold its lime division to Chemical Lime Co. of Ft. Worth, TX. The Montevallo and Alabaster plants in Shelby County were renamed Allied Lime Co.

Salt.—Alabama ranked 10th among the 13 salt-producing states. Production by the Olin Corp. was by solution mining at the McIntosh salt dome in Washington County. Olin used the brine to produce chlorine, caustic soda, compressed hydrogen, and salt at the McIntosh plant. Sales were to the pulp and paper, water purification, and sewage treatment industries. Salt was shipped to a company plant in Georgia.

Olin continued to develop a cavity in the McIntosh dome for the Alabama Electric Cooperative. The cooperative planned to construct a $65 million powerplant at the dome and will pump compressed air into the cavity. The air will be recovered through a turbine and motor-generator to generate electricity during periods of high energy demand. This will be the first compressed-air energy storage plant in the United States.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

The sale of construction sand and gravel ranked fourth in Alabama's total mineral value and accounted for 8% of the total. The estimated output of 10.4 million short tons valued at $36.5 million ranked Alabama 32d among the 50 sand- and gravel-producing States. In 1988, the last year that industry data were tabulated for a full year, 55 operations reported sand and gravel production from 25 of the State's 67 counties. The five leading counties, Montgomery, Macon, Mobile, Chilton, and Franklin, accounted for 60% of the total tonnage.

Industrial.—Eight firms produced industrial sand and/or gravel from 14 mines in six counties. Mobile, Bullock, and Tuscaloosa Counties accounted for 65% of the total value. Approximately 56% of the tonnage produced was industrial sand; the remaining 44% was gravel. The leading industrial sand uses were for molds and cores for the foundry industry, for sand blasting media, and for filtration; the leading industrial gravel uses were for silicon, ferrosilicon production, and nonmetallurgical flux.

In January, Manley Brothers of Indiana Inc., a wholly owned subsidiary of Hepworth Minerals & Chemicals Ltd., purchased Besco Products Inc. Besco operated a coated sand plant at Birmingham.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Alabama stone statistics are compiled by geographical districts as depicted in the State map. Table 4 presents end-use statistics for Alabama's three districts.

Crushed.—The sales of crushed stone, valued at $167 million, ranked first in Alabama's mineral value and accounted for approximately 36% of the total reported for the State. Output and value increased 1.7 million short tons and $21 million, respectively, from the data reported by industry in 1987. The minuscule change in output from 1987 was due to several factors, principally double-digit interest rates and overbuilding in some metropolitan areas.

A variety of stone types, chalk, chert, dolomite, granite, limestone, marble, and marl, were produced by 25 companies from 52 quarries in 19 counties. The five leading counties, Shelby, Jefferson, St. Clair, Madison, and Talladega, accounted for 73% of the tonnage produced. A substantial tonnage of chalk was quarried and used for hazardous waste containment at Emelle, Sumter County.

Limestone and dolomite (including chalk and marl) were the principal stone types quarried; 21 companies operated 46 quarries to produce 30 million tons, almost 95% of the total stone produced instate.

Dolomite producers, three companies with four quarries, were located in Bibb, Lee, Shelby, and Talladega Counties. Production, almost 2.3 million short tons, accounted for approximately 1% of the total stone crushed.

Marble was quarried, crushed, and ground by two companies in Talladega County. Ground marble was sold to the paint, rubber, plastics, and food industries. Minor tonnages were sold for coal mine dusting and landscape applications. One firm mined and crushed granite in Coosa County. Chert was mined for road base construction in several counties in the northern part of Alabama. Chert tonnage and value are not included in Table 1. The three leading end uses reported for the State's crushed stone output were cement manufacture (18%), concrete aggregate (17%), and road base (11%).

In April, Vulcan Materials Inc. purchased the assets of Dolocito Quarry Co., which included a limestone quarry and crushing facility in Tarrant.[10] In

TABLE 2

ALABAMA: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1988		1989	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Paper and pulp	473,682	21,823	448,825	20,384
Water purification	255,990	9,998	247,250	11,889
Other[1]	720,069	34,755	785,168	38,088
Total	1,449,741	66,576	1,481,243	70,361

[1] Includes acid water neutralization, agriculture, alkalies, aluminum and bauxite, animal and human food, basic oxygen steel, electric steel, mason's lime, open hearth steel, ore concentration, other chemical and industrial, other construction, other metallurgy, petroleum refining, road stabilization, sewage treatment, sugar refining, and tanning.

September, Vulcan announced plans to purchase three companies in Kentucky, Reed Crushed Stone Co., Reed Terminal Co. Inc., and BRT Transfer Terminal. Included in the purchase were a quarry, three coal blending and rail-to-barge transfer terminals, and a rail-to-barge stone terminal.[11]

In February, Dravo Basic Materials Co. began shipping crushed limestone from a quarry at Freeport, Grand Bahamas, to its distribution terminal in Mobile.[12]

At yearend, Alabama's Lay Lake experienced a "shell rush." Divers from several States were scouring the lake bottom for mussel shell, which sold for $1.35 a pound. Divers were making $350 to $400 for a 4-hour work day. Buyers sent the shell to Mobile where it was shipped to Japan and used for a variety of applications ranging from aphrodisiacs to face powder. Some shells were cubed and inserted into live oysters to form cultured pearls.[13]

Dimension.—Alabama's dimension stone industry consisted of three firms that produced dimension limestone, marble, and sandstone from operations in Franklin, Blount, and Talladega Counties. Alabama Limestone Co. produced rough blocks and cut and veneer stone from an underground quarry and surface mill in Franklin County. This was one of two underground dimension limestone operations in the country. Lamb Stone Co. operated a surface quarry in Blount County to produce sandstone blocks and sawed and dressed stone and flagstone.

Marble of Alabama Inc., Sylacauga, produced dimension stone using surplus blocks from the old Moretti-Harrah operation.

Production of dimension stone increased over that reported in 1988.

Sulfur (Recovered).—Alabama's ranking of sixth among the 26 sulfur-producing States remained unchanged. Five companies recovered sulfur at seven natural gas processing plants and/or petroleum refineries. Production totaled 409,000 metric tons, and value was reported at $40 million.

Talc.—Cyprus Minerals Co. continued as the only talc producer in the Southeast. The company mined and ground talc at its Winterboro facility near Alpine. The company also ground talc from Montana and Australia. Principal markets were the cosmetic and pharmaceutical industries.

Other Industrial Minerals.—In addition to the commodities listed in table 1, several minerals were shipped into Alabama and processed into higher value products. Norton Co. produced high-purity fused aluminum oxide and aluminum-zirconium oxide for abrasive use at a plant in Huntsville, Madison County. Muscle Shoals Minerals, at Barton in Colbert County, imported magnesium minerals from Mexico, Turkey, and Greece to produce fused magnesium oxide used in heating elements. The company also imported zirconium ore from South Africa and obtained zirconium concentrates from Florida to produce a fused zirconium oxide. International Minerals and Chemicals Co., at Florence in Lauderdale County, used fluorspar in the manufacture of fluorosilicic acid. The Tennessee Valley Authority, at Muscle Shoals, and USS Agri-Chemicals Inc., at Cherokee, both in Colbert County, operated hydrous ammonia plants. Two firms, W. R. Grace and Co. and Armstrong World Industries, expanded perlite at plants in Irondale, Jefferson County, and at Mobile, Mobile County. The crude perlite was obtained from mines in Western States. Vermiculite from South Carolina was exfoliated by W. R. Grace at its Irondale plant. Principal markets were in concrete, fireproofing, and insulation. Syn-

TABLE 3

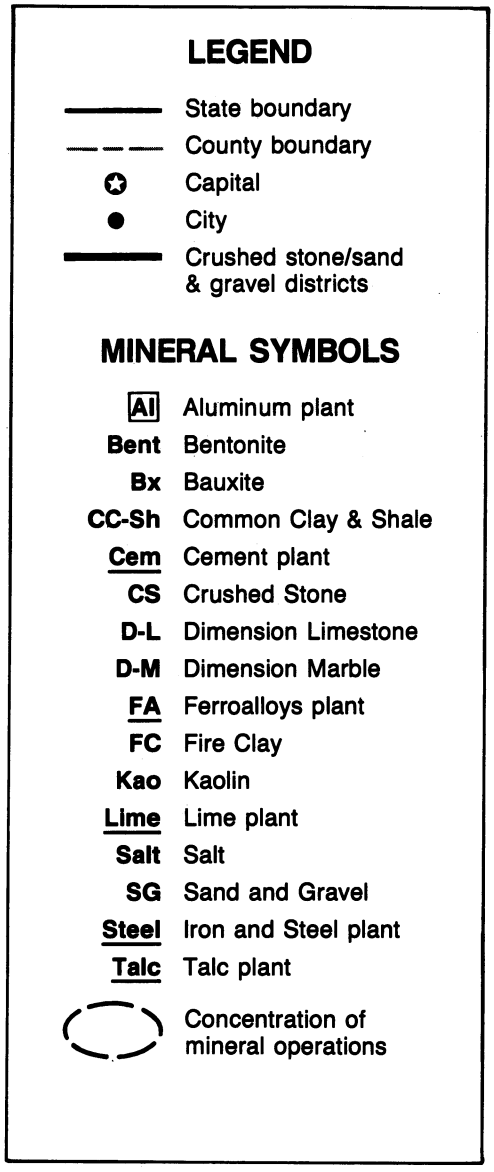
ALABAMA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

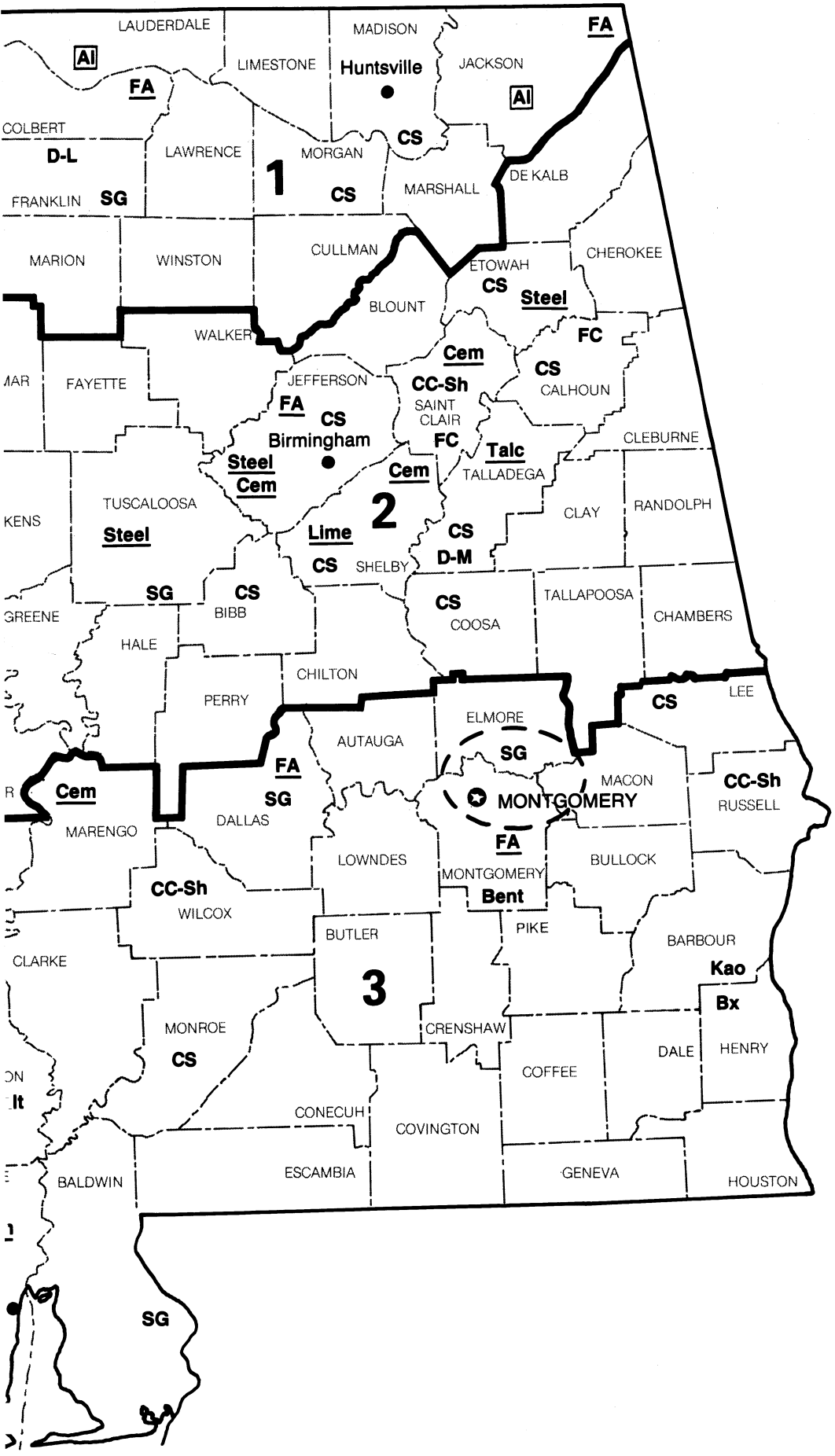
Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	911	3,851
Coarse aggregate, graded:		
Concrete aggregate, coarse	4,576	17,743
Bituminous aggregate, coarse	2,972	11,925
Bituminous surface treatment aggregate	719	2,876
Railroad ballast	308	1,126
Fine aggregate (−3/8 inch):		
Stone sand, concrete	622	2,474
Stone sand, bituminous mix or seal	1,464	5,631
Screening, undesignated	95	399
Coarse and fine aggregates:		
Graded road base or subbase	3,019	11,228
Unpaved road surfacing	371	1,367
Crusher run or fill or waste	2,431	9,672
Other construction materials[2]	300	1,444
Agricultural: Agricultural limestone and poultry grit and mineral food	725	4,905
Chemical and metallurgical:		
Cement manufacture	4,854	11,706
Lime manufacture	2,350	8,365
Flux stone	235	921
Other miscellaneous uses[3]	1,409	59,142
Unspecified:[4]		
Actual	4,378	12,558
Total[5]	31,739	167,333

[1] Includes limestone, dolomite, and marble; granite withheld to avoid disclosing company proprietary data.
[2] Includes stone used in filter stone, and terrazzo and exposed aggregates.
[3] Includes stone used in dead burned dolomite, chemical stone for alkali works, mine dusting or acid water treatment, whiting or whiting substitute and other fillers or extenders.
[4] Includes production reported without a breakdown by end use.
[5] Data may not add to totals shown because of independent rounding.

ALABAMA



Principal Mineral-Producing Localities


LAUDERDALE
AI
FA
LIMESTONE
MADISON
Huntsville
JACKSON
FA
AI
COLBERT
D-L
LAWRENCE
MORGAN
CS
1
CS
MARSHALL
DE KALB
FRANKLIN
SG
MARION
WINSTON
CULLMAN
ETOWAH
CS
Steel
CHEROKEE
BLOUNT
WALKER
FC
Cem
CS
CALHOUN
FAYETTE
JEFFERSON
CC-Sh
SAINT CLAIR
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Birmingham
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Talc
CLEBURNE
Steel
Cem
Cem
TALLADEGA
TUSCALOOSA
2
CLAY
RANDOLPH
Steel
Lime
CS
D-M
CS
SHELBY
SG
CS
BIBB
CS
TALLAPOOSA
CHAMBERS
GREENE
HALE
COOSA
CHILTON
PERRY
CS
LEE
ELMORE
AUTAUGA
SG
FA
MACON
CC-Sh
Cem
SG
MONTGOMERY
RUSSELL
MARENGO
DALLAS
FA
LOWNDES
MONTGOMERY
BULLOCK
CC-Sh
Bent
WILCOX
BUTLER
PIKE
BARBOUR
CLARKE
Kao
3
Bx
MONROE
CRENSHAW
DALE
HENRY
CS
COFFEE
CONECUH
COVINGTON
BALDWIN
ESCAMBIA
GENEVA
HOUSTON
SG

TABLE 4

ALABAMA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	W	W	396	1,854	W	W
Coarse aggregate, graded[2]	W	W	5,018	19,177	W	W
Fine aggregate (−3/8 inch)[3]	W	W	1,128	4,611	—	—
Coarse and fine aggregates[4]	W	W	2,230	8,876	W	W
Other construction aggregates	W	W	144	557	—	—
Agricultural[5]	W	W	317	2,172	W	W
Chemical and metallurgical[6]	—	—	7,530	21,317	—	—
Special[7]	—	—	1,318	58,817	—	—
Unspecified:						
Actual[8]	W	W	3,261	10,964	W	W
Total	W	W	[9]21,343	128,345	W	W

W Withheld to avoid disclosing company proprietary data.
[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 fine aggregate (screening-undesignated).
[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run or fill or waste.
[5] Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[6] Includes crushed stone for cement manufacture, lime manufacture, dead burned dolomite, flux stone, and chemical stone for alkali works.
[7] Includes crushed stone for mine dusting or acid water treatment, whiting or whiting substitutes, and other fillers or extenders.
[8] Includes production reported without a breakdown by end use.
[9] Data do not add to total shown because of independent rounding.

thetic iron oxide pigments and regenerator oxides were produced as a byproduct of steelmaking by Gulf States Steel Inc. at its Gadsden plant in Etowah County. Mica was produced as a byproduct of tantalum ore beneficiation in Coosa County and sold to a North Carolina mica firm. Harbison-Walker produced a synthetic mullite at its operation in Eufaula. Union Carbide Corp. produced zeolite catalysts at a plant in Chickasaw, near Mobile. Partek Insulations Inc. utilized diabase from North Carolina in the manufacture of mineral fiber at its new plant in Phenix City.

The Port of Mobile was a major shipping point for industrial minerals. Imported commodities included gravel, gypsum, ilmenite, limestone, manganese, potash, pumice, rutile, and sodium sulphate. Exported mineral commodities included clinker-cement, gravel, limestone, sand, and shell.

Metals

Alabama's metal industry consisted of one extractive metal producer and several metal-manufacturing operations. Two extractive bauxite producers mined the clay for a nonmetal end use.

Aluminum.—Reynolds Metals Co. broke ground for a $125 million casting facility at its Listerhill alloys plant in Colbert County. The additions are to include five 240,000-pound melting furnaces, six tilt-holding furnaces, and five computer-controlled electromagnetic casting units. The plant's annual capacity for cast sheet ingot will increase from approximately 800 million pounds to more than 1 billion pounds. Completion date was scheduled for late 1991.[14]

The secondary aluminum smelter at Steele, St. Clair County, was sold to Leggett and Platt Inc. The smelter, which produced ingot from scrap, had an 8-million-pound-per-month capacity.

Bauxite.—Two companies mined bauxite, a high-alumina clay, in Barbour and Henry Counties in southeastern Alabama. Production and value increased significantly over that reported in 1988. Most of the ore was calcined and sold for refractory manufacture. A third company in Eufaula, Carbo Ceramics, purchased bauxite for the manufacture of proppants for the petroleum industry. Arkansas and Georgia were the only other States with bauxite production.

Ferroalloys.—Alabama ranked third among the 16 States with ferroalloy production. The State's ferroalloy industry produced 107,000 short tons valued at $98 million. This was a 2,000-short-ton increase over that reported in 1988. Value, however, was $12 million below the $110 million reported in 1988.

In August, Alabama Silicon announced plans to purchase the closed Woodward Coal and Iron plant in Bessemer. The company planned to produce ferrosilicon for the iron and steel industries.[15]

Iron and Steel.—Alabama's steel industry consisted of Gulf States Steel Co. and USX Corp. (integrated steel mills); Birmingham Steel Corp., Commercial Metals Co., and SMI Steel Inc. (minimills); and Tuscaloosa Steel Corp. (plate mill).

During the year, Gulf States broke ground for a $27 million modernization program that included relining a blast furnace and rebuilding one of the fur-

nace stoves.

In March, USX dedicated its refurbished plant at Fairfield following the installation of a $200 million continuous slab caster and modernization of the hot strip mill.

Tuscaloosa Steel was granted permission by the U.S. Department of Commerce to exceed import quotas for continuous cast steel slab.

Lead.—Interstate Lead Co. in Leeds operated a secondary lead smelter. Scrap batteries were the primary smelter feed.

Tantalum.—Coosa Mining Ltd., owned by O'Dell Construction Co., completed its first full year of tantalum concentrate production in Coosa County near Rockford. The company mined a pegmatite and used wet gravity methods to recover a tantalum concentrate. Scrap mica and beryl were recovered as a byproduct.

Other Metals.—Manganese and chromite were ground by the Phenix City firm, Prince Manufacturing Co., for use in brick colorants. Kerr McGee Chemical Corp. operated a synthetic rutile plant near Mobile. Ilmenite was imported from Australia as plant feed, and the synthetic rutile was shipped to a company plant in Hamilton, MS, for titanium dioxide pigment manufacture. Fifty thousand tons of iron ore fines were recovered from tailings in Franklin County and used in the manufacture of cement.

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[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL. He has 29 years of industry and government experience and has covered 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] Alabama Business and Economic Indicators, Center for Business and Economic Research. V. 59, No. 6, June 1990.

[4] Washington Post. Long Feared, Methane Now Valued. Mar. 17, 1990.

[5] Dean, L. S. (ed.). Minerals in Alabama, 1989. Alabama Geological Survey, Information Series 64H, 1990.

[6] Alabama Business and Economic Indicators, Center for Business and Economic Research. V. 59, No. 6, June 1990.

[7] Birmingham Post-Herald. $2 Million Interstate Fine Posted. Nov. 2, 1989.

[8] American Metal Market. Firm Fined $242,000 for Toxic Waste. June 15, 1989.

[9] SOMED News. School of Mines and Energy Development, University of Alabama, Tuscaloosa, AL. 1988–89 Annual Report, p. 15.

[10] Birmingham Post-Herald. Vulcan Buys Quarry's Assets. Apr. 26, 1990.

[11] ———. Vulcan Buying Kentucky Stone Firms. Sept. 1, 1989.

[12] Rock Products. Dravo Steps Up Oceanic Shipping. June 1989.

[13] The Birmingham News. Lay Lake Treasure. Dec. 23, 1989.

[14] Alabama Development News. Reynolds Breaks Ground for $125 Million Project. V. 19, No. 9. Aug. 1989, p. 1.

[15] Birmingham Post-Herald. Alabama Silicon To Buy Bessemer Plant. Aug. 11, 1989.

TABLE 5

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 517 Bessemer, AL 35020	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	Chilton, Elmore, 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.	120 Long Ridge Rd. Stamford, CT 06904	Brine wells and chemical plant	Washington.

See footnotes at end of table.

TABLE 5—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.	Autauga, Elmore, Montgomery.
Southern Industries, Radcliff Materials	Box 2068 Mobile, AL 36601	do.	Mobile and Montgomery.
C. T. Thackston Sand & Gravel Inc.	Box 3211 Montgomery, AL 36109	do.	Montgomery.
Stone:			
Allied Products Co.	Box 628 Alabaster, AL 35007	Quarries and plants	Jefferson and Shelby.
Blue Circle Inc.	Box 182 Calera, AL 35040	Quarry and plant	Shelby.
Dravo Lime Co.	One Gateway Center Seventh Floor Pittsburgh, PA 15222	do.	Do.
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, 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.

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 Tom L. Pittman[1]

Alaska's nonfuel mineral production reported to the Bureau of Mines in 1989 was $213.4 million; in 1988, the value was $118.7 million. Alaska ranked 36th among the States in 1989, up from 40th in 1988. The production of gold, lead, silver, and zinc by the Greens Creek Mine accounted for a large proportion of the increase in value. Tin output was about one-half of the 1988 level; the chief producer in the United States for the past 15 years suspended operations. The estimated production of construction sand and gravel was about the same as that of 1988. The reported value of crushed and broken stone increased by about 60%. About 217 mechanized placer and four lode gold mines operated. The Greens Creek Mine started production early in the year. The Red Dog zinc-lead-silver mine tested mill components in November and December, preparing for concentrate production early in 1990. Nonfuel mineral exploration expenditures were estimated by the State to be about $46.8 million, almost 10% above the amount for 1988. More than 90% of this amount was for precious metal activities. The State's development total for 1989 was about $132.1 million, about one-half of the 1988 expenditure. The decrease in development expenditures was due to the virtual completion of the development phases at the Greens Creek and Red Dog Mines.

Four of the new State laws affecting mining changed the method of mineral entry on State lands, related to the release of hazardous substances, and withdrew about 260,000 acres of land in two areas from mineral entry. The new claim location and leasing procedure requires advance payments of rents, specified annual work or payments, and royalties after production begins. New reclamation regulations for all State, Federal, and private lands are to be formulated by the Department of Natural Resources unless a reclamation law is passed by the 1990 legislature. The full impact of the new hazardous substances bill will not be known until the definitions of hazardous substance are defined and the penalties are specified in implementing regulations.

The Minerals Management Service (MMS) issued a draft environmental impact statement (DEIS) preliminary to offering for lease about 147,000 acres of Federal offshore continental shelf lands in Norton Sound. The DEIS identified a possible mercury hazard. A thorough study alleviated the concerns, but had delayed the proposed lease sale from 1989 to probably mid-1991. A Memorandum of Agreement between the Corps of Engineers and the Environmental Protection Agency (EPA) specifying a "no net loss" policy for activities and developments on wetlands may cause serious problems in Alaska and could prevent much future development. Alaska has about 170 million acres of wetlands that include most of the favorable terrain and suitable locations for building and development. The EPA guidelines to require 100% recycling of placer mining effluents were tested in 1989 and will become effective in 1990. Many placer mines have been preparing to conform to these and other environmental and reclamation regulations, resulting in an improvement in water quality in most of the mining areas but a lesser gold production.

A statewide mining claim information system has been developed and installed by the Bureau of Mines and the Alaska Division of Mining that is accessible in a personal computer format. The system is available to individual users. Claim information may be retrieved by claim name, owner name, location, and by Federal and State claim registry numbers.

TRENDS AND DEVELOPMENTS

In 1989, Alaska became an important producer of zinc, silver, and lead because of output by the Greens Creek Mine. Published State surveys listed State production of zinc at 18,007 metric tons, silver at 162.1 metric tons, and lead at 8,598 metric tons. In 1988, there was no reported production of zinc or lead and only about 1.5 metric tons of silver. In 1990, Greens Creek Mine should have a full year and the Red Dog Mine most of a year of production. In 1990, Alaska should rank first among the States in zinc production, lead within the top three, and silver within the upper five. In 1989, the Greens Creek Mine was the top silver producer in the country with less than a full year of operation. State surveys indicate nonfuel exploration expenditures were about $46.8 million in 1989, an increase over the $42.7 million estimated for 1988. About one-half of these outlays was for gold exploration in southeastern Alaska. Recent and current exploration results indicate the next major developments in Alaska may be the reactivation of the old Alaska Juneau Mine as a 22,500-short-ton-per-day producer and the Kensington Mine as a 4,000-short-ton-per-day mine. Current significant exploration projects for low-grade, bulk-minable gold deposits have been reported at the Fort Knox deposit, Ester Dome, and other areas near Fairbanks; Rock Creek and Mount Distin near Nome; and in other localities in the State. The current trend in exploration has been to find and develop large gold-bearing deposits that promise economies of scale and long life if above about 0.035 troy ounce of gold per ton. Several deposits averaging more than about 0.12 troy ounce of gold per ton with probable

TABLE 1

NONFUEL MINERAL PRODUCTION IN ALASKA [1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands
Gem stones		NA	$86	NA	$50	NA	W
Gold [2]	kilograms	3,812	54,895	4,210	59,320	5,756	$70,800
Sand and gravel (construction)	thousand short tons	e27,200	e73,400	17,200	48,749	e17,000	e48,500
Silver [2]	metric tons	([3])	111	1	135	W	W
Stone (crushed)	thousand short tons	2,033	8,945	e1,800	e8,400	2,900	20,300
Combined value of cement (portland), lead (1989), tin, zinc (1989), and values indicated by symbol W		XX	4,010	XX	2,040	XX	73,752
Total		XX	141,447	XX	118,694	XX	213,352

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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] Less than 1/2 unit.

operating rates of 300 to 4,000 short tons per day were being explored. Increasing interest was exhibited in copper deposits with some gold values situated in relatively accessible locations in southeastern and southwestern Alaska.

Production of gold from placer mines will decrease because of dwindling reserves at some deposits, operating time and costs required to comply with water quality and reclamation costs, and the rising costs of fuel, labor, supplies, and transportation. The generally lower market price of gold will cause some operations to cease or suspend operations. The tightening economics has caused some operators to seriously investigate innovative and more efficient mining and recovery equipment and processes. Water quality in placer mined streams is improving because of improved stream diversions, settling ponds, and complete process water recycling. The reported production of construction sand and gravel was about the same as in 1988, but the production of crushed and broken stone reportedly increased from an estimated value of $8.4 million in 1988 to $20.3 million in 1989.

The detailed results of State surveys of the mining industry were published in Alaska's Mineral Industry, 1989—Special Report 44.[2] The report was produced and distributed by the Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys (DGGS) and Division of Mining (DOM), and by the Division of Business Development of the Department of Commerce and Economic Development.

EMPLOYMENT

State surveys estimated mineral industry employment at 4,179 people, a decrease of about 4% from the 4,353 estimate for 1988. The small decrease in employment was due to a decrease in development projects. Mechanized placer production employed 1,316 persons; development, 785; base metal production, 407; construction sand and gravel, 625; recreational mining, 325; exploration, 252; lode gold and silver production, 161; and undistributed coal, jade, tin, soapstone, and crushed stone production, 308 persons. Most of the mineral industry employees in base metal, lode gold and silver, and coal mining operations work all year, but most of the other operations are seasonal and work variously from 3 to 6 months of the year. The increasing employment in lode mining will increase the proportion of full year jobs and help to stabilize the mineral industry work force.

REGULATORY ISSUES

The State turbidity requirement of five nephelometric turbidity units was still difficult for many placer operators to meet, but the requirement for 100% recycling of practically all placer and other mine effluents will cause turbidity of discharges to be less of a problem. Current and additional proposed regulations for nonpoint-source discharges caused concern and will probably add to the operating costs of some mines. Regulations to implement the changes in the State mining laws that became effective August 31, 1989, were not all completed and published before the end of 1989. The new statute requires rent on mining claims, leasehold locations, and upland and offshore mining leases on all State land open to mineral entry. The annual rents are due in advance on September 1 and are in arrears after November 31 of each year. The Alaska Division of Mining is drafting royalty regulations that will require the payment of a net production royalty by each operating mine. The above statute also provided that the Department of Natural Resources (DNR) must draft a new set of reclamation regulations applicable to all mining activity in Alaska unless the legislature convening in January 1990 enacts a new mining reclamation statute. Mining interests are generally in favor of having the DNR draft regulations that will implement the regulations currently in force, thus not duplicating some of them, causing conflicts and establishing another enforcement hierarchy. Environmental groups are afraid reclamation regulations set by DNR will be too lenient, and they are drafting reclamation bills to introduce in the next legislature. Wetlands regulations of the Corps of Engineers, State of Alaska, and some lesser governmental units were becoming more numerous and confusing. Late in 1989, the Corps of Engineers and the EPA signed a Memorandum of Agreement that established a nationwide policy of "no net loss" of wetlands. Regu-

lations and definitions to implement this policy had not been worked out or published by the end of 1989; they are of critical importance and concern to the mineral industry.

EXPLORATION ACTIVITIES

Exploration expenditures reported by State surveys for nonfuel minerals were estimated at $46.8 million in 1989, an increase of almost 10% over the expenditures of $42.7 million in 1988. Expenditures by commodity groupings were precious metals, $43.2 million (92.2%); base metals, $3.5 million (7.5%); and industrial minerals, $0.1 million (0.3%). More than one-half of the expenditures was in southeastern Alaska, about 20% in the eastern interior, and lesser and decreasing amounts in the southwestern, western, south-central, Alaska peninsula, and northern regions. Reported mineral exploration furnished 90,872 worker-days of employment, the equivalent of 252 full-time jobs, about the same as last year. About one-half as many mining claims were recorded as in 1988. There were 1,664 claims recorded on Federal land, down from 3,786 claims in 1988. New State claims decreased from 8,062 recorded in 1988 to 3,928 recorded in 1989. There were 69,715 active Federal and State claims in 1989, about 8% lower than those in 1988. More exploration money was being spent on previously established or fairly advanced projects than on basic exploration and new projects.

About 82% of Federal lands in Alaska had been closed to mineral entry through 1989, and additional lands were being proposed for restricted-use categories in the Tongass National Forest of southeastern Alaska and in other parts of the State. There have been many closures of State lands without regard to mineral potential, and there is planned legislation to withdraw more State land for parks and other restricted uses. The new State mining law provided for the advance payments of annual rents on State mining claims and royalty payments on production beginning in 1990. New reclamation regulations must be formulated by the Department of Natural Resources or by legislative action in 1990. These factors, declining metal prices, and other economic conditions tended to discourage new claim locations on Federal and State lands. Several thousand State claims will probably be abandoned in 1990 because of the new rent-in-advance regulation. Several large exploration projects were being pursued on lands belonging to Native corporations because no claim staking is required and individual project deals can be negotiated directly with the land owners.

State surveys listed 15 companies that drilled a total of 639,480 feet on various nonfuel projects in 1989. The 1988 survey indicated 19 companies drilled 805,850 feet. There were 242,440 feet of hard-rock core drilling and 89,790 feet of hard-rock rotary drilling reported in 1989, compared with 223,630 feet of core and 130,220 of rotary drilling in 1988. About 409,300 feet of blasthole drilling was reported by three operating mines in addition to project drilling. Placer exploration footage dropped from 152,000 feet in 1988 to 97,250 feet in 1989. All of the placer thaw-field drilling was done by the Alaska Gold Co. ahead of its two dredges near Nome. Reported thaw-field drilling dropped from 300,000 feet in 1988 to 210,000 feet in 1989. Several Alaskan placer operators are stripping permafrost overburden mechanically and with explosives. Alaska Gold Go. was changing from cold-water thawing of overburden and gravel to mechanical overburden stripping and cold-water thawing of the pay gravel.

LEGISLATION AND GOVERNMENT PROGRAMS

Four mineral-related bills submitted to the 1989 session of the State legislature were enacted. The most important was Chapter 129, Session Laws of Alaska 1989 (SLA 89). This statute changed the method of mineral entry on State lands from a system similar to the Federal mining law to a claim location and leasing procedure requiring annual advance payments of rents, specified annual work or payments, and production royalties. Rents begin at $20 for each mining claim and at $0.50 per acre for each mining lease and will increase periodically depending on how long the claim or lease is held. A new net royalty payment of 3% will be required from each operating mine. Chapter 39, SLA 89, Release of Hazardous Substances, may impact the mineral industry more or less severely, depending on the definitions of hazardous substances and the penalty schedules in the implementing regulations. About 100,000 acres of State land were withdrawn from mineral entry by Chapter 110, SLA 89, creating Katchemak Bay State Park and Wilderness. Chapter 111, SLA 89, Redoubt Bay Critical Habitat Area, withdrew another 160,000 acres from mineral entry. At least 12 other bills important to the mineral industry were carried over for action by the 1990 session of the legislature.

The U.S. Minerals Management Service (MMS) completed a DEIS proposing to lease about 140,000 acres of Federal offshore lands in Norton Sound. This land is generally seaward of the State offshore leases being operated by Western Gold Exploration and Mining Co. (WestGold) using the bucketline dredge BIMA. The possibility of an accumulation of mercury in the food chain and effects on the local people was identified in the DEIS. MMS delayed the lease sale and contracted with Batelle Northwest to conduct metal analyses of various water and organism samples and of human hair samples collected from residents of Nome. None of the results exceeded established EPA standards. The lease proposal was delayed about 18 months and is expected to be offered in mid-1991. A Federal Court injunction was resolved that had prevented or restricted mining activities on Federal lands in the drainages of the Fortymile and Chatanika Rivers and Beaver and Birch Creeks. This action allowed 10 small placer mines to start up in the Circle mining district. The Division of Mines completed an air photo survey of mining districts in the northern, western, eastern interior, southwestern, and south-central regions. These maps have been printed on a scale of 1 inch equals 300 feet. Copies of the maps may be obtained from the Fairbanks office of the Division of Mines.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Gold.—Gold production reported to

the Bureau of Mines in 1989 was 5,756 kilograms (185,047 troy ounces) valued at $70.8 million. This production was reported by 4 lode and 13 placer operators and was probably about 65% of the statewide total. Alaska's gold production was estimated at 8,852 kilograms (284,616 troy ounces) valued at $108.7 million by the State surveys. This amount was lower than the State's preliminary estimate of 9,234 kilograms published in Public-Data File 90-10, referenced and cited in the gold chapter of the 1989 Minerals Yearbook (Volume I). The State estimated 8,258 kilograms (265,500 troy ounces) of gold, worth $112.8 million, was produced in 1988.

The State production surveys for 1989 were "based on data compiled from about 150 DGGS questionnaires returned by companies and individuals; responses from a telephone survey of 25 companies that mine sand and gravel, and two that quarry stone; production information provided by the Bureau of Land Management (BLM); the U.S. Army Corps of Engineers (COE); the Alaska Department of Transportation and Public Facilities (DOTPF); and precious metal refiners." These surveys showed gold was recovered by 217 placer mines and 5 lode mines. The placer operations produced about 87% of the gold. Most of the increase in 1989 gold production over that of 1988 was from the Greens Creek Mine. The average price of gold used by the State in 1989 was $382 per ounce, down from $422 per ounce in 1989. Alaska's largest placer and lode gold producing companies, in descending order, were: Valdez Creek Mining Co., Westgold, Greens Creek Mining Co., Alaska Gold Co., Polar Mining Co., Citigold Alaska Inc., Windfall Gold Mining Corp., Alaska Placer Development Inc., GHD Resource Partners Ltd., and Sphinx America Inc. These eight placer companies and two lode companies recovered about 61% of the gold produced in 1989.

The northern region produced 211 kilograms (6,800 ounces) of gold from the operations of 13 companies. Production was about the same as in 1988, even though the number of mines increased by five. There were two summer floods that interrupted production, and six mining companies had mechanical problems. Six companies redesigned their operations so they could recycle washery waters. There were 14 miners active in the Koyukuk-Nolan-Wiseman area on the Hammond River and on the following creeks: Boulder, Chapman, Emma, Gold, Jim Pup, Nolan, Prospect, and Sheep. Paul Dionne drove an exploration drift into a hillside placer on Nolan Creek during the winter of 1989-90 and found nuggets up to 21 ounces while shoveling pay gravel, according to the State survey. Paradise Valley Mining Co. continued to operate its mechanized placer mine and tourist mine on Birch Creek in the central rooks Range, east of Wild Lake. Tobin Creek Mining Co. operated again on Tobin Creek in the Chandalar district on ground leased from Little Squaw Gold Mining Co. After the operator, Tom Walker, died late in June, the mining operation was curtailed. Gold Dust Mines Inc. obtained a nearby lease from Little Squaw and planned to move its mining outfit and IHC jig washing plant in from Fairbanks during the winter of 1989-90. A small-scale placer mine was operated on Weise Creek in the Ambler district by the John Slatt-Baldwin partnership.

There was some exploration for gold in the northern region. Little Squaw Gold Mining Co. worked on placer and lode claims in the Chandalar district. Silverado Mines U.S. Inc. explored placer and lode claims, and Dennis Anderson explored placer ground on Nolan Creek. Paradise Valley did some rotary drilling and trenching on placer and lode prospects near Wild Lake.

The western region led the State in the production of gold. The State survey estimated about 43 operators recovered 2,721 kilograms of gold (87,500 ounces) and employed 437 people seasonally during the year. The offshore dredge BIMA produced 30,661 ounces of gold from June 9 to November 11, according to the State survey. The operator, WestGold, encountered delays owing to stormy weather and mechanical breakdowns, therefore recovered gold was about 14% less than in the 1988 season. Failure of the lower tumbler assembly on the digging line of 33-cubic-foot buckets caused a production delay of 24 days. In November, winter shelf ice formed, and getting the BIMA to its winter berth at the Nome Causeway required an ice-breaking operation. The company employed 128 people, including 110 Alaskans, in 1989. Alaska Gold Co. operated Dredge No. 5 on the 3rd Beach strandline deposit northeast of Nome and Dredge No. 6 on the Submarine Beach deposit west of the Nome airport. The 9-cubic-foot dredges operated 160 days and recovered about 21,000 ounces of old, according to the State survey. Windfall Gold Mining Co. completed mining its available economic reserves and closed out its operation on the 3rd Beach deposit east of Dredge No. 5. Windfall completed 5 years of mining on ground it leased from Alaska Gold Co. That area near Cooper Gulch had been previously dredged, but there were sidepay portions that the dredge could not work. Windfall pioneered reclamation and revegetation in the Nome district. The company was unable to obtain other suitable placer ground in the Nome area. Anvil Mining Inc. produced placer gold from a large opencut placer mine east of Windfall's operation.

There were several smaller operations in the Nome district. Engstrom Dredging Co. completed mining on Basin Creek and several old cuts and planned to float its 1½-cubic-foot dredge downstream about one-half mile to unworked ground. GHD Resource Partners Inc. leased ground from the Berg-Wetlesen partnership and started a large-scale opencut placer mine at Kiwalik Flats near Candle. The State survey credits GHD with processing 98,000 cubic yards of gravel in 1989. Smaller placer mines worked on Mud Creek in the Candle district and on Bull Run Bench, Bear Creek, Candle Creek, and Iron Creek in the Fairhaven district. N. B. Tweet and Sons and five other outfits mined placers in the Kougarok district. Plat Bliss continued to operate his bucketline dredge on the Ungalik River. The State survey lists Green Mining and Exploration on Windy Bench, Howard Miskovich on Timber Creek, and Keith Tryck on Ophir Creek as the best operations in the Ruby-Poorman area. Sphinx America Inc. started a new operation on Midnight Creek, and there were three smaller mines in this area. Rosander Mining Co. continued its longtime operation on Colorado Creek in the Tolstoi district. Alamin Mining Corp. sold its operation on Bear Creek in midseason but took it back in December. Robert Magnuson mined on the Deg-

nan claims on Madison Creek. Conrad House mined in the Kiyuh Hills area.

Exploration expenditures in the western region totaled $3.7 million in 1989, about 8% lower than those in 1988. Placer Dome U.S. Inc. completed 60,000 feet of core drilling, trenching, and other exploratory work and collected a 132-ton bulk sample on the Rock Creek property. Placer has been operator of the property about 8 miles north of Nome since 1987. At the end of the 1989 season, Placer turned the property back to the Golden Creeks Joint Venture (GCJV). Aspen Exploration, the next operator for GCJV, announced an option agreement with Tenneco Minerals to continue exploration in 1990. GCJV announced the deposit contained drill-indicated reserves of 6.66 million short tons at an average grade of 0.071 ounce of gold per short ton. The bulk sample yielded a 92% recovery of gold using grinding and flotation milling. Westgold continued exploratory drilling on its offshore placer deposits. Goldmor Resources leased the Illinois Creek deposit southwest of the Kaiyuh Hills and continued exploration originally done by Anaconda Minerals in 1980. The State survey reported reserves are estimated at 1.7 million short tons averaging 0.071 ounce of gold and 2.05 ounces silver per short ton. A 5-ton bulk sample was removed for heap-leaching recovery evaluation. Central Alaska Exploration Corp. optioned the Nixon Fork gold-copper-bismuth property from Battle Mountain Exploration Co. Battle Mountain had previously delineated a resource of gold in skarn deposits averaging 1.105 ounces of gold per ton and containing an estimated 320,000 ounces of gold. There were lesser exploration projects reported in the Seward Peninsula and the Ruby districts.

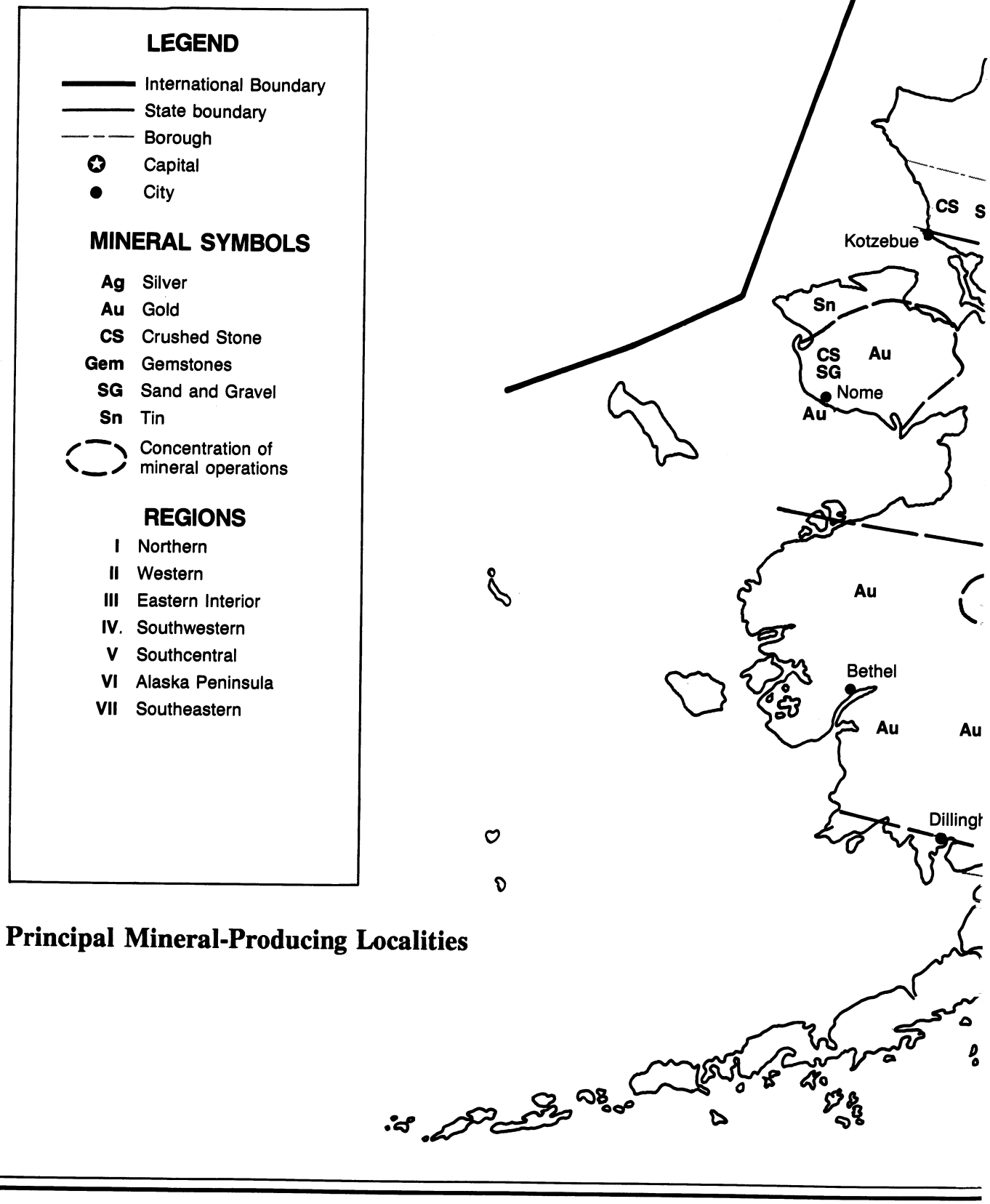
The eastern interior region was second in gold production to the western region. The State survey reported the region recovered 2,466 kilograms (79,300 ounces) of gold and had 115 producers that employed 494 people. In 1988, the reported production was 2,381 kilograms (76,550 ounces) of gold recovered by 89 operators employing 415 people. The largest increase in operations was in the Circle district. The 1987 court injunction that curtailed placer operations on Federal claims in the Birch Creek drainage was rescinded early in 1989. The BLM completed a review of the cumulative impacts of placer mining, and operations were resumed under Surface Management Regulations (43 CFR 3902) enforced by the BLM. There were 36 mechanized mines and 6 development projects active in 1989. In 1988, there were 24 mines and 11 development projects active. The largest operators were GHD Resources Partners Ltd. on Eagle Creek, Paul and Co. on Crooked and Porcupine Creeks, Alaska Ventures on Mammoth Creek, and Helen Warner on Porcupine Creek. The Circle district suffered from a flash flood in late June and early July that buried considerable heavy equipment and caused other damage. The district's 36 active mines produced an estimated 559 kilograms (18,000 ounces) of gold in 1987, according to the State survey.

There was limited activity in the Livengood-Tolovana district. Alaska Placer Development Inc. continued working the Livengood bench, and Mammoth Mines on Wilbur Creek resumed underground placer mining in early winter. Mammoth mines in the winter and stockpiles pay gravel for sluicing the following summer when water is available. There was some other exploration and mining activity in the district on Livengood and Lillian Creeks. In the Fortymile district, about 13 mines produced, compared with 9 in 1988. The increase resulted from termination of the court injunction against BLM. There were miners on at least 10 creeks and the Fortymile River. The mines were mostly small mechanized sluicing operations and large suction dredges. Dave Likens designed and was building a floating washing plant called a New Zealand Floater, similar to plants working in New Zealand and the Yukon Territory. The plants operate in closed circuit within their ponds and reclaim the ponds behind themselves as they advance. Shoreham Resources Ltd. opened up a large placer operation on Cache Creek in the Eureka-Tofty district. The State survey reported the mine recovered 2,900 ounces of raw placer gold and concentrates containing cassiterite and cesium. The company stripped overburden with a closed-circuit hydraulic system and also increased its recoverable reserves of placer gold. There was some mining on Eureka Creek and several small mines active in the Rampart district.

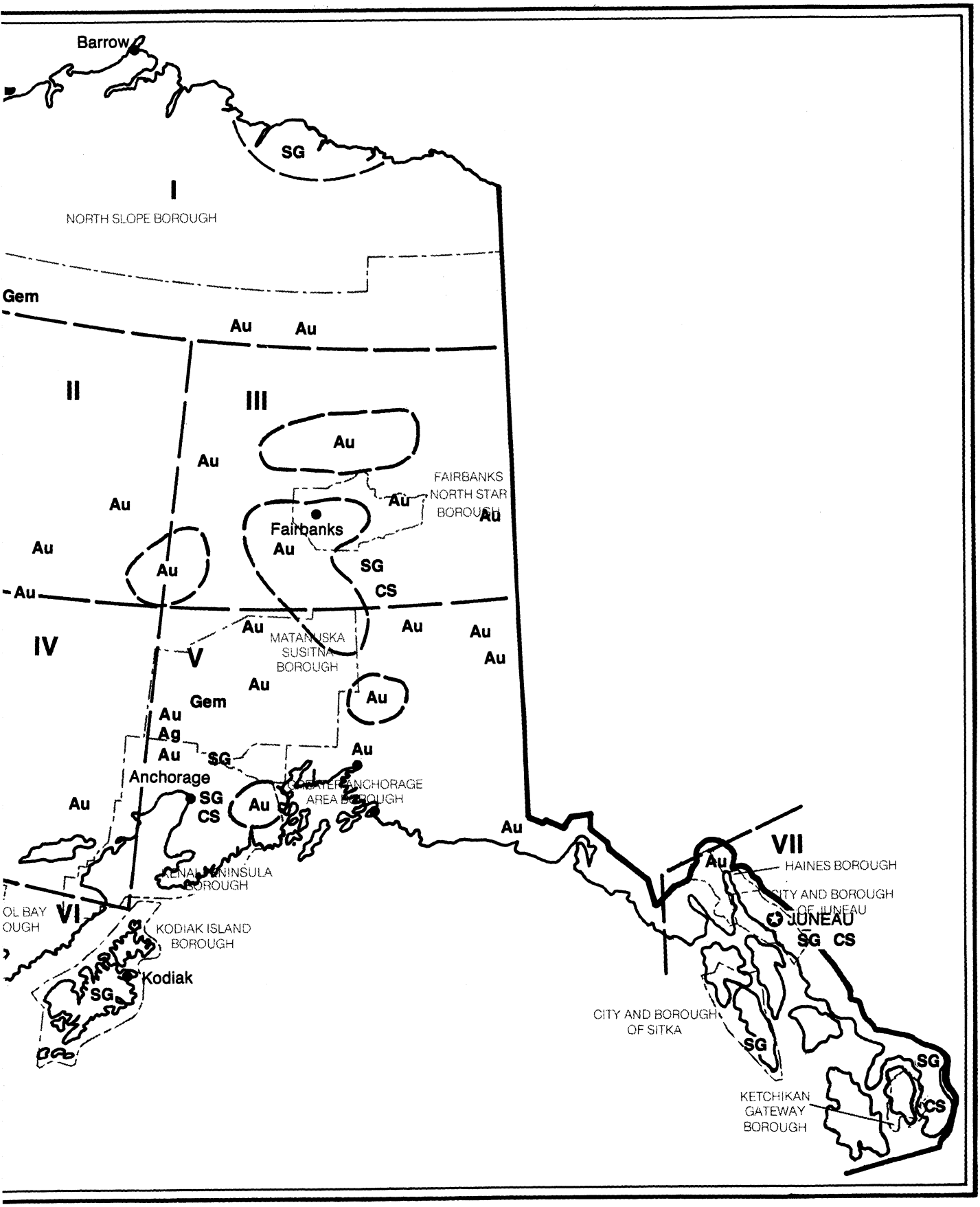
The Fairbanks mining district reported 26 placer mines and 2 lode mines recovered an estimated 1,104 kilograms (35,500 ounces) of gold with 8,600 ounces of alloyed silver, according to the State survey. Polar Mining Inc. on Goldstream Creek was one of the two largest operators in the district. The other large mine was run by Sphinx America Inc. on Fairbanks Creek. The two companies processed a total of 950,000 cubic yards of gravel through similar trommel and sluice plants. Each company removed overburden by drilling, blasting, and mechanical haulage, and continued stripping in the winter months. Sphinx closed its operation on Fairbanks Creek because of the low price of gold. Several placer mines operated on patented Federal claims leased from Alaska Gold Co., whose forerunner operated up to eight bucketline dredges in the Fairbanks district prior to 1964. Mines working on this leased ground include Walter Roman on Pearl Creek, Ron Roman and Thurman Oil and Mining on Fish Creek, and A. F. Hopen on Dome Creek. There are smaller scale mines active in the district on about 14 other creeks. Mike and Frank Roberts have a moderate-scale underground placer drift mine on Dome Creek downstream from the old dredging operation. The frozen pay gravel is drilled with a jackleg and blasted with ANFO explosives. The gravel is loaded and hauled by diesel equipment to the surface stockpile for sluicing the following summer. Don Reed ran a small underground placer mine on Vault Creek.

There were two lode gold operations on Ester Dome, about 8 miles west of Fairbanks. Citigold Alaska Inc. operated an opencut lode mine on the Ryan Lode property. The company mined about 155,000 tons of ore and loaded it on two heap-leach pads for cyanide solution extraction of gold and silver content. The mine recovered about 7,400 ounces of gold and 5,700 ounces of silver during the 1989 season, according to State survey figures. Citygold is the only heap-leach gold mine that operated in Alaska. Inferred ore reserves listed were about 1.1 million short tons averaging about 0.1 ounce of gold and 0.075 ounce of silver per short ton based on mining to a depth of 230 feet. The company will further explore the ore zone and mine less tonnage in 1990. Leaks were found in the

ALASKA



Principal Mineral-Producing Localities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primary liners of the 1987 and 1988 leaching pads. The Alaska Department of Environmental Conservation (DEC) required the operator to neutralize the pads. Several regulatory, political, and public relations complications developed, and some of them were not resolved in 1989. Tricon Mining Ltd. operated the nearby Grant Mine for Silverado Mines U.S. Ltd. with opencut ore from various veins treated in a conventional cyanide mill with a rated capacity of 235 short tons per day. The operation was suspended in late February 1989 when the permitted capacity of the tailings impoundment was reached. Tricon had some regulatory problems because of an alleged leak in the compacted silt tailings pond liner. Silverado negotiated an option agreement with American Copper and Nickel Inc. to explore the Grant Mine and other Silverado properties on Ester Dome.

Tri-Valley Mining Co. operated and explored its Democrat Mine property in the Richardson district about 70 miles southeast of Fairbanks. The State survey reported the area contains vertical ore zones up to 300 feet wide that contain veinlets of quartz, feldspar, native gold, and complex antimony-lead-silver sulfosalt minerals. Drill sampling and evaluation of ore reserves has been difficult because of the large size of many of the gold particles. Milling consisted of crushing the ore to minus 4 inches, screening through a trommel, and concentration with jigs and sluices. Tri-Valley smelted and poured gold-silver bars from the sulfide-sulfsalts mill concentrate. The company planned to upgrade the milling plant in 1990.

The Bonnifield district supported eight placer operations, about the same as in 1988. They mined on the Delta and Totatlanika Rivers, on Bonnifield, California, Eva, Gold King, Moose, and St. George Creeks, and in the Grubstake area. The Kantishna district operators were still shut down because of a 1985 court order (Sierra Club v. National Park Service). The National Park Service (NPS) was enjoined from issuing plans of operations to active mines until individual and cumulative environmental impacts were evaluated. A draft environmental impact statement was issued early in 1989 that addressed mining's cumulative impacts on NPS lands. The proposed alternatives for property owners were to sell to NPS or to accept certain restrictions on the uses of private property and mine under strict supervision.

Exploration expenditures of $9.17 million in 1989 were reported by the State survey. This was about a 44% increase above the $6.33 millon reported for 1988. Fairbanks Gold Co. ran the largest exploration project in the eastern interior region at its Fort Knox deposit. This deposit is about 12 miles northeast of Fairbanks on Gilmore Dome and was formerly known as the Monte Cristo or Melba prospect. The company's annual report for 1989 listed a drill-indicated resource of between 80 and 100 million short tons of material averaging between 0.036 and 0.047 ounce of gold per short ton. The resource was said to contain between 3.1 and 4.2 million ounces of gold at an approximate 0.02 ounce of gold per ton cutoff grade. The resource calculations include only the drill holes in an area 2,700 feet long by 1,200 feet wide. The resource evaluations were made by three major mining companies and by an independent consultant. The outcrop area of the mineralized intrusive is about 5,000 feet long and averages about 1,400 feet wide. The intrusive is described as granodiorite-quartz monzonite with gold deposited in quartz veinlets, fractures, and shears. Drilling indicated the values persist to more than 1,000 feet below the surface, and the ore is oxidized to that depth. Exploration expenditures were more than $4 millon in 1989, and $9.2 million was budgeted for 1990 exploration. Cyanidation tests by Lakefield Metallurgical Laboratories recovered 95% of the gold after grinding to minus 65 mesh and 97% after grinding to minus 100 mesh. These results were the averages on each of seven samples, each treated for 24 hours.

Nerco Minerals Co. explored the old Liberty Bell Mine. Nerco explored its Alaska Range gold-silver-zinc-lead prospects in a joint venture with Phelps Dodge Corp. Fairbanks Exploration Inc. had a joint venture project with ASARCO Incorporated in the Livengood area and worked alone in the Fairbanks and Circle districts. Tri-Valley Mining Co. explored on a 64-square-mile claim block in the Richardson district. Caithness Gold Mining and Palomar Capital Corp. formed a joint venture to explore 3.5 million acres of land belonging to Doyon Corp., the largest Native corporation in Alaska. There were several other lode exploration projects and at least six placer exploration projects in the region.

The State survey estimates the south-central region produced 2,273 kilograms (73,100 ounces) of gold in 1989, up from 2,124 kilograms (68,300 ounces) in 1988. The principle gold producer was the Denali Creek placer mine about 55 miles east of Cantwell. The mine was operated by the Valdez Creek Mining Co., which is owned by three Canadian companies: Camindex Mines Ltd., Cambior Mines Ltd., and American Barrick Resources Corp. From January through October, the Denali Mine recovered 71,992 ounces of raw placer gold that contained 61,403 ounces of refined gold and 10,400 ounces of refined silver from 453,473 cubic yards of pay gravels, according to State survey information. Average grade of the pay gravel was 0.135 ounce of gold per cubic yard. About 6,408,120 cubic yards of overburden was stripped. This mine has been the largest gold producer in Alaska for 5 of the past 6 years. The mine was closed October 17, 1989, because of declining gold prices, a forecast of rising operating costs, and the necessity to reroute Valdez Creek to continue mining upstream. The owners announced in December that there was a possibility the mine might reopen in 1990. Other placer mines in the region were relatively small scale. Active gold placer mines were reported from the Willow Creek area, Chistochina district (4 reported), Paxon (2), Yentna (7), Hope district (10), Valdez area (1) Cordova (2), and Nelchina district (2).

Two lode mines produced small amounts of gold from high-grade ores from two old mines. Alaska Hardrock Mining Co. and joint-venture partner Thor Gold Inc. mined 4,600 tons of ore from the Independence Mine that averaged 0.75 ounce of gold per ton. Alaska Hardrock announced plans to build a 50-ton-per-day mill and do exploratory and development work in the mine. Alaska Frontier Services recovered some 2-ounce gold ore from the old Palmer Mine in the Hope district. Frontier also trenched and sampled the Palmer Creek lode deposit and collected bulk samples for metallurgical testing.

Exploration expenditures in the south-

central region were estimated to have been $2.44 million, down from $9.19 million in 1988. Work was continued on several lode deposits and on at least 13 gold placer deposits and prospects. Cominco Alaska Exploration Co. worked on precious-metal and base metal deposits near Paxon in the Rainbow Mountain-Cantwell Glacier area. Platinum-group metals also occur in lode deposits in this area. Cominco and Platinova continued work as joint venturers on exploration of large low-grade copper-gold resources in the Rainy Pass-Mount Estelle area of the western Alaska Range. Amax Exploration Co. drilled and sampled its Gold Hill lode prospect about 10 miles south of the Denali Mine gold placer. Can Alaska Resources explored a large area on Rainbow Hill that might be a possible lode source for placer gold produced at the Denali Mine. Holes drilled in altered granodiorite included a 40-foot intersection averaging 0.33 ounce of gold per short ton and another hole with 40 feet averaging 0.20 ounce of gold per short ton. Dan Renshaw continued exploratory work at the Gold Cord Mine and Sheared prospect in the Hatcher Pass area. The Johnson River volcanogenic massive sulfide gold-zinc property belonging to Cook Inlet Region Inc. was still leased by Howard Keck and Associates. A small amount of exploratory work was done on the property by Hunt, Ware and Proffett.

The State survey report showed that placer exploration was widespread in the region, and the most important projects were in the general area of the Denali Mine. Valdez Creek Mining Co. explored Windy Creek and extensions of paystreaks they have been working on. Rowallan Mining Partnership continued to explore and develop its White Creek, Blue Sky, and Northern Lights claim groups. These claims are on or near White Creek, about 4 miles upstream from the Denali Mine. Rowallan reported that about 10,000 feet of rotary drilling indicated significant reserves of placer gold under much less overburden than at the Denali Mine. Nine small placer exploration projects were reported from Lake Creek, Cache Creek district; Chistochina district; Willow Creek, Hatcher Pass district; Canyon, Mills, and Dianne Creeks, Kenai Peninsula; Nelchina district; and the Valdez and Prince William Sound areas.

The southwestern region was credited with a production of 434 kilograms (13,950 ounces) of gold in 1989, down from 460 kilograms (14,800 ounces) of gold produced in 1988. Twenty-six mine operators reported from this district. Excessive rainfall, flooding, and the mandated preparations for 100% recycling of mining wash water were the main causes of decreased production in 1989. The Maguson Mine continued operation on Ganes Creek in the Innoko district. There were six other mines working on Anvil, Dodge, Little, Spruce, and Yankee Creeks. Micso-Walsh Mining Co. recovered placer gold and gold-silver-tungsten concentrates from a combined residual and stream placer deposit at the Golden Horn Mine on Otter Creek, near Flat, in the Iditarod district. Flat Creek Placers continued mining on Flat and Willow Creeks. There were smaller mines working on Prince and Chicken Creeks. Julian Creek Mining Co. continued mining on Julian Creek, and there were small mines on Michigan and Granite Creeks in the George River drainage. Tuluksak Dredging Co. ran a large nonfloating washing plant operation on Bear Creek, and Marvel Dome Mining Co. sluiced on Eureka Creek, in the Nyac district. There were several smaller placer mines active in the region.

Exploration expenditures were about $4.58 million in 1989, an increase from the $3.68 million reported in 1988. Western Gold Exploration and Mining Co. (WestGold) outlined a large-scale, low-grade gold resource in quartz porphyry and altered wall rocks in the Donlin Creek area. WestGold sent a large bulk sample of the antimony-gold mineralization to a metallurgical laboratory for leaching and other extraction tests. The deposit is in the Aniak district and is on land leased from Calista Corp. More than 40,000 feet of diamond core drilling and rotary drilling on the deposit were completed. The company also investigated other lode deposits and some placer deposits in the Aniak area and looked at the gold potential in the vicinity of the Red Devil mercury mine. Battle Mountain Exploration Co. continued drilling, trenching, and other work on quartz stringer antimony-gold deposits on Granite Creek in the Iditarod district. According to the State survey, Jim Wylie trenched and bulk sampled his Mountain Top mercury deposit looking for gold concentration. The deposit is known to contain anomalous gold values. Misco-Walsh Mining Co. extended its trenching program on the Golden Horn Mine deposit into the antimony-gold Mining Gulch area. Hunt Oil Co. continued exploration of its 92 State lode mining claims in the Big River-Lime Hills area. The claims contain gold and base metal values in skarns bordering a granitic stock. There were several other small lode and placer exploration projects active in the region.

The southeastern and Alaska Peninsula regions had an estimated gold production of 776 kilograms (24,967 ounces) of gold in 1989, up from 26 kilograms (850 ounces) of gold in 1988. The increase in gold recovered was almost all because the Greens Creek Mine started producing base and precious-metal concentrates early in the year. The State survey reported Greens Creek production at 23,530 ounces of gold contained in zinc and lead flotation concentrates. The mine is on Admiralty Island, about 18 miles southeast of Juneau. The mine operator is Kennecott Corp, a subsidiary of RTZ Corp., the world's largest mining company. Greens Creek Mining Co. is owned by Kennecott (53.1%), Hecla Mining Co. (28%), CSX Oil and Gas Corp. (12.6%), and Exalas Resources Ltd. (6.3%). RTZ Corp. purchased most of the assets of BP Minerals America, including the Kennecott Corp., and Kennecott was designated the manager for Greens Creek and other U.S. properties. Greens Creek was mining and milling about 1,100 tons of underground ore per day during the latter part of 1989. A small strandline gold placer mine operated on the beach near Yakataga on the Gulf of Alaska. The deposit also contains concentrations of garnet and ilmenite. Three small gold placers were active in the Porcupine district northeast of Haines, and a small placer was reported on the Salmon River north of Hyder.

Exploration expenditures in the southeastern region were about $25.01 million, more than one-half of the total nonfuel exploration funds spent in Alaska in 1989. Exploration expenditures during 1988 were estimated at $20.64 million by the State surveys. Echo Bay Exploration Inc. (Echo Bay) was the operator on the two largest gold lode exploration projects

in the region. Work continued at the old Alaska Juneau Mine, near Juneau. The property is leased by Echo Bay (85%) and Watts, Griffis and McOuatt Ltd. (15%) from the Alaska Electric Light and Power Co. and the City and Borough of Juneau, joint owners. The Alaska Juneau Mine recovered about 3.1 million ounces of gold from 1883 to 1944. The published minable reserves at the end of 1989 were 44.6 million short tons averaging 0.051 ounce gold per ton. During the year, Echo Bay diamond drilled 31,000 feet of core holes and drove about 1,500 feet of drifts and crosscuts. Echo Bay planned to drill about 80,000 feet of core holes in 1990 to expand the ore reserves and to accomplish some infill drilling. By the end of the planned drilling program, the company hoped to have reserves of about 100 million tons and be able to pursue the necessary feasibility studies, environmental impact studies, and permitting required to bring the property to production. Preliminary development plans envisage an underground mine delivering 22,500 tons of ore per day to an underground mill with crushing, grinding, and concentrating units. The gravity and flotation concentrates would be piped to a surface refinery and cyanide plant for recovery of the gold and silver values.

Echo Bay and Coeur Alaska Inc., a subsidiary of Coeur d'Alene Mines Inc., are the joint-venture partners in the ownership and exploration of the Kensington Mine about 40 miles north of Juneau. Announced reserves at the mine at the end of 1989 were 8.4 million short tons of ore averaging 0.154 ounce of gold per ton. The ore occurs as a quartz vein stockwork in Jualin diorite. The gold is mostly associated with telluride minerals, different from other known ores in the Juneau Gold Belt. Current exploration has revealed at least 820 feet of length along strike, 1,970 feet down dip from the surface outcrop, and a steeply dipping ore zone about 66 feet wide. Contract core drilling totaled 54,000 feet in 1989. Echo Bay conducted baseline environmental studies and did other work preparing for the project feasibility study to be completed in early 1991. Preliminary plans called for an underground mine producing 4,000 short tons of ore per day by long hole open stoping. Crushing and grinding would be underground with a flotation plant, concentrates cyanidation unit, and refinery built on the surface. The Jualin Mine, south of the Kensington, was explored by Placer Dome U.S. Inc. as the new operator, following a buy-in deal with International Curator and Granges American. The old Jualin Mine worked individual quartz veins that were emplaced in the lode zone now being explored. Placer Dome drilled about 20,300 feet of core holes in 1989. Announced proven and probable reserves totaled about 1 million tons averaging 0.309 ounce of gold per ton. Placer Dome also drilled about 7,000 feet of core holes on the Dream Prospect and did some exploratory work on other projects out of Juneau, near Haines, and on Prince of Wales Island. The Red Diamond prospect near the south end of Douglas Island was leased by Hecla Mining Co. from Hyak Mining Co. Kennecott Corp. explored in the Nevada Creek area east of the Red Diamond.

Lac Minerals (USA) Inc., operator in a joint venture with Noranda Exploration Inc., carried out low-level exploration projects at the Niblack and Ruby Tuesday gold-silver-base metal massive sulfide deposits on Prince of Wales Island and at the Kaigani deposit on Dall Island. Sealaska Corp. did general exploratory scouting on Native lands on Prince of Wales Island and may have made a significant gold-copper discovery in the old Dolomi district. Pulsar Resources, a subsidiary of Hyder Gold Corp., continued exploration at gold prospects on several different claim blocks in the Hyder district. Several small companies did exploratory work during 1989 on various gold prospects in the Juneau district and other areas in the southeastern region.

There were no reports of gold production from the Alaska Peninsula region in 1989. The State surveys listed exploration expenditures at $2.01 million, up from $1.71 million in 1988. More than 7,000 feet of diamond core drilling was accomplished at the Shumigan and Apollo gold deposits on Unga Island by Alaska Apollo Gold Mines Inc. Alaska Apollo reported reserves were 208,260 short tons carrying 0.765 ounce of gold per ton. Aleut Corp. lands in the region were being explored by Battle Mountain Exploration Co., mainly for epithermal gold deposits. Drilling programs were pursued on its Unga Island prospects and on the Centennial project on Popof Island. The Mount Dana ash flow west of Sand Point yielded gold by panning over its 24-square-mile area and was being investigated by Battle Mountain.

Silver.—Silver production reported to the State in 1989 was 5,211,591 troy ounces valued at $27,360,852. The State survey reported 47,790 ounces of silver valued at $281,950 produced in 1988. Alaska ranked sixth among the States in the production of silver. The Greens Creek Mine started up early in 1989 and produced 5,166,591 ounces of silver from 264,600 short tons of ore. The silver was contained in zinc and lead flotation concentrates and was shipped to foreign countries for smelting and recovery. Greens Creek recovered more silver than any other mine in the United States in 1989. The silver-gold-zinc-lead ore is mined underground by drift-and-fill stoping in flatter sections of the deposit and by cut-and-fill methods in the steeper sections. The flotation concentrator was treating an average of 1,100 short tons of ore per day late in the year. State surveys estimated about 45,000 ounces of silver was recovered in the refining of placer gold in 1989. In 1988, the reported silver production was 47,790 ounces, all from the refining of placer gold. Exploration of lode silver and silver-base metal deposits was generally at low levels of effort and expenditure because of the comparatively low price of silver.

Tin.—The State reported 1989 tin production of 87.99 metric tons valued at about $672,000. Tin production in 1988 was reported to be 136.08 metric tons valued at about $950,000. Lost River Mining produced 81.65 metric tons of tin in cassiterite placer concentrates during 1989. The company worked out the placer reserves on Cape Creek after 15 years of mining, terminated its operation, and dismantled its equipment. The cassiterite concentrates were sold to industrial users based in Europe. Shoreham Resources Ltd. produced about 6.35 metric tons of tin in a byproduct cassiterite concentrate recovered from its new gold placer operation in the Tofty area. The concentrate was produced from sluicing 26,000 cubic yards of paystreak gravel. Sphinx America Inc. recov-

ered a small amount of tin from its new operation on Midnight Creek in the Ruby-Poorman district. Exploration for tin was at a low level of effort and expenditures because of continued low prices and marketing problems. Killarney Creek, in the Tofty district, was explored for placer tin and gold by Bruce Savage. Cominco-Alaska Exploration Co. maintained its tin-tungsten deposit on Sleitat Mountain, about 70 miles west of Iliamna. The deposit contains high-grade cassiterite and wolframite concentrations in near-vertical greisen zones hosted in a granitic rock. The deposit is about 3,000 feet long.

Zinc and Lead.—The amounts and value of silver, lead, and zinc production in Alaska reported to the Bureau of Mines in 1989 was withheld to avoid disclosing company proprietary data. Data gathered by the State survey has been published in its annual report. The State reported the production of 18,007 metric tons of zinc valued at $29,383,386 and 8,698 metric tons of lead valued at $7,672,009. There was no reported production of zinc or lead in Alaska in 1988. Alaska ranked fifth among the States in the production of zinc and fourth in the production of lead in 1989. The Greens Creek Mine produced lead concentrates, zinc concentrates, and a mixed lead-zinc concentrate that required treatment by the Imperial Smelting Process. Concentrates were shipped to smelters in Belgium, England, France, Italy, Japan, and Korea, according to the State survey. Capital costs of the project were about $140 million, up from the preliminary estimate of about $87 million. The mine and mill had a usual quota of startup problems caused by bad weather, breakdown, equipment adjustments and adaptations, safety-caused delays, and some unforeseen conditions in the underground mine. A delay of 6 weeks in production from some of the massive sulfide high-grade ore sections was caused by secondary sulfide dust explosions following regular production blasts. The secondary explosions were hot enough to melt ventilation tubing and produced excessive amounts of sulfurous gases. The problem required experimentation with different explosives and blasting procedures and other possible factors. Use of a sprinkler system to saturate the mine walls and sulfide dust in the atmosphere during the blast apparently solved the problem. Greens Creek did exploration drilling, sampling, and geological mapping on the Fowler, Hi East and West, Little Sore, Mammoth, and Mariposite mining claims. Their claims were all in the immediate vicinity of the mines' ore bodies. Granges Inc. leased the Boulder Patch, or Boulderado, zinc-copper-silver prospect on Mount Henry Clay from Newmont and drilled four holes searching under an adjacent glacier for the bedrock source of the highly mineralized surface boulders.

The Red Dog open pit zinc-lead-silver mine, about 90 miles north of Kotzebue, was brought to the operating stage late in 1989, but no production was credited to the operation. Ore was mined, and the processing units in the mill were tested, adjusted, and "run in" preparatory to the regular production of zinc, lead, and lead-zinc flotation concentrates early in 1990. The mine was prepared for an initial production rate of about 5,200 short tons per day, to build up to 6,000 tons per day in 1993. The mill was assembled at the site near the mine from prefabricated modules designed by Cominco Alaska Inc. in collaboration with engineering consultant Ralph M. Parsons Co. of Pasadena, CA. The mill modules were built in the Phillipines, transported by barge to the port site south of Kivalina, and moved by transporters over the new road about 52 miles to the mine. The modules contained the complete equipment and facilities for grinding and flotation concentration of 6,000 short tons of open pit ore per 24-hour day. Ore is crushed to minus 8 inches and ground by sag mills, ball mills, and tower mills. Lead rougher tails are reground to 85% passing 30 microns and go to zinc rougher flotation. The lead and zinc rougher concentrates are each reground in tower mills before each goes to its multistage cleaning circuit. Rougher flotation is in Maxwell cells; column flotation cells are used in the cleaning circuits. Concentrates are trucked from the mill to the storage building at the port for shipment during the short ice-free season. Shipping will usually start about mid-July and hopefully be possible for about 100 days. The concentrates storage building is 1,400 feet long, 250 feet wide, and 125 feet high with a rated capacity of about 816,000 tons. It is the largest building in Alaska. Concentrates are carried by conveyor belt from storage to the beach and over three offshore artificial "islands" to a bargeloading facility. Barges will deliver concentrates to ships 4 to 5 miles at sea, where the water is 55 to 60 feet deep. About 50% of the concentrates will go to Cominco's smelter at Trail, British Columbia, Canada, and about 25% to smelters in Japan and Korea. The remaining 25% is the bulk zinc-lead concentrate that will go to Imperial Smelting Process smelters in Europe.

The published reserve figure for the Red Dog ore deposit is 85 million short tons averaging 17.1% zinc, 5.0% lead, and 2.4 ounces per ton silver. The deposit is rated the second largest zinc-lead-silver deposit discovered to date, second only to the original Broken Hill deposit in Australia. The land and deposit are owned by the NANA Regional Corp., and the deposit and necessary land are leased, equipped, and operated by Cominco. The road, dock, loading, and port facilities were financed by bonds issued by a State agency, the Alaska Industrial Development and Export Authority. The road and port project cost about $175 million and is known as the Delong Mountains Transportation System. Project costs will be paid back to the Authority by Cominco and any other mines or industrial users that may be future users of the system. Cominco conducted a limited drilling and exploration program on other zinc-lead deposits in the Noatak district west of the Red Dog deposit. NANA Regional Corp. carried out preliminary geologic mapping and geochemical sampling on other lands along the western part of the Brooks Range.

Other Metals.—A small but undisclosed amount of platinum production was reported to the State. The 25 ounces reported in 1988 was recovered with placer gold and marketed. The R. A. Hanson Co. Inc. owns the platinum claims, dredge, and other equipment of the Goodnews Bay Mining Co. in the southwestern region. Hanson tried to drive an adit into a buried channel that has drilled platinum reserves but encountered water and other problems. Most of the area is free of permafrost. The company also drilled some clay-rich reserves and announced plans to rework some of the gravel and clay-rich tailings from the prior dredging operation using opencut

methods. Investigation of possible methods to mine the large drilled reserve of platinum-group metals in the buried channel continued. Prospecting for platinum was continued in the western region on Boob, Hurst, Ledge, and Tolstoi Creeks by Tolstoi Mining Co. Bob Titcheval worked in the Nelchina district in the southcentral region on platinum prospects. Some mercury production was reported to the State, but information concerning the amount and source was withheld. There was no reported tungsten production in 1989. There was a small amount of exploration for copper, and only minimum necessary work was done to hold some nickel-copper claims.

Industrial Minerals

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988. Production of construction sand and gravel in 1989 was estimated to be about 17.0 million short tons valued at $48.5 million. The reported production in 1988 was 17.20 million short tons valued at $48.749 million. There was no reported production of industrial sand and gravel in Alaska. The State survey reported the production of 14.4 million short tons in 1989, about 16% below the 17.2 million short tons produced in 1988. A drastic decline in construction in the North Slope oilfields reduced consumption in urban areas, and a lack of major highway construction and repair projects reduced the need for construction sand and gravel. State survey figures show that between 1974 and 1988 about 29% of the statewide production was used for oilfield facilities construction in the northern region. In 1989, oilfield consumption was only about 1.3% of statewide sand and gravel production. Most of the oilfield use was for repair projects. The two main operators reclaimed and recycled sand and gravel from obsolete roads, runways, and drill pads and reused the material. About 1.5 million tons of sand and gravel was used to build the first phase of the tailings dam at the Red Dog Mine. Construction of WestGold's new sheet-pile dock at Nome and State road construction on the Seward Peninsula required about 2.5 million tons of sand and gravel. The eastern interior region produced about 4.6 million tons of sand and gravel, as reported to the State by 12 firms. Consumption declined about 20% from 1988 usage. Road rebuilding projects along the Alaska Highway and the construction of the Geist Road extension through the railroad and industrial area in Fairbanks were the largest users in the region. Earthmovers Inc. enlarged its Aurora and Hanson Road gravel pits to supply the Geist Road project. Fairbanks Sand and Gravel Co. mined sand and gravel from State leases on the flood plain of the Tanana River using a barge-mounted clam shell excavator. The mined material was crushed, screened, and graded into the various products that were in demand. The other 10 producers obtained their much smaller amounts of sand and gravel from a variety of sources. Alaska Gold Co. sold washed coarse gravel reclaimed from its old dredge tailings to numerous firms and other users.

The south-central region used an estimated 4.5 million tons of sand and gravel, slightly more than the estimated usage in 1988. The largest user in 1989 was the Department of Transportation and Public Facilities (DOTPF) for contracted road rebuilding near Valdez and bicycle paths in Valdez. The Bradley Lake hydroelectric powerplant construction project was another large user. The Alaska Railroad hauled about 1.65 million tons of sand and gravel to Anchorage from pits near Palmer for projects that included causeway work in the port area and completion of the large new municipal waste disposal facility. Rogers and Babler Inc. produced sand and gravel in support of its contract projects, but did not produce for contract and user sales as it formerly had. Knik Construction Co. and Calista Corp. produced small amounts of sand and gravel in the southwestern region and the Bristol Bay Native Corp. produced small tonnage for uses in the Dillingham, Aleknagik Road, and Naknek Lake areas. About 1.29 million tons of sand and gravel was consumed in the southeastern region in 1989, down from about 2.9 million tons in 1988. Completion of the road to the Jualin Mine and completion of road, mill, and infrastructure construction at the Greens Creek Mine caused most of the drop in 1989 production and usage. DOTPF used about 350,000 tons of material for road construction and repair in the Haines, Juneau, Ketchikan, and Sitka areas. The U.S. Forest Service used an unspecified amount of sand and gravel in the construction of 16.9 miles of road in the Stikine area and the rebuilding of 4.7 miles of road near Petersburg. Juneau Ready Mix Hildre Sand and Gravel production in Juneau was about one-half that of 1988. Production at Ketchikan was nominal and mostly used for road and airport repairs and upkeep.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed and broken stone production reported to the Bureau of Mines in 1989 was 2.9 million short tons valued at $20.3 million, up from an estimated 1.8 million tons valued at $8.4 million in 1988. This was a substantial decrease from the 3.6 million tons valued at $24.65 million reported in 1988. The continued low level of urban and other highway construction activity and virtual completion of construction at the Greens Creek and Red Dog Mines contributed to the slump in stone production. All of the production reported to the Bureau of Mines was crushed and broken stone. There was no production of dimension stone reported. Most of the stone produced in Alaska in 1989 was used on various road projects in southeast Alaska. The U.S. Forest Service reported about 1.9 million tons of crushed and broken stone was used on forest roads. The Bureau of Indian Affairs and South East Inc. were the other largest users, also in southeast Alaska. Yutan Construction Co. was the largest producer reporting from the Fairbanks area. The State survey reported output from Yutan Construction Co.'s Browns Hill Quarry was about 60% of the 1988 amount. About 350,000 short tons of riprap and quarry stone was produced by two quarries in the Fairbanks area and used on the Geist Road project. DOTPF used more than 225,000 tons of undifferentiated gravel and riprap on road maintenance in the Fairbanks, Delta, Tok, Nenana, and Healy areas. Small amounts of crushed and broken stone were used in naval and civil projects in the Aleutian

TABLE 2

ALASKA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch): Riprap and jetty stone	98	762
Coarse and fine aggregates:		
Graded road base or subbase	955	5,702
Unpaved road surfacing	137	453
Terrazzo and exposed aggregate	340	2,844
Crusher run or fill or waste	49	380
Other construction material[2]	81	553
Agricultural: Agricultural limestone	473	3,950
Special: Asphalt fillers or extenders	378	3,160
Unspecified:[3]		
Actual	389	2,497
Total	2,900	[4]20,300

[1] Includes limestone, dolomite, marble, and granite.
[2] Includes stone used in macadam, filter stone, concrete and bituminous aggregate (coarse), bituminous surface-treatment aggregate, railroad ballast and stone sand, concrete, and bituminous mix or seal.
[3] Includes production reported without a breakdown by end use.
[4] Data do not add to total shown because of independent rounding.

Islands and on the Alaska Peninsula. Wrangell Forest Products and Aleutian Constructors produced crushed and broken stone in these areas.

Other Industrial Minerals.—Gray portland cement was produced in Anchorage by Alaska Basic Industries using domestic clinker and gypsum shipped to the Port of Anchorage. Agricultural limestone was produced by Alaska Limestone Co. at its quarry and plant near Cantwell. The limestone was crushed, sized, and bagged. Most of the material was sold in the Anchorage area. The value of gem stone production reported to the Bureau of Mines was withheld to avoid disclosing company proprietary data. The State survey valued jade and soapstone production at $1.14 million in 1989. The 1988 value was not published by the State, but the value for 1987 was $78,000. An unspecified amount of carving-grade soapstone was mined and marketed. Jade Mountain Products produced jade and converted it to tiles, slabs, and other marketable forms at its cutting and polishing plant. The company is a subsidiary of NANA Regional Corp., based in Kotzebue. NANA owns the Empire nephrite jade property in the Jade Mountains and acquired the two blocks of claims known as the Stewart Mine in the Cosmos Hills. The jade deposits are in the Kiana and Shungnak districts east of Kotzebue. The State survey estimated horticultural peat production at 51,000 cubic yards valued at $352,000 in 1989, down from 55,000 cubic yards worth $375,000 in 1988. Most of the peat was mined from pits in the Fairbanks area on ground owned by the University of Alaska.

[1] State Mineral Officer, Bureau of Mines, Juneau, AK.

[2] Bundtzen, T. K., R. C. Swainbank, J. R. Deagen, and J. L. Moore. Alaska's Mineral Industry, 1989. Div. of Geol. and Geophys. Surv. Spec. Rep. 44, 1990, 100 pp.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	Region
Cement (portland):			
Alaska Basic Industries	1813 East First Ave. Anchorage, AK 99501	Grind and blend	Cook Inlet-Susitna.
Gold:			
Alaska Gold Co.	Box 640 Nome, AK 99762	Placer-dredge	Seward Peninsula.
Citigold Alaska Inc.	3400 International Way Fairbanks, AK 99701	Lode-open pit	Yukon River.
Greens Creek Mining Co.	300 Vintage Blvd. Suite 200 Juneau, AK 99801	Placer	Southeastern.
Polar Mining Co.	4545 Woodriver Dr. Fairbanks, AK 99709	do.	Yukon River.
Valdez Creek Mining Co.	610 East 4th Ave. Anchorage, AK 99507	do.	Cook Inlet-Susitna.
Western Gold Exploration and Mining Co.	Box 1210 Nome, AK 99762	Placer-dredge offshore	Yukon River.
Sand and gravel (construction):			
Anchorage Sand & Gravel Co.	1813 East First Ave. Anchorage, AK 99501	Pit	Cook Inlet-Susitna.
Earthmovers Inc.	925 Aurora Dr. Fairbanks, AK 99709	do.	Yukon River.
Juneau ReadiMix Hildre Sand & Gravel	Box 270 Juneau, AK 99802	do.	Southeastern Alaska.
Bureau of Land Management	Box 13, 701 C St. Anchorage, AK 99513	do.	Various.
U.S. Forest Service, Region 10	Box 21628 Juneau, AK 99802	do.	Southeastern Alaska.
Stone:			
Aleutian Constructors	3909 Arctic Blvd. Anchorage, AK 99501	Quarries	Various.
South Coast Inc.	Box 6820 Ketchikan, AK 99901	do.	Southeastern Alaska.
Bureau of Indian Affairs	Box 3-8000 Juneau, AK 99802	do.	Various.
U.S. Forest Service, Region 10	Box 21628 Juneau, AK 99802	do.	Southeastern Alaska.
Yutan Construction Co.	Box 1775 Fairbanks, AK 99707	Quarry	Yukon River.
Tin:			
Lost River Mining	Box 411 Nome, AK 99672	Placer	Seward Peninsula.
Zinc, silver, lead:			
Greens Creek Mining Co.	300 Vintage Blvd. Suite 200 Juneau, AK 99801	Lode-underground	Southeastern.

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 Michael N. Greeley[1] and Leroy E. Kissinger[2]

Arizona mines led the United States in the production of nonfuel minerals in 1989. The total value of output, more than $3 billion, increased about 10% over that of the previous year.

The State led the Nation in copper and molybdenum production and was also among the top producers of gem stones, lime, rhenium, sand and gravel, silver, and sulfuric acid. Metal output valued at $2.75 billion represented more than 90% of all nonfuel mineral production in the State. Nearly one-quarter of the value of all metals produced in the United States in 1989 was attributed to the mines of Arizona. Industrial mineral production for the year was $289 million or about 10% of the total mineral value in the State.

TRENDS AND DEVELOPMENTS

After reaching a low point in 1984, the production of nonfuel minerals in Arizona began an upward trend that continued through the end of the decade. Both segments of mineral output, metals and industrial minerals, contributed to the impressive growth. The value of production doubled in the past 5 years, and alltime records were set in 1988 and 1989.

In terms of total value, the State's copper mines continued a long history of dominating Arizona's nonfuel minerals industry. These mines produced most of the metals and all of the molybdenum recovered in Arizona and thereby determined in large measure the impact of mineral production in the State. Underpinning the success of the minerals industry during the last half of the 1980's were steps taken early, primarily by the copper producers, to cut costs and improve production. Although total employment was nearly halved, copper output was maintained. Elimination of the cost-of-living-adjustment in employee contracts also significantly reduced annual labor costs. Additionally, marginal operations were stopped, and enormous investments

TABLE 1

NONFUEL MINERAL PRODUCTION IN ARIZONA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	197,903	$1,905	168,392	$1,590	188,211	$2,506
Copper[2]	do.	751,073	1,365,994	r842,728	r2,238,875	898,315	2,593,292
Diatomite	do.	—	—	7,257	1,208	W	W
Gem stones		NA	3,000	NA	3,300	NA	2,821
Gold[2]	kilograms	1,791	25,798	4,549	64,106	2,810	34,564
Lime	do.	546	21,932	674	29,637	W	W
Perlite	thousand short tons	49	1,361	W	W	W	W
Pumice	metric tons	907	7	907	7	—	—
Sand and gravel:							
Construction	thousand short tons	e38,100	e141,300	32,399	123,854	e33,900	e133,900
Industrial	do.	W	W	119	3,045	W	W
Silver[2]	metric tons	114	25,666	152	31,974	171	30,186
Stone:							
Crushed	thousand short tons	7,712	33,999	e7,400	e33,000	6,649	28,552
Dimension	short tons	—	—	W	e1	W	W
Combined value of cement, gypsum, iron oxide pigments (crude, 1989), lead (1988–89), molybdenum, pyrites, salt, tin (1988–89), and values indicated by symbol W		XX	129,398	XX	235,596	XX	214,546
Total		XX	1,750,360	XX	2,766,193	XX	3,040,367

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

were made in new technology to improve productivity. Among some of the new improvements were increased application of solvent extraction-electrowinning, column flotation, in-pit crushing and modern materials handling methods, and flash smelting.

These measures taken by the mining companies coupled with generally strong market prices for most of the metals bolstered growth in the industry. Supporting increased production was the expansion of output at most copper mines and the startup of several primary gold mines.

During most of the decade, no obvious trend developed in the output of construction-related commodities. In the mid-1980's, there was strong demand for cement and construction sand and gravel while construction of an aqueduct from the Colorado River to Tucson, under authority of the Central Arizona Project, was at peak level. When residential and nonresidential construction activity began to decline toward the end of the decade, output of some commodities stagnated and others, as in the case of portland cement, decreased markedly.

EMPLOYMENT

During 1989, the Arizona mining industry, including fuel minerals, increased its employment about 1% over that of 1988 to an average of 12,100 workers.[3] The average number of copper exploration and production employees increased from 9,500 in 1988 to 10,400 in 1989. The number of miners and other workers in the copper sector represented about 86% of all employees in the State's mineral industry.

Total income earned in all mining sectors of the State was $425 million. The copper industry contributed $386 million or about 91% of the total wages paid to all mineral industry employees. During the year, the average weekly earnings of all workers (including management) was $676. The average weekly earnings of an employee in the State's copper sector was $714.

REGULATORY ISSUES

To facilitate eventual development of its Copper Basin copper deposit in Yavapai County, the Phelps Dodge Corp. continued efforts to exchange land with the Bureau of Land Management (BLM) and the U.S. Forest Service. During 1989, the Forest Service issued a contract to have a detailed Environmental Impact Statement (EIS) prepared on the proposed mine. The EIS, due in 1992, is required before the exchanges can be made.

Early in the year, Cyprus Minerals Co. continued to develop means to prevent waterfowl 'from landing on cyanide-bearing tailings ponds at the company's Copperstone gold mine in La Paz County. Gold production was curtailed while this environmental problem was addressed. By midyear, the problem was successfully resolved by suspending netting over the ponds.

During the year, Cyprus received complaints from area residents concerning dust blown from its mill-tailings pond at the Sierrita Mine in Pima County. The company continued an intensive investigation, begun in 1988, to determine the most suitable method to solve the problem.

An explosives manufacturing plant near St. David in Cochise County was identified by the Environmental Protection Agency (EPA) as a possible source of nitrate contamination in the local ground water acquifer and the nearby San Pedro River. The plant, owned and operated by the Apache Powder Co. since 1922, sells most of its product to the mining industry. The area was designated by the EPA as a Superfund site; in October, Apache agreed to pay for studies to determine whether or not the company is responsible for the contamination.

Late in the year, three companies were ordered by the EPA to stop mining construction sand and gravel in the Verde River. D & M Materials, Superior Companies, and Valley Concrete & Materials Inc. were accused of violating provisions of the Clean Water Act by using illegal fill procedures in their dredging operations. The companies have produced sand and gravel for years in a 12-mile stretch of the river from Cottonwood to Camp Verde, in Yavapai County.

EXPLORATION ACTIVITIES

The level of exploration effort for nonfuel minerals decreased slightly during the year in Arizona. According to the BLM, the State ranked third in the Nation for the number of unpatented claims considered active in 1989.

Early in the year, Oneida Resources Inc. acquired the Mexican Hat property in Cochise County. The company's 1989 annual report stated that initial diamond drilling confirmed the presence of disseminated gold mineralization potentially over a large area. In May, Oneida and Placer Dome U.S. Inc. reached an agreement whereby Placer could assume management of the project. During the year, Placer earned a 60% interest in the property by investing approximately $2 million and completing a two-stage exploration program.

Two other areas of mineralization in the vicinity of the Mexican Hat project that were investigated during 1989 included drilling at the Commonwealth Mine by DRX Inc. and drilling on the Turquoise property by the Santa Fe Pacific Minerals Corp.

Norgold Resources and ASARCO Incorporated conducted an exploration drilling program and metallurgical testing at the Yarnell gold mine in Yavapai County. Drilling nearby in northern Maricopa County was also conducted for gold exploration by East West Minerals N.L. at the Clementine Mine, U.S. Borax and Chemical Co. on the Picacho property, and Westmont Mining Inc. on the Newsboy property. In Mohave County, Combined Metals Reduction Co. explored for gold at the Klondyke property, and American Copper & Nickel Company Inc. continued gold exploration on the Roadside deposit.

Exploration drilling for gold was done jointly by Fischer-Watt Gold Co. Inc. and International Prospector Inc. on the Secret Pass deposit (Mohave County) and GEXA Gold Corp. on the Broken Rock property (Mohave County).

Other gold evaluation in the State included column leach testing done by La Teko Resources Ltd. on mineralized samples taken from the Margarita deposit in Pima County and drilling conducted by States Exploration Ltd. on the Treasure King prospect in Yavapai County.

Several oxide copper properties were investigated intensively during 1989. The Arizona Copper Co. (AZCO) continued to drill and conduct metallurgical tests at the Sanchez deposit in Graham County. A. F. Budge (Mining) Ltd. began a drilling program on the Korn Kob property in Pima County.

LEGISLATION AND GOVERNMENT PROGRAMS

In 1989, the Arizona State legislature introduced a number of environmental bills, but only a few were passed and signed by the Governor. House bill 2429 established a policy to prevent the removal of water from Arizona without a permit from the Department of Water Resources. House bill 2453 required compliance with certain Federal laws on hazardous materials and directed the Department of Environmental Quality to establish a data automation management system. With the enactment of House bill 2604, the State air quality permit fee was increased from $6,000 to $10,000.

During the year, the Center for Advanced Studies in Copper Recovery was established at the University of Arizona and funded by a $4 million grant administered by the Department of Defense—Directorate of Stockpile Management. Six research projects involving various aspects of copper leaching and recovery of critical byproducts from the solution stream were approved. It was anticipated that continuation of the center will be supported by a combination of public and private grants.

The Arizona Department of Mines and Mineral Resources (DMMR) continued to update its Arizona Mineral Industry Location System data bases. The computer data bases known as AZMILS contain basic information concerning mine and mineral locations in the State's 15 counties. Several publications issued in 1989 by the DMMR and designed to promote mineral development in the State included SR-15, The Primary Copper Industry of Arizona, 1988, and D-36, Directory of Active Mines in Arizona, 1989-90. Open-file reports were OFR 89-1, Industrial Minerals in Arizona's Paint Industry; OFR 89-2, Industrial Minerals in Arizona's Wallboard Joint Cement Industry; and OFR 89-3, Industrial Minerals in Southern California's Wallboard Joint Cement Industry. The agency also released a new map, MM-17, entitled "Metallogenic Provinces of Arizona." This 1:1,000,000-scale map was issued in a preliminary form and defines 49 provinces in the State.

In 1989, the Arizona Geological Survey (AZGS) issued a data base for Arizona's metallic mineral districts that complements the AZMILS series created by the DMMR. Released as OFR 89-8, this data base is known as AZMIN and includes the geologic classification and age of mineral deposits in the State. The AZGS also completed a series of county bibliographies by publishing C-27, Bibliography of Metallic Mineral Districts in Gila, Maricopa, Pinal, and Yavapai Counties and C-28, Bibliography of Metallic Mineral Districts in Apache, Coconino, and Navajo Counties.

During the year, the Bureau of Mines issued nine open-file reports addressing mineral land assessment in Arizona. These reports summarized mineral evaluations of wilderness study areas under BLM jurisdiction.

Also in 1989, the Bureau and the U.S. Geological Survey published "Mineral Summaries—Bureau of Land Management Wilderness Study Areas in Arizona." The summaries covered 2.1 million acres currently under consideration for Federal wilderness status in Arizona. Joint studies were conducted on 42 of the 84 proposed wilderness areas. According to the report, approximately one-half of the areas studied have identified mineral resources; nearly 70% have high or moderate potential for mineral resources.

This and other reports were submitted to the State's congressional delegation for its deliberations concerning the BLM wilderness proposal made in 1988. The BLM recommended that 1 million acres of its land in Arizona be added to the National Wilderness Preservation System. After public hearings were held in mid-1989, the delegation was divided on its recommendation; one faction proposed about 900,000 acres of BLM land be designated as new wilderness, and the other recommended 2.8 million acres. Some acreage would be taken from land administered by the Fish and Wildlife Service. One wilderness organization proposed that more than 4 million acres be included.

The Bureau of Mines continued to supervise the administration of the Arizona Mining and Mineral Resources Research Institute (MMRRI). The Institute, housed at the University of Arizona, was administered by a faculty member of the Department of Materials Science and Engineering. Total funds allocated by the Bureau to the MMRRI were approximately $207,000.

During the year, the Bureau of Mines continued its in situ copper mining research project in cooperation with the Santa Cruz Joint Venture (a mining partnership formed between ASARCO Santa Cruz Inc., a subsidiary of Asarco and Freeport Copper Co., a subsidiary of Freeport McMoRan Gold Co.). Near Casa Grande in Pinal County, the project site was drilled to obtain mineralized samples and fracture orientation data from the buried Santa Cruz oxide copper deposit. By yearend, five deep drill holes were completed. Plans were made to equip these holes for injection and recovery of solutions and to characterize the permeability of the deposit.

Several other programs were conducted in the State by the Bureau of Mines in 1989. Deposits of strategic and critical minerals were tabulated and described. Work was begun in west-central Arizona to evaluate mineral occurrences that are associated with detachment faults in that area. An evaluation of the mineral resources of the Coronado National Forest continued through the year.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Copper.—Arizona continued as the Nation's leading copper producer in 1989. The combined output of mines in the State was 60% of the total domestic production. Seven of the top 10 copper-producing mines in the United States were in Arizona.

There were 15 principal copper mining operations in the State during the year. These facilities produced more than 1.9 billion pounds, an increase of about 6% over that of 1988. Tight supplies, strong demand, and disruptions of several foreign sources increased the domestic producer copper price from a 1988 average of $1.21 per pound to $1.31 in 1989. Increased production and high prices raised the total value of the metal produced in Arizona by almost 16% compared with that of the previous year. The total value of this copper, about $2.6 billion, represented 82% of the value of all nonfuel mineral production in the State.

A publication issued annually by the Arizona DMMR reported that nearly one quarter of all copper produced in the State was recovered by leaching oxide ores and low-grade dumps. Ninety-five

percent of this leached copper was recovered by electrowinning; the balance was recovered by cementation.[4] (In the rest of this chapter, all production statistics for copper and molybdenum were taken from the DMMR publication referred to in the preceding statement, unless specified otherwise.)

The Morenci Mine in Greenlee County, 85% owned by the Phelps Dodge Corp., was the Nation's largest producer of copper in 1989. During the year, a record 274,250 metric tons (302,300 short tons) was produced at the mine, and about 21% of this copper was electrowon. At yearend, a $44 million expansion of the solvent extraction-electrowinning (SX-EX) plant at Morenci was completed to double the plant's annual capacity from 45,350 metric tons (50,000 short tons) to 90,700 metric tons (100,000 short tons).

Phelps Dodge and its minority partner, Sumitomo Metal Mining Arizona Inc., also continued to expand and modernize conventional mining and processing facilities at Morenci. During the year, an in-pit crushing and conveyor belt system was completed at a cost of $48 million to replace the former rail haulage system. In August, it was announced that the Northwest Extension ore body would be developed. The deposit that is adjacent to and north of the Morenci Mine contains oxide and sulfide reserves. As part of the $112 million Northwest Extension Project, annual capacity of the SX-EW plant will be enlarged to 154,200 metric tons (170,000 short tons).

Phelps Dodge's Copper Queen facility, composed of a dump-leaching and precipitation operation in Bisbee (Cochise County), produced 2,200 metric tons (2,400 short tons) of cement copper. A preliminary feasibility study was completed at the nearby Cochise copper project in 1989. The study recommended that bulk sampling, trial heap leaching, and further metallurgical testing of the chalcocite mineralization be pursued. Eventually the deposit may be treated by the SX-EW method.

Cyprus Minerals Co. recovered 262,000 metric tons (288,800 short tons) of copper from its six properties in Arizona. This output ranked the company second for total copper produced in the State during 1989. Almost 31% of the company's production was by SX-EW, the largest amount of copper produced in this manner by any operator in the State.

The Bagdad Mine in Yavapai County produced 90,100 metric tons (99,300 short tons) and was Cyprus' largest source of copper. A $21 million project was begun during the year to increase annual production capacity at the mine to about 100,000 metric tons (110,000 short tons). The expansion, to be completed by mid-1990, will include a fifth milling unit in the concentrator and an accompanying increase of ore production.

Cyprus' Sierrita Mine in Pima County produced 72,700 metric tons (80,100 short tons) of copper in 1989. Sulfide ores were sent from the company's nearby Twin Buttes property to the Sierrita concentrator by a 6.8-mile overland conveyor belt installed during the year. An idle SX-EW plant was put back into operation at the Twin Buttes Mine also in 1989. Production at this mine totaled 39,100 metric tons (43,100 short tons).

The balance of copper recovered by Cyprus was by leaching processes applied to ores at the Casa Grande (Pinal County), Miami (Gila County), and Mineral Park (Mohave County) properties. The largest of these was the operation at Miami, which produced 56,300 metric tons (62,100 short tons) of cathode copper in a SX-EW plant and a small amount of cement copper in a precipitation facility. At the Casa Grande property, 2,300 metric tons (2,500 short tons) of cathode copper was produced in a SX-EW plant. Solutions for this plant were recovered from in situ mining of both previously broken ore and undisturbed ground that compose the mineralized deposit. At the Mineral Park Mine, 1,500 metric tons (1,700 short tons) of cement copper was precipitated from solutions recovered from both in situ and dump-leach operations.

Throughout the year, the Magma Copper Co. operated the underground San Manuel Mine (Pinal County) and the open pit Pinto Valley Mine (Gila County), with collateral production facilities at both properties. Magma's 1989 annual report stated that 114,600 metric tons (126,300 short tons) of copper was produced at the San Manuel operation. More than 28% of this amount or 32,700 metric tons (36,000 short tons) was recovered as cathode copper in the SX-EW plant. Solutions treated by solvent extraction included those recovered by heap leaching and by in situ mining. In 1989, Magma resumed limited development of the deep Kalamazoo ("K") sulfide deposit that is offset from the San Manuel ore body. If proven economical, according to the company, mining of the "K" deposit would increase the life of the sulfide mine beyond the current projection of 6 years.

Magma's Pinto Valley Mine produced 83,300 metric tons (91,800 short tons) of copper during the year. Of this amount, 9,500 metric tons (10,500 short tons) was recovered in the SX-EW plant. Similar to the San Manuel operation, leach solutions treated by solvent extraction were recovered from waste dumps and from in situ operations. Another source of copper at Pinto Valley included 80-year-old mill tailings that were leached initially in early 1989. This leaching operation was designed to hydraulically mine the Miami No. 2 tailings and process the copper-bearing solutions in an enlarged SX-EW facility.

Late in the year, Magma announced a $12 million plan to rehabilitate the high-grade Magma Mine at Superior (Pinal County). The underground mine was closed in 1982 because of low productivity and depressed copper prices. The company expected production to resume in late 1990.

The new smelter at San Manuel reached full production during its first entire year of operation in 1989. According to Magma's 1989 annual report, the smelter processed 852,700 metric tons (940,000 short tons) of copper concentrates from company mines and from other sources, including purchased concentrates and tolled concentrates. Approximately one-third of the concentrates treated during the year were from outside sources. Eventually the company expects to become the largest custom copper smelter in the world.

Magma negotiated new 3-year contracts, effective July 1, 1989, with labor unions at its Pinto Valley and San Manuel operations. Employees' base wages will increase each year of the contract, and quarterly wage premiums will be paid when the average commodity exchange (COMEX) price of copper is 95 cents per pound or higher. A price-related bonus schedule contained in the previous contract was eliminated in the new agreement.

Total copper production at mines in Arizona, operated by Asarco and reported in its 1989 annual report, was 174,100 metric tons (191,900 short tons). The largest of its operations was in Pinal County at the Ray Mine, which produced

67,900 metric tons (74,900 short tons) of copper in concentrates and 36,300 metric tons (40,000 short tons) of copper in electrowon cathodes. Production at the Mission Complex, composed of the Eisenhower, Mission, Pima, and San Xavier Mines in Pima County, was 65,300 metric tons (72,000 short tons) of copper. The Silver Bell Mine (Pima County) produced 4,500 metric tons (5,000 short tons) of cement copper.

Early in the year, Asarco announced a 3-year plan to expand and modernize its copper operations to end its dependence on outside sources of smelter feed. The expansion will include the reactivation of the idle Pima mill, adjacent to the Mission Mine; installation of additional mining equipment at Mission; and construction of a new mill and concentrator, portable in-pit crusher, and 18-mile tailings pipeline at the Ray unit. Expenditures were expected to be about $230 million.

In February, enlargement and improvements of the Mission concentrator were completed at a cost of $13 million. The project raised annual capacity of the Mission Complex to 79,000 metric tons (87,000 short tons) of copper concentrates. Improvement of the mill at the Ray unit was completed also during the year at a cost of $12 million. In August, a new slag cleaning furnace was commissioned at Asarco's Hayden smelter (Gila County). This work was done as the first phase of a $22 million project to increase smelter throughput and reduce the amount of copper contained in the slag.

Effective July 1, 1989, Asarco negotiated a new 3-year contract with labor unions at the Mission Complex, Silver Bell Mine, and Hayden smelter. Across-the-board wage increases will be spread over the 3 years.

Other producers of copper in the State included Arimetco Inc. and Kocide Chemical Corp. Arimetco's Emerald Isle Mine (Mohave County) produced 21.8 metric tons (24 short tons) of cement copper recovered by in situ mining and precipitation. The mine was purchased by Arimetco from TSC Enterprises Inc. in June. During August, the company also acquired the Johnson Camp Mine (Cochise County) from Cyprus and announced a $3 million plan to resume SX-EW operations in 1990. The output at Kocide's Van Dyke Mine (Gila County) was 296.6 metric tons (327 short tons) of cement copper recovered in a manner similar to that employed at the Emerald Isle. The Van Dyke operation ceased in October, however, because of technical problems that included a buildup of soluble iron and diminished solution flow rates.

Toward yearend, South Atlantic Ventures Ltd. announced its plan to bring the Oracle Ridge Mine in Pima County into production. Capital costs to develop the underground mine and construct a concentrator were estimated at $6 million. According to the company's 1989 annual report, proven and probable ore reserves in the Oracle Ridge deposit total approximately 3.6 million metric tons (4 million short tons) with grades of 2.33% copper and 0.67 troy ounce of silver per short ton at a cutoff grade of 1.5% copper. Production, scheduled to begin in late 1990, was expected to be at an annual rate of 5,125 metric tons (5,650 short tons) of copper, 4.7 metric tons (151,000 troy ounces) of silver, and 68 kilograms (2,200 troy ounces) of gold.

Gold.—The total value of gold produced in Arizona decreased 38% from that of 1988. The decrease was due primarily to a drop in gold prices and to a cessation or reduction of mining operations at several gold properties in the State. Stan West Mining Corp. ceased operations at the underground McCabe Mine in Yavapai County, citing lack of working capital and use of inappropriate mining methods. The mine was in production from September 1988 to March 1989; in 1988, its gold output was 135.3 kilograms (4,350 troy ounces). Expenditures to bring the mine into operation were about $35 million.[5] Roddy Resources Inc. stopped mining during the year at the Bighorn Mine (also known as the U.S. Mine) in Maricopa County but did continue to recover gold from an existing heap-leach pad. According to the 1989 annual report of Belmoral Mines Ltd., an associated company, output at the mine was 137.5 kilograms (4,422 troy ounces) of gold.

Cyprus' Copperstone Mine in La Paz County, the largest primary gold mine in the State, continued production through the year. According to the company's 1989 Form 10-K, the open pit mine produced 2,280 kilograms (73,300 troy ounces) of gold. Development of an underground mine beneath the surface operation, begun in 1988, was discontinued during the second half of 1989 because of high costs and lower-than-anticipated ore grades.

In its 1989 Form 10-K, Echo Bay Mines Ltd. reported that the Congress Mine in Yavapai County produced 42.6 kilograms (1,369 troy ounces) of gold before suspension of operations during the first quarter of the year. At midyear, the company sold the underground mine to Malartic Hygrade Gold Mines Ltd. for a combination of securities and cash, valued at $9.6 million. Soon after the acquisition, Malartic initiated a program to construct a carbon-in-pulp mill with a capacity of 350 short tons per day and to continue mine development. The company expected to complete the mill and begin gold production at an annual rate of 933 kilograms (30,000 troy ounces) by mid-1990. In its 1989 Form 10-K, Malartic stated that proven and probable ore reserves were 466,400 short tons with an average grade of 0.293 troy ounce of gold per ton.

A. F. Budge (Mining) Ltd. operated two gold mines in the State. The operation at the historic Vulture Mine (Maricopa County), begun by Budge in 1988, produced gold by leaching mill tailings placed on heaps. Production at the underground United Verde Extension Mine (Yavapai County) began in 1989. Siliceous mine-run ore was shipped as flux to the Hidalgo copper smelter owned by Phelps Dodge in southwestern New Mexico.

Queenstake Resources Ltd. produced 40.3 kilograms (1,297 troy ounces) of gold at the Gold Prince Mine according to the company's 1989 annual report. The mine product was also sold as silica flux to the Hidalgo smelter.

Molybdenum.—Production of molybdenum in Arizona continued to increase and was the highest of any State in the Nation. Output rose about 2% over the production of 1988, which in turn was more than 12% over that of 1987. In 1989, the total production of molybdenum by Arizona mines was 13,500 metric tons (29.8 million pounds).[6] This amount represented more than 22% of all domestic production.

For years, all molybdenum produced in the State has been a byproduct or coproduct of primary copper ores. In 1989, molybdenite concentrates were recovered at six mines. The Sierrita Mine (Pima County), owned and operated by Cyprus, was the largest producer. The company's 1989 Form 10-K reported output from the mine was 6,700 metric tons (14.8 million pounds) of molybdenum. This production included molybdenum

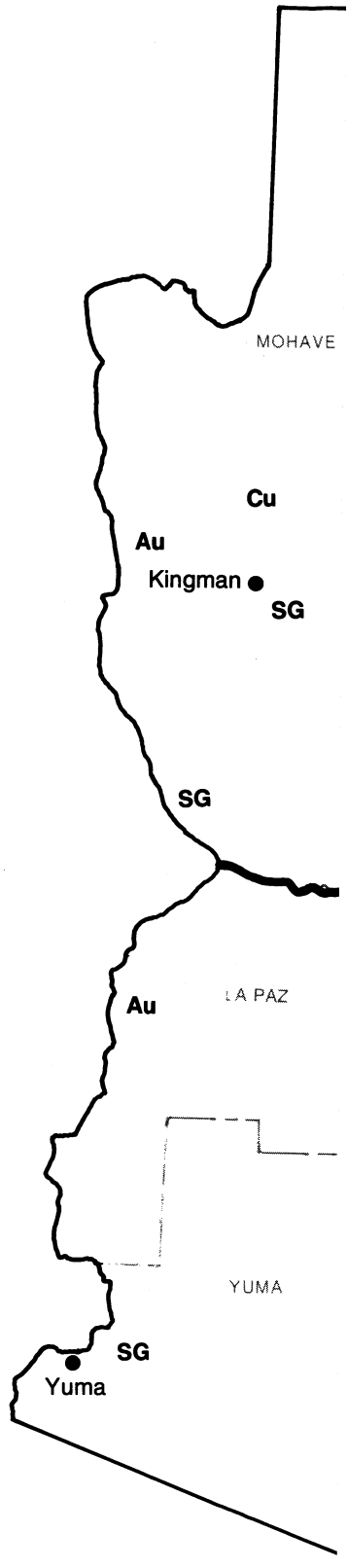
ARIZONA

LEGEND

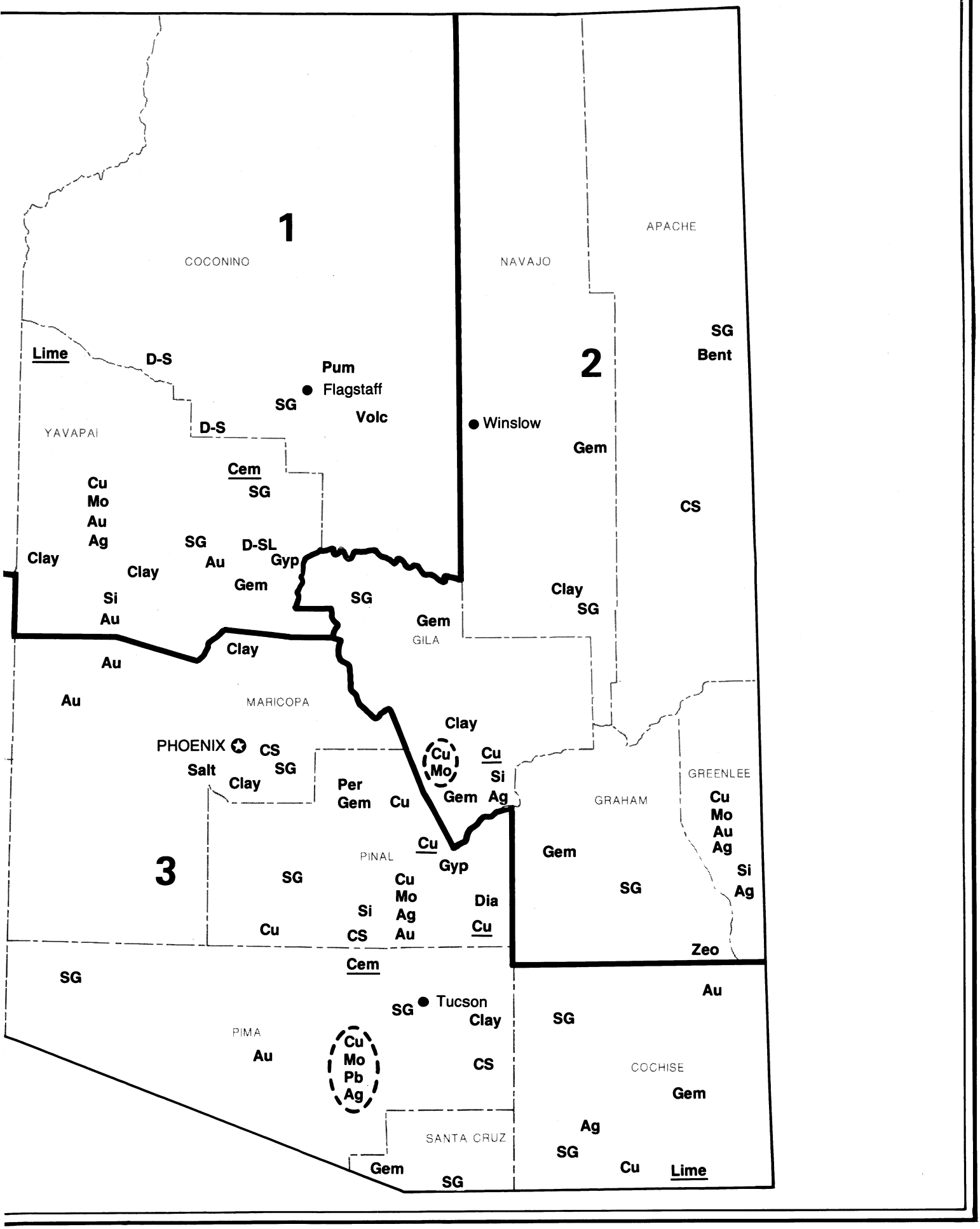
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

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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Volc
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Au
CS
COCHISE
Gem
Ag
SG
SANTA CRUZ
Cu
Lime
Gem
SG

recovered in the Sierrita concentrator from copper ore extracted at Cyprus' Twin Buttes Mine. Molybdenum output at the Twin Buttes property was reported separately by the company for 1988, the year when operations began at the mine; in that year, 36.7 metric tons (81,000 pounds) was produced.[7]

The second largest producer of molybdenum in Arizona was the Cyprus-owned Bagdad Mine in Yavapai County. Output at the mine was 3,950 metric tons (8.7 million pounds), according to the company's 1989 Form 10-K. Other properties that produced molybdenum were the Pinto Valley and San Manuel Mines owned by Magma and the Morenci Mine owned by Phelps Dodge. Production at each of these mines, respectively, was 575 metric tons (1.3 million pounds), 1,380 metric tons (3 million pounds), and 860 metric pounds (1.9 million pounds).

Silver.—Arizona was ranked fifth in the United States in silver output in 1989. Production increased more than 12% over that of the previous year to about 171 metric tons (5.5 million troy ounces). This quantity was more than 8% of total domestic production of silver.

Five mines in the State were among the 25 leading silver operations in the Nation. These mines plus two others, all primary copper producers, were responsible for nearly 97% of Arizona's output. Cyprus' Sierrita Mine, including the Twin Buttes property, was the largest producer of byproduct silver. Asarco's Mission Complex, ranking second, produced 42.4 metric tons (1,362,000 troy ounces) according to the company's 1989 annual report. Production of silver at Asarco's Ray Mine was reported to be 13.7 metric tons (439,000 troy ounces). Magma stated in its 1989 annual report that the combined output of the Pinto Valley and San Manuel divisions was about 44.9 metric tons (1,445,000 troy ounces), with San Manuel contributing more than 60% of the total. Phelps Dodge's Morenci Mine and Cyprus' Bagdad Mine were large producers of byproduct silver.

Approximately two-thirds of the remaining silver production in the State was derived from siliceous ores shipped to copper smelters. The largest of these producers was the underground Ash Peak Mine operated by Arizona Flux Mines Inc. in Greenlee County. Other major sources of silver-bearing flux were the Commonwealth tailings in Cochise County and the Mammoth tailings and the Reymert lode mine in Pinal County. According to the 1989 annual report of the Plexus Resources Corp., the Reymert Mine produced 5.2 metric tons (167,000 troy ounces) of silver during the fiscal year that ended June 30. Plexus held a royalty interest in the mine, which was operated by Triple Nichol Inc. for Cyprus Minerals.

PBR Minerals Inc. began to heap leach precious-metal-bearing materials at its Grand Central property in Tombstone (Cochise County) in 1989.[8] The company initially treated ore that had been previously crushed, agglomerated, and leached by Tombstone Exploration Inc., which closed its operation in mid-1984. PBR expended about $2.5 million to bring the property into production. During the year, the company produced 1.85 metric tons (59,604 troy ounces) of silver and 28.2 kilograms (907 troy ounces) of gold.

Other Metals.—Arizona was the only State in which rhenium was recovered in 1989. It was produced by Cyprus at the Sierrita Mine. The metal, occurring as a trace element in molybdenite, was recovered as ammonium perrhenate by roasting molybdenum concentrates.

Approximately 15% of the Nation's domestically produced uranium was mined in Arizona. In 1989, six uranium mines in Arizona, in Coconino and Mohave Counties, were either in production or under development by Energy Fuels Nuclear Inc.

A relatively small amount of lead was produced as a byproduct at the Mission copper complex, and lode tin was recovered at the Cheops property in Graham County. There was no recorded production of other metals during the year in the State except trace metals recovered at copper refineries.

Industrial Minerals

Cement.—Arizona ranked in the top half of all cement-producing States during the year. Output, however, of masonry cement has continued to decline since 1987, and, in 1989, was about 20% less than that of the previous year. The production of portland cement decreased 5% from that of 1988. Compared with the previous year, the average price in 1989 increased about 6% for masonry cement and decreased about 1% for portland cement.

Arizona Portland Cement Co., a subsidiary of the Calmat Co., was the largest producer of cement in the State. According to Calmat's 1989 Form 10-K, its Rillito plant in Pima County has an annual production capacity of 900,000 short tons of clinker. During the year, the company completed the installation of a roll press and high-efficiency separator at the facility. The company continued to reduce fuel costs by burning rubber tire chips in kilns at the cement plant.

Southwestern Sunbelt Cement, a subsidiary of Southdown Inc., began construction during early 1989 of a $2.5 million cement distribution terminal in Casa Grande (Pinal County). At the time of construction, the new terminal was jointly owned by Southdown and Cementos Mexicanos SA, which was the largest producer of cement in Mexico. The terminal will receive cement imported from Mexico.

After dissolving its association with Cementos Mexicanos, however, Southdown initiated and led six other U.S. cement producers in Arizona, Florida, New Mexico, and Texas in the filing of an antidumping petition against Mexican cement producers. The petition, filed in September 1989 with the International Trade Commission (ITC), alleged that cement from Mexico was being sold in these States at less than fair-market value. By yearend, the ITC issued a preliminary determination that there was a reasonable indication of material injury to the domestic producers. A final ruling was to be issued in 1990.

Clays.—In 1989, production of all clays increased almost 12% over that of the previous year. The output of common clay and shale rose about 6% to 151,400 metric tons (166,800 short tons) and that of bentonite increased sharply by more than 41% to 36,900 metric tons (40,600 short tons). Most of the bentonite produced in Arizona was the low-swelling calcium variety.

Gem Stones.—Arizona slipped from third to fourth place nationally in the value of production of gem stones. The State ranked second in the Nation, however, as a source of inorganically derived gem materials. Arizona produced a greater variety of gem stones than any other State. Output included agate, amethyst, antlerite, azurite, chryscolla, garnet, jade, malachite, obsidian, onyx, opal, peridot, petrified wood, shattuckite, smithsonite, and turquoise.

TABLE 2

CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch): Riprap and jetty stone	199	1,205
Coarse and fine aggregates:		
Graded road base or subbase	108	157
Unpaved road surfacing	821	3,959
Terrazzo and exposed aggregates	169	698
Other construction materials[2]	373	1,103
Other miscellaneous uses[3]	3,470	15,064
Unspecified:[4]		
Actual	816	2,652
Estimated	692	3,713
Total[5]	6,649	28,552

[1]Includes limestone, sandstone, dolomite, granite, slate, and miscellaneous stone.
[2]Includes stone used in other fine aggregate, stone sand (concrete), and screenings, undesignated.
[3]Includes stone used in cement and lime manufacture, flux stone, mine dusting or acid water treatment, and roofing granules.
[4]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5]Data may not add to totals shown because of independent rounding.

Gypsum.—Mine production of gypsum in the State increased about 4% during 1989 over that of the previous year. Average prices increased approximately 11%, from $6.80 per short ton to $7.53 per short ton.

Three companies operated four mines during the year and supplied agricultural, cement, and wallboard customers. Most of the production was in Pinal County.

The National Gypsum Co. was the largest producer of crude gypsum in the State. According to its 1989 Form 10-K, output at the company's Feldman Mine (Pinal County) was 155,000 short tons. National Gypsum's subsidiary, the Gold Bond Building Products Div., calcined gypsum and manufactured wallboard and joint treatment products at its plant in Phoenix.

Lime.—Domestically, Arizona jumped to eighth place in lime production during the year. Although the State's output remained fairly constant since 1988, average prices registered a small increase in 1989. The entire commercial production was from two plants owned by Chemstar Inc., one at Paul Spur in Cochise County and the other at Nelson in Mohave County. Magma Copper produced hydrated lime for its own use at the company's San Manuel division in Pinal County.

Chemstar, a privately owned company, was the largest producer of hydrated lime and quicklime in the Western United States. The Nelson facility, one of the firm's largest, had a rated capacity of 1,800 short tons of high-calcium quicklime per day. The Paul Spur plant was rated at 1,000 short tons per day.

Perlite.—In 1989, the State was the second leading producer of perlite in the country. Although production dropped slightly from that of 1988, average prices fell about 9%, from $29.47 per short ton in 1988 to $26.79 in 1989. Surface mines near Superior (Pinal County) were operated by the Harborlite Corp. and the Nord Perlite Co. Expanded perlite was produced primarily for horticultural purposes by Therm-O-Rock Industries Inc. in Maricopa County.

Sand and Gravel.—**Construction**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Arizona construction sand and gravel statistics are compiled according to geographical districts as depicted on the State map. The State's production in 1989 was estimated to have risen about 5% from that of 1988. As a result, Arizona ranked sixth nationally in the output of construction sand and gravel, and its total dollar value in the State was second only to that of copper. Most of the production was in District 3, which encompasses the metropolitan centers of Phoenix and Tucson.

Industrial.—Production of industrial sand continued during 1989 at the Houck Mine in Apache County. This relatively valuable commodity, composed of well-rounded and well-sorted quartz grains, was produced by the Arizona Silica Sand Co. and sold chiefly for hydraulic fracturing and construction of molds.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Statistics for crushed stone production are reported for three geographical districts as shown on the State map. Table 3 presents end-use statistics for these districts. Reflecting a downward trend since 1987, production in 1989 was about 10% less than the estimated level of output in 1988. The kind of stone mined and crushed, listed in descending order of amount produced, was limestone, granite, volcanic cinders, quartzite, and marble.

Dimension.—Seven companies quarried dimension stone in Arizona and supplied various users during 1989. A diversity of products, including onyx marble, sandstone, and schist, were mined principally in the counties of Coconino, La Paz, Maricopa, Mohave, and Yavapai.

Other Industrial Minerals.—Arizona was one of only five States in which diatomite was produced in 1989. Output during the year fell considerably from that of 1988. The State's sole source of the relatively high-value commodity was the Whitecliffs Mine in Pinal County, operated by Whitecliffs Industries.

Swansea Minerals Inc. shipped iron oxide pigment from the Swansea Mine in La Paz County. The pigment, occurring as specular hematite, was used in paint and coatings. Pumice was produced in Coconino County at mines operated by Arizona Tufflite Inc. and Mountain View Mining Inc. Most of the material was used by the garment and building block

TABLE 3

ARIZONA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	W	W	W	52	W	W
Fine aggregate (-3/8 inch)[2]	W	547	W	W	W	W
Coarse and fine aggregates[3]	149	308	48	136	901	4,370
Other construction aggregates	347	436	47	79	178	1,196
Agricultural[4]	—	—	—	—	(5)	(5)
Chemical and metallurgical[6]	(5)	(5)	—	—	(5)	(5)
Special[7]	—	—	—	—	(5)	(5)
Other miscellaneous	1,802	9,045	—	—	1,669	6,020
Unspecified:						
Actual[8]	—	—	25	264	791	2,388
Estimated[9]	—	—	253	2,068	440	1,645
Total[10]	2,298	10,335	372	2,598	3,978	15,619

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[1]Includes riprap and jetty stone.
[2]Includes stone sand (concrete), fine aggregate (screening-undesignated), and other fine aggregates.
[3]Includes crushed stone for graded road base or subbase, unpaved road surfacing, and terrazzo and exposed aggregates.
[4]Includes poultry grit and mineral food.
[5]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[6]Includes crushed stone for cement manufacture, lime manufacture, and flux stone.
[7]Includes crushed stone for mine dusting or acid water treatment and roofing granules.
[8]Includes production reported without a breakdown by end use.
[9]Includes estimates for nonrespondents.
[10]Data may not add to totals shown because of independent rounding.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Arizona Portland Cement Co., division of California Portland Cement, a subsidiary of CalMat Co.[1 2]	Box 338 Rillito, AZ 85654	Quarry and dry-process, four-rotary-kiln plant	Pima.
Salt River Pima-Maricopa Community[1 2]	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	Navajo and Yavapai.
Clinton-Campbell Contracting Inc.	1814 South 7th Ave. Phoenix, AZ 85007	do.	Maricopa and Pima.
Engelhard Corp. (formerly Harshaw/Filtro Corp.)	Box 155 Sanders, AZ 86512	Surface strip mine	Apache.
McKusick Mosaic Co.	Rt. 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.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Copper—Continued			
ASARCO Incorporated—Continued			
Mission Complex[3 4 5]	Box 111 Sahuarita, AZ 85629	Open pit mines and mill	Pima.
Ray Unit[3 5 6]	Box 9 Hayden, AZ 85235	Open pit mine, dump- and heap-leach, precipitation, SX-EW plants	Gila and 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.[5 6]	Box 245 Bagdad, AZ 86321	Open pit mine, mill, dump-leach, SX-EW plant	Yavapai.
Cyprus Casa Grande Corp.	Box C-9 Casa Grande, AZ 85222	In situ mine and SX-EW plant	Pinal.
Cyprus Miami Mining Corp.	Box 1559 Claypool, AZ 85532	Dump- and heap-leach, precipitation plant, SX-EW, smelter, refinery, rod mill	Gila.
Cyprus Mineral Park Corp.	Box 6249 Kingman, AZ 86401	Dump-leach and precipitation plant	Mohave.
Cyprus Sierrita Corp.[3 5 6]	Box 527 Green Valley, AZ 85622	Open pit mine, mill, leach dumps, precipitation plant, SX-EW plant	Pima.
Cyprus Twin Buttes Corp.[3 5 6]	1855 La Canada Green Valley, AZ 85622	Open pit, leach dumps, SW-EX plant	Do.
Magma Copper Co.:			
Corporate Headquarters	Box M San Manuel, AZ 85631	Offices	Pinal.
San Manuel Div.[2 3 5 6 7]	Box M San Manuel, AZ 85631	Underground mine, mill, in situ and heap leaching, SX-EW plant, acid plant, smelter, refinery, rod mill	Do.
Pinto Valley Div.[3 5 6]	Box 100 Miami, AZ 85539	Open pit mine, mill, leach dumps, in situ leach, SX-EW plant	Gila.
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.
Morenci Branch[3 5 6]	Box 4521 Morenci, AZ 85540	Open pit mine, mills, dump-leach, precipitation, and SX-EW plants	Greenlee.
Diatomite:			
Whitecliffs Industries	7400 North Oracle Rd., #371 Tucson, AZ 85704	Surface mine and plant	Pinal.
Gold:			
A. F. Budge Ltd.	4301 North 75th St. #101 Scottsdale, AZ 85215	Underground mine and tailings leach	Maricopa and Yavapai.
Cyprus Copperstone Gold Corp.	Box A1 Parker, AZ 85344	Open pit mine, agitation leach	La Paz.
Malartic Hygrade U.S. Inc. (formerly Echo Bay Inc.)[5 8]	Box 361 Congress, AZ 85332	Underground mine	Yavapai.
Roddy Resources Inc. (formerly J. Devins Resource Group)	Box 2406 Wickenburg, AZ 85358	Open pit mine and heap leach	Maricopa.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Gypsum:			
National Gypsum Co:			
Gold Bond Building Products Div.	Box 3990 Phoenix, AZ 85036	Plant	Maricopa.
Feldman Quarry	Star Rt., 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.
Iron oxide pigment:			
Swansea Minerals Inc.	6360 East Rose Circle Dr. Scottsdale, AZ 85251	Mine tailings	La Paz.
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.	6732 West Willis Rd. Chandler, AZ 85226	Plant	Maricopa.
Pumice:			
Arizona Tufflite Inc.	2432 West Peoria, #1081 Phoenix, AZ 85029	Open pit mine	Coconino.
Mountain View Mining Inc.	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 85068	Pits	Do.
Baseline Materials Inc.	38353 Schneph Rd. Queen Creek, AZ 85242	do.	Do.
Blue Circle West Inc.	2625 South 19th Ave. Phoenix, Az 85009	do.	Do.
CalMat Co. of Arizona, a subsidiary of California Portland Cement Co., a subsidiary of CalMat Co.	1801 East University Dr. Box 52012 Phoenix, AZ 85036	Pits and plants	Do.
Earth Products Inc.	Box 278 Humboldt, AZ 86329	do.	Yavapai.
Mesa Materials Inc.	3410 North Higley Rd. Mesa, AZ 85205	Pits	Maricopa.
Phoenix Redi-Mix Co.	3635 South 43rd Ave. Phoenix, AZ 85009	do.	Do.
Salt River Sand & Rock	Box 728 Mesa, AZ 85211	do.	Do.
The Tanner Companies	3640 South 19th Ave. Box 52124 Phoenix, AZ 85072	Pits and plants	Coconino, La Paz, Maricopa, Pima, Pinal, Yavapai, Yuma.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel (construction)—Continued			
Union Rock & Materials Corp.	Box 8007 Phoenix, AZ 85006	Pits and plants	Maricopa and Pima.
Sand and gravel (industrial):			
Arizona Silica Sand Co.	Box 108 Houck, AZ 86506	Open pit mine	Apache.
Silver:			
PBR Minerals Inc.[3]	905 Skyline Dr. Tombstone, AZ 85638	Open pit mine and heap leach	Cochise.
Stone (crushed):			
Arizona Granite	7401 West Villa Rita Dr. Peoria, AZ 85345	do.	Maricopa.
Madison Granite Supplies	7050 Grand Ave. Glendale, AZ 85301	Quarry and plant	Do.
Perkins Cinders Inc.	Rt. 1, Box 3125 Show Low, AZ 85901	do.	Navajo.
Red Mountain Mining Inc.	4250 North Bush Highway Mesa, AZ 85205	do.	Do.
Superlite Block Co.	Box 23163 Phoenix, AZ 85063	Quarry	Coconino.
Stone (dimension):			
Blaser Corp.	N. Hwy. 89 Chino Valley, AZ 86323	Quarries and plant	Coconino and Yavapai.
Dunbar Stone Co.	Box 246 Ash Fork, AZ 86320	do.	Coconino, Maricopa, Mohave, Yavapai.
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.
Little Hill Mines Inc.[5 8]	Box 332 Oracle, AZ 85623	Open pit mine	Pinal.
Queenstake Resources Ltd.[5 8]	Box 217 Willcox, AZ 85644	Underground mine	Cochise.
Triple Nichol Inc.[5]	R.R. 1, Box N123 Globe, AZ 85501	Surface and underground mines	Gila and Pinal.
Vermiculite (exfoliated):			
W. R. Grace & Co., Construction Products Div.	4220 West Glenrosa Phoenix, AZ 85019	Plant	Maricopa.
Therm-O-Rock Industries	6732 West Willis Rd. Chandler, AZ 85226	do.	Do.
Zeolite:			
GSA Resources[1]	Box 16509 Cortaro, AZ 85652	Surface strip mine	Cochise.
Union Carbide Corp.	Box 1029 Grand Junction, CO 81502	do.	Do.

[1]Also clays.
[2]Also limestone.
[3]Also gold.
[4]Also lead.
[5]Also silver.
[6]Also molybdenum.
[7]Also lime.
[8]Also copper.

industries. The recovery of pyrite continued at the San Manuel property operated by Magma Copper in Pinal County. Output in 1989 increased more than 19% over that of the previous year.

Solution mining and processing of salt continued at the Luke facility owned by the Morton Salt Co. Production in 1989 increased almost 17% over that of 1988, and average prices rose nearly 14% from $52.76 per short ton to $60.05 per short ton. At midyear, Morton Salt became a division of Morton International, which had been spun off from Morton Thiokol Inc.

More sulfuric acid, produced as a by-product of base metal smelters and roasters, was recovered at copper facilities in Arizona than in any other State. In 1989, Arizona's output was about 40% of the Nation's sulfuric acid produced in this manner. Production in the State, 1.6 million short tons, increased by about 18% more than that of 1988. Most of the acid was used by the copper industry in SX-EW plants.

Exfoliated vermiculite was produced by Therm-O-Rock Industries and W. R. Grace and Co. at their plants in Maricopa County. Crude vermiculite was shipped into Arizona from outside sources.

Arizona led the Nation in the production of natural zeolites. Four companies mined the chabazite variety of zeolite from the Bowie deposit that straddles the Cochise-Graham County line.

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[1]State Mineral Officer, Bureau of Mines, Tucson, AZ. He has covered the mineral activities in Arizona for 3 years. Assistance in the preparation of the chapter was given by Donna Bruns, editorial assistant.

[2]Director, Arizona Department of Mines and Mineral Resources, Phoenix, AZ.

[3]Leaming, G. F. The Copper Industry's Impact on the Arizona Economy 1989, West Econ. Anal. Cent. (Marana, AZ), 1990, 32 pp.

[4]Beard, R. R. The Primary Copper Industry of Arizona in 1989, AZ Dep. Mines & Miner. Resour. (Phoenix, AZ), 1990, 74 pp.

[5]Rodian, S. Stan West Seeks Still More Equity. The Business Journal, Jan. 23, 1989.

[6]Reference cited in footnote 4, p. 27.

[7]Beard, R. R. The Primary Copper Industry of Arizona in 1988. AZ Dep. Mines & Miner. Resour. (Phoenix, AZ), 1989, 77 pp.

[8]Walenga, K. To Produce Silver-Gold From Old Grand Central. Pay Dirt, Southwestern ed., Apr. 1989, pp. 4A-5A.

THE MINERAL INDUSTRY OF ARKANSAS

This chapter has been prepared under a Memorandum of Understanding between the 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]

In 1989, the value of Arkansas's nonfuel mineral production was $382 million, according to data reported to the Bureau of Mines, Department of the Interior, by the State's mineral industry. The 1989 mineral value was a $75 million increase over that reported in 1988 and a new State record high. Arkansas ranked 26th in total domestic mineral value and was the only State with bromine, diamond, and vanadium production.

TRENDS AND DEVELOPMENTS

During the 1980's, Arkansas's mineral industry marketed approximately $4.5 billion worth of nonfuel mineral commodities. In 1980, the mineral industry produced more than $380 million of mineral commodities. Mineral demand and sales fell in 1981 and 1982, a result of the nationwide recession. The industry recovered in 1984, but the 1984–85 market for Arkansas's mineral output was stagnant, and its value fell slightly in 1985. The following year, 1986, marked the beginning of a 4-year trend of increased demand and sales. In 1988, the industry exceeded the $300 million sales plateau for the first time, and in 1989, the $300 million level was again topped.

The year 1989 marked an alltime high for industrial plant expansions and programmed capital investments in Arkansas. Several of the new or expanded facilities were companies using mineral raw materials as plant feed. The estimated capital investment in these facilities using minerals totaled more than $53 million.

EMPLOYMENT

Mining employment in the 1980's peaked at almost 6,000 in 1982 and dropped to a 9-year low at the beginning of 1989. The decline in employment in the mining sector, which included oil and gas exploration and development employment, occurred because of the downturn in petroleum-natural gas drilling activity and the demise of the Aluminum Co. of America (Alcoa) bauxite mines.

REGULATORY ISSUES

Four of the State's mineral processing facilities ranked high on the U. S. Environmental Protection Agency (EPA)

TABLE 1

NONFUEL MINERAL PRODUCTION IN ARKANSAS[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Abrasives[2]	metric tons	W	W	1,120	$429	W	W
Clays	do.	824,082	$8,651	844,466	15,376	871,313	$17,391
Gem stones		NA	1,800	NA	2,300	NA	4,041
Sand and gravel:							
Construction	thousand short tons	e7,200	e23,900	7,722	26,201	e7,500	e25,500
Industrial	do.	505	5,147	669	6,784	545	5,507
Stone:							
Crushed	do.	15,234	63,847	e17,100	e70,100	3 18,791	3 76,419
Dimension	short tons	10,541	629	e10,541	e629	W	W
Combined value of bauxite, bromine,[e] cement, gypsum, lime, stone (crushed slate and dolomite, 1989), talc and pyrophyllite, tripoli, vanadium (1989), and values indicated by symbol W		XX	160,188	XX	r184,785	XX	253,051
Total		XX	264,162	XX	306,604	XX	381,909

[e] Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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 stones; kind and value included with "Combined value" data.

toxic emissions list. The Alcoa plant at Bauxite topped the list. Records indicated that the facility produced more than 100 million pounds of aluminum oxide waste. The EPA, however, was considering removal of aluminum oxide from its list of toxic chemicals, so the Alcoa facility's ranking on the toxic waste list could change.

Agrico Chemical Co.'s plant at Blytheville emitted approximately 15 million pounds of ammonia in 1987. Plans were underway to install equipment that would lower plant emissions by 60%.

The U.S. Vanadium Corp. plant at Hot Springs discharged 3.4 million pounds of ammonium sulfate into Lake Catherine. The Great Lakes Chemical Co. in El Dorado, using deep-well injection technology, disposed of 8.8 million pounds of waste into formations below the water table.[3]

A large quantity, 150,000 to 200,000 tons, of spent aluminum smelter pot linings was shipped to Reynolds Metals Co.'s plant in Bauxite for treatment and burial. The waste, from five States and Canada, contained cyanide and fluorides.[4]

A former surface mine, used by the city of Texarkana in the early 1970's as a dumping site, was the center of a controversy at yearend. The EPA was reviewing trace element data from site samples to determine if the site should be placed on the cleanup list.[5]

EXPLORATION ACTIVITIES

Late in the year, agreements were signed to allow exploratory drilling at the site of the former Davis lead-zinc mine. The mine, in operation between 1913 and 1919, closed after a cave-in. Production from the mine was reported as "up to 300 train car loads of lead."[6]

LEGISLATION AND GOVERNMENT PROGRAMS

The 1989 Arkansas Legislature adjourned without acting on any bills that would have impacted the State's mineral industry.

The Arkansas Geological Commission (AGC) entered into an agreement with the Texas Bureau of Economic Geology and the Gas Research Institute to provide information to be included in two volumes of the three-volume National Gas Atlas. The atlas, when complete, will include both data on reservoirs that contain more than 10 billion cubic feet of gas and data on the type of exploration "play."

The AGC purchased an 18,000-square-foot building to house the Well Sample Library. In addition to the library, the new facility will also house the AGC Land Survey Division.

The Harrison Conterminous United States Mineral Appraisal Program (CUSMAP), a cooperative mineral appraisal program between the AGC, the U.S. Geological Survey, and the Missouri Geological Survey, was completed. Papers were also presented from the results of work done on the Midcontinent Strategic and Critical Minerals Project.

Data obtained during the past several years on the lignite resources of the State are being compiled into a comprehensive report. During the investigation, several interim reports were published that stimulated extensive exploration by four mining companies. In 1989, GCO Minerals mined about 222,000 tons of lignite in Saline County for a successful test burn at the AP&L White Bluff powerplant. State resources were estimated at 9 billion tons, of which one-half was considered recoverable.

In cooperation with the U.S. Geological Survey, the AGC entered the sixth year of a geologic mapping program (COGEOMAP) in the Ouachita Mountains. It is a multiyear effort to refine knowledge of the geology of this extremely complex province and to better evaluate its economic potential. The project covers approximately 177 7.5-minute quadrangles, or nearly 100,000 square miles. Publication scale of the maps will be at 1:250,000.

The Arkansas Department of Pollution Control and Ecology, Surface Mining and Reclamation Division, as part of its program to regulate reclamation at all nonquarry surface mines, worked closely with industry on water quality problems at several abandoned barite mines.

The U.S. Forest Service (USFS) held the first competitive bidding for quartz crystal mining in the Ouachita National Forest. The June proceedings resulted in high bids of more than $18 million being received. One-half of the bid money and annual mining fees will be returned to the State for county roads and schools within the forest boundary. On July 1, the USFS issued 5-year contracts to each of the successful bidders.[7]

The U.S Senate Subcommittee on Interior Appropriations approved $120,000 for the University of Arkansas to continue research on petroleum recovery from tar sands. Also appropriated was $300,000 to the State Plant Materials Center in Booneville to continue research into revegetation of abandoned mines throughout northwestern Arkansas.

The U.S. Senate also approved a Department of the Interior plan to allot $1.5 million to the State Office of Surface Mining. The money was for the revegetation of abandoned mines in northwestern Arkansas.[8]

The controversy over exploratory drilling and mining in the Crater of Diamonds State Park continued through yearend. Four companies, Arkansas Diamond Development Co., Continental Diamonds Inc., Kennecott Corp., and Capricorn Diamonds Pty. Ltd., formed a joint venture and were to split drilling costs with the State if drilling were allowed. The drilling was to determine the extent and quality of the diamond-bearing zone. If the results were favorable, a part of the park would be mined; an area would be retained for park visitors to search for diamonds. The drilling-mining plan was opposed by a coalition of environmental groups, The Friends of the Crater of Diamonds State Park, the Sierra Club, and the Arkansas Wildlife Federation. The environmental coalition threatened a lawsuit if drilling plans continued.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Fifteen industrial minerals were mined or manufactured in the State during 1989. Bromine, cement, and crushed stone accounted for more than 75% of the State's total mineral value.

Abrasives (Natural).—Arkansas continued to rank second among the four States producing natural abrasives. The raw material, novaculite, a dense, hard,

fine-grained metamorphic variety of chert, was mined in Garland County by Norton Co., Oilstones Inc., Hiram A. Smith Whetstone Co. Inc., and Dans Whetstone Cutting Co. Inc. and in Hot Springs County by Arkansas Whetstone Co. Inc. The novaculite was mined by standard quarrying methods, and diamond saws were used to cut run-of-mine material into 2-, 4-, or 6-inch blocks. These blocks were cut into smaller sizes and shapes for final finishing. Output consisted of whetstones, hones, scrapers, and files. Crude novaculite was exported to Europe and Japan. Output increased slightly, but there was a significant decrease in value.

Bromine.—Arkansas remained the only bromine-producing State, and bromine sales exceeded those of all other nonfuel mineral commodities produced in 1989. Bromine was recovered by four companies, the Ethyl Corp. and Dow Chemical USA in Columbia County and Arkansas Chemical Inc. and G.L. Chemical Co. in Union County.

Bromine was recovered from brines within the Smackover Formation approximately 7,000 to 8,000 feet beneath the surface in Columbia and Union Counties. The bromine-bearing brines were recovered through wells drilled into the brine horizon. Once on the surface, bromine was liberated from the brines by reaction with chlorine-laden steam. A fraction was refined and marketed as elemental bromine; principal sales were to chemical companies. Most of the output was used in the manufacture of fire control, agricultural and specialty chemicals, and oilfield fluids.

Cement.—Arkansas ranked 27th among the 38 cement-producing States in portland cement output and 17th among the 38 States in masonry cement output. The industry, composed of the Arkansas Cement Corp. and the Ideal Cement Co., produced both masonry and portland cement. The two companies used the wet process and operated five kilns. Raw material for clinker manufacture—clay-shale, limestone, and sand—was mined locally; gypsum was purchased from an in-State firm. Output of masonry and portland cement production decreased below that reported in 1988. The decrease was attributed to a slowdown in construction activity below the 1988 level.

Clays.—The State continued to rank 18th among the 44 clay-producing States. Arkansas's clay industry consisted of 20 companies producing common clay and kaolin. Output of common clay and shale and kaolin, 871,000 metric tons valued at $17.4 million, increased 27,000 metric tons, and value was up almost $2 million.

Gem Stones.—Diamond collecting at the Crater of Diamonds State Park in Pike County continued as the leading gem activity during 1989. The controversy over test drilling and possible commercial mining within the park is noted in the Legislation and Government Programs section.

Quartz crystal collecting paralleled the popularity of diamond "hunting," and many commercial mines produced crystals for the retail market. Some mines were open to public collecting on a fee basis. Experienced mineral collectors visited numerous localities in the State in search of samples of Arkansas's unique mineral heritage.

Gypsum.—Arkansas continued to rank ninth of the 21 States reporting gypsum production. Weyerhaeuser Co. operated the Briar Mine in Howard County, and Harrison Gypsum Co. Inc. worked the Highland Mine in Pike County. Weyerhaeuser calcined gypsum for use in wallboard production, and Harrison sold crude gypsum to cement companies for use in clinker manufacture. Weyerhaeuser sold its gypsum operation to Briar Gypsum Co., a subsidiary of Boral Ltd. (Australia), around the end of 1989. A third firm, Temple Inland Forest Products Co., purchased gypsum mined by an Oklahoma firm for use in wallboard manufacture. Output and value of Arkansas mined gypsum increased over that reported by the two companies in 1988.

Lime.—Arkansas Lime Co. in Independence County continued as the State's sole hydrated lime and quicklime producer. The company used limestone mined locally as a kiln feed to produce lime. Output and value rose slightly above that reported by the company in 1988.

Quartz.—Quartz crystals occurred in an east-west trending zone extending into Oklahoma from a few miles west of Little Rock. Much of the zone containing crystals underlies the Ouachita National Forest. For several decades small miners worked these deposits, selling crystals to mineral shops and the general public. The miners dealt with several Federal agencies, depending on whether mining was on land that was "public domain" or "acquired status." A change in the law, Section 323 of Public Law 100–46, directed that quartz mining be administered solely by the Forest Service. The first competitive bids for mining leases on quartz-bearing acreage was held in midyear; the high bids totaled more than $18 million.

Sand and Gravel.—Both construction and industrial sand and gravel were mined in the State in 1989. Estimated output, about 8 million short tons, was slightly below that reported by industry in 1988. The value of both construction and industrial sand and gravel fell almost $2 million below that reported by the industry in 1988.

Construction.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

In 1988, the last year that the Bureau of Mines conducted a full-year canvas of the construction sand and gravel industry, 51 companies operated 67 pits in 35 counties. Production was centered in Little Rock, Ouachita, and Pulaski Counties.

Industrial.—Industrial sand production was reported by three companies operating three pits in Hempstead, Izard, and Miller Counties. Principal sales were to the foundry, glassmaking, and blasting industries. Output decreased 124,000 short tons, and value fell $1,277,000.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Arkansas stone statistics are compiled by geographical districts as depicted in the State map. Table 3 pre-

ARKANSAS

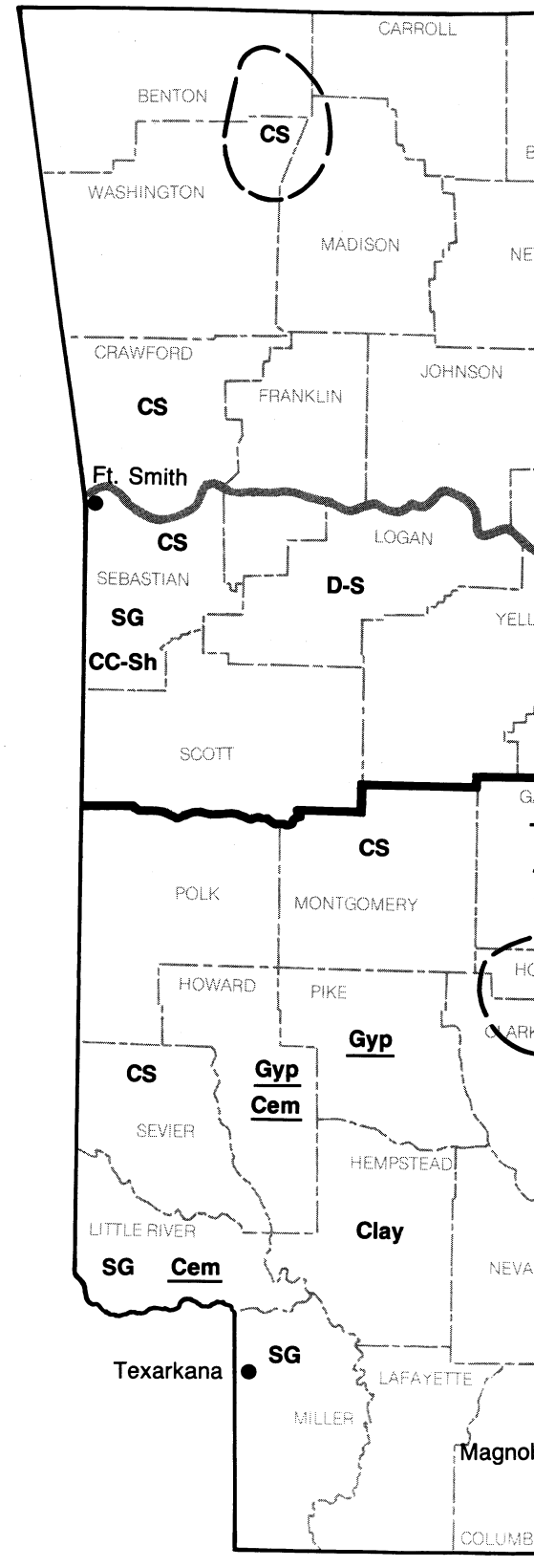
LEGEND

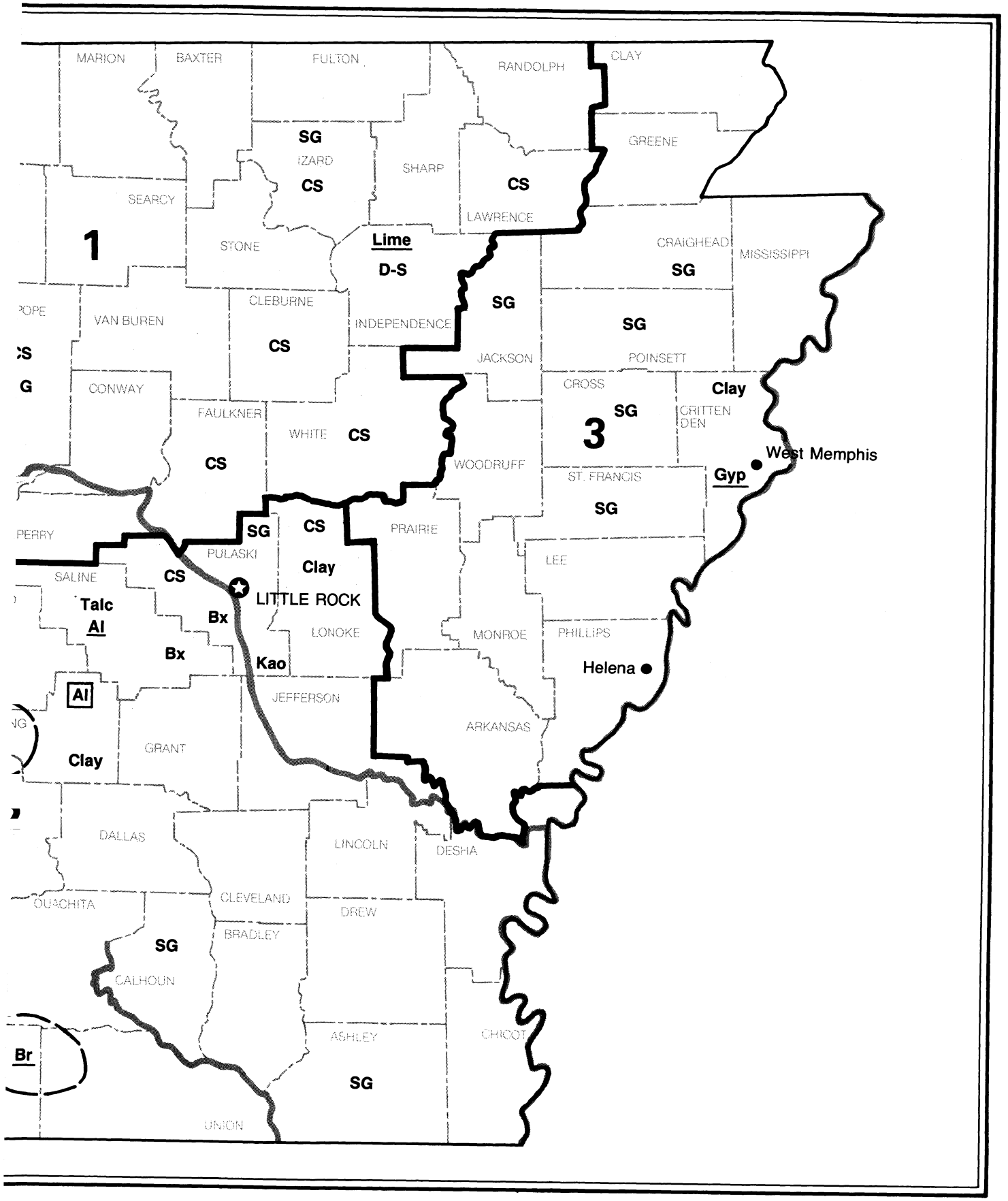
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

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




MARION
BAXTER
FULTON
RANDOLPH
CLAY
GREENE
SG
IZARD
CS
SHARP
CS
SEARCY
LAWRENCE
1
STONE
Lime
D-S
CRAIGHEAD
SG
MISSISSIPPI
POPE
VAN BUREN
CLEBURNE
CS
INDEPENDENCE
SG
SG
JACKSON
POINSETT
CONWAY
CROSS
SG
Clay
CRITTEN DEN
FAULKNER
CS
WHITE
CS
3
WOODRUFF
West Memphis
Gyp
ST. FRANCIS
SG
PERRY
SG
CS
PRAIRIE
PULASKI
Clay
LEE
SALINE
CS
LITTLE ROCK
Talc
Al
Bx
LONOKE
MONROE
PHILLIPS
Bx
Kao
Helena
Al
JEFFERSON
ARKANSAS
Clay
GRANT
DALLAS
LINCOLN
DESHA
OUACHITA
CLEVELAND
DREW
BRADLEY
SG
CALHOUN
ASHLEY
CHICOT
Br
SG
UNION

sents end-use statistics for Arkansas' two districts.

Crushed.—The State ranked 32nd among the 48 States reporting crushed stone production. Stone sales ranked second in Arkansas's mineral value, behind bromine, in 1989. Production was reported by 33 companies operating 46 quarries in a 27-county area. Output, 18.8 million short tons of crushed stone valued at $76.4 million, exceeded the 1988 estimate by 1.7 million short tons and $6.3 million.

The leading stone types produced during 1989 were granite, 7.4 million short tons (39%); limestone, 7.6 million short tons (40%); and sandstone, 3.3 million short tons (18%); dolomite, slate and "other" stone types accounted for the remainder.

Granite was produced by five companies in Pulaski and Pope Counties in the central and western part of the State. Sandstone was mined and crushed by 9 firms operating 11 quarries in a 10-county area. Crawford, Sebastian, and Pulaski were the leading counties in sandstone output, accounting for 65% of the total. Limestone mining was by 15 firms operating 24 quarries and crushing plants in 14 counties. Little River, Independence, and Washington Counties were the leaders in limestone output, accounting for 47% of the production.

Dolomite output was reported from Lawrence County, slate from Saline County, and "other" stone from Crawford, Garland, Montgomery, and Saline Counties.

Industry reports on the major crushed stone sales included graded road base, cement manufacture, riprap and jetty stone, bituminous aggregate, and concrete aggregates.

Dimension.—Dimension sandstone was quarried by two companies at unspecified locations. Output was reported as cut and veneer stone by one firm; the second failed to specify end use. Production and value decreased below that reported in 1988.

Talc.—Saline County was the site of The Milwhite Co.'s Congo surface mine. The central Arkansas mine provided feed for the Bryant mill near Benton. Much of the mill output was sold to the ceramics and paper industries. Both output and value were unchanged from those of 1988.

Tripoli.—Arkansas was one of four States reporting the production of tripoli, a microcrystalline, friable material composed of approximately 97% silica. Malvern Minerals Co. mined a 40-foot thick tripoli bed by open pit methods. The crude tripoli was trucked to a mill in Hot Springs for drying, grinding, and classification by air separators. Production and value increased significantly above that reported by the firm in 1988.

Other Industrial Minerals.—In addition to the commodities listed in table 1, several minerals were recovered as byproducts from other mineral processing or shipped into the State for processing into higher value products.

Arkansas was 1 of 26 States in which 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 in Columbia County.

The State continued to rank seventh among the 13 States with synthetic graphite production. Great Lakes Carbon Group and Superior Graphite Co. operated plants in Ozark and Russellville, respectively, to produce graphite electrodes from petroleum coke.

Perlite from New Mexico was expanded by Strong-Lite Products Corp. at its Pine Bluff plant. Concrete aggregates and horticultural markets consumed much of the company's output.

Vermiculite was exfoliated by Strong-Lite at Pine Bluff and W.R. Grace and

TABLE 2

ARKANSAS: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	689	2,572
Filter stone	4	12
Coarse aggregate, graded:		
Concrete aggregate, coarse	457	2,506
Bituminous aggregate, coarse	523	2,711
Bituminous surface treatment aggregate	27	140
Railroad ballast	31	171
Fine aggregate (-3/8 inch):		
Stone sand, bituminous mix or seal	195	591
Screening, undesignated	203	828
Coarse and fine aggregates:		
Graded road base or subbase	2,560	9,325
Unpaved road surfacing	85	409
Crusher run or fill or waste	133	651
Other construction materials[2]	73	253
Agricultural: Agricultural limestone and poultry grit and mineral food	235	1,287
Other miscellaneous uses[3]	3,212	9,022
Unspecified:[4]		
Actual	6,055	24,924
Estimated	4,310	21,017
Total	[5]18,791	76,419

[1] Includes limestone, sandstone, granite, and miscellaneous stone; dolomite and slate withheld to avoid disclosing company proprietary data.
[2] Includes stone used in macadam.
[3] Includes stone used in cement manufacture, mine dusting or acid water treatment, other fillers or extenders, and roofing granules.
[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.

TABLE 3

ARKANSAS: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2	
	Quantity	Value	Quantity	Value
Construction aggregates:				
Coarse aggregate (+1 1/2 inch)[1]	267	1,251	426	1,333
Coarse aggregate, graded[2]	W	W	W	W
Fine aggregate (−3/8 inch)[3]	W	W	W	W
Coarse and fine aggregates[4]	2,046	7,454	732	2,931
Other construction aggregates	1,391	6,097	117	1,104
Agricultural[5]	235	1,279	(6)	8
Chemical and metallurgical[7]	—	—	(6)	(6)
Special[8]	(6)	(6)	(6)	(6)
Other miscellaneous	54	296	3,159	8,726
Unspecified:				
Actual[9]	4,027	16,895	2,028	8,030
Estimated[10]	366	1,645	3,944	19,372
Total[11]	8,386	34,916	10,406	41,503

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[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 fine aggregate (screening-undesignated).
[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[5] Includes agricultural limestone and poultry grit and mineral food.
[6] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[7] Includes crushed stone for cement manufacture.
[8] Includes crushed stone for mine dusting or acid water treatment, other fillers or extenders, and roofing granules.
[9] Includes production reported without a breakdown by end use.
[10] Includes estimates for nonrespondents.
[11] Data may not add to totals shown because of independent rounding.

Co. at a plant in North Little Rock, which was shut down during the year. Crude vermiculite was obtained from mines in South Carolina and other States. Markets for the exfoliated material included texturing paints, aggregates, insulation, and agricultural and fireproofing applications.

Metals

Bauxite and vanadium ore were the only metallic minerals mined in Arkansas during the year. Scrap metal was the other major "ore" processed in State.

Aluminum.—Alcoa operated an alumina chemical plant in Saline County. At yearend, the plant was using bauxite mined instate and imported from foreign sources.

Alcoa donated approximately 5 acres of land in Saline County to the Arkansas Geological Commission. The donation was to preserve a remarkable exposure of nepheline syenite containing several dikes and a unique xenolith of Paleozoic rock.

Bauxite.—Production was maintained at the single operating mine in 1989; however, Alcoa employees at Benton were told that bauxite reserves were near depletion and that the Saline County mine would be closed in 1990. The closing was projected to affect 200 jobs.

Iron and Steel.—Arkansas's steel industry consisted of Arkansas Steel Associates and Nucor-Yamato Steel Co. The two minimills operated by the two firms contained four electric furnaces and had an annual capacity of 870,000 short tons per year.

Arkansas Steel Associates was founded when Razorback Steel Co., Newport, was sold to a partnership formed by Sumitomo Corp. of America (SCA). The partnership included SCA and its parent company, Sumitomo Metal Industries Ltd. of Osaka, Japan; Yamato Kogyo Co. Ltd. of Himeji, Japan; and Auburn Steel Co. of Auburn, NY, owned by Kyoei Steel Ltd. of Osaka, Japan. Razorback, a small, independent minimill, produced 220,000 tons of steel per year in two, 30-ton electric furnaces.

Nucor-Yamato Steel Co's. minimill at Blytheville was equipped with a plasma dust-processing facility during 1989. The processing facility at the 650,000-ton-per-year minimill was completed in May and operated by International Mill Service, Inc. The new dust facility, using dust generated during steel making, was capable of handling 12,000 tons of dust per year.[9]

Vanadium.—U.S Vanadium, a subsidiary of Strategic Minerals Corp. of Danbury, CT, continued to operate the Nation's only vanadium mine-mill in the Hot Springs area. The mine was reopened in 1989 after a 4-year closure. Economics dictated the mine closing and reopening. Mill roaster feed included both newly mined and stockpiled ore as well as Venezuelan feedstocks.

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[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL. He has 29 years of industry and government experience and has covered the mineral activities in Arkansas since 1989. Assistance in the preparation of the chapter was given by Maylene E. Hubbard, editorial assistant.

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

[3] Searcy Daily Citizen. State 10th in Toxic Emissions. Aug. 21, 1989.

[4] Malvern Daily Record. Waste Shipped to Bauxite Plant. Sept. 13, 1989.

[5] Texarkana Gazette. Study Expected to Last Until February. Nov. 6, 1989.

[6] DeQueen Bee (Sevier County). Old Mine Sparks New Interest. Dec. 14, 1989.

[7] Paris Express/Progress. Quartz Bids Top $18M. July 12, 1989.

[8] Arkansas Gazette. $17 Million for State in Senate Spending Package. Oct. 8, 1989.

[9] American Metal Market. Nucor-Yamato Hires IMS to Build, Run EF Dust Unit. V. 97, No. 28, Feb. 9, 1989, p. 3.

TABLE 4

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 Spring, AR 71901	Quarry	Garland.
Tripoli:			
Malvern Minerals Co. Inc.	Box 1246 Hot Spring, 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 6057 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 (1988):			
Construction:			
Jeffrey Sand Co.	Box 998 Fort Smith, AR 72901	Pits and plant	Faulkner, Pulaski, Sebastian.
St. Francis Materials Co., a division of Ben M. Hogan Co. Inc.	Box 999 Forrest City, AR 72335	do.	Calhoun, Craighead, Poinsett, St. Francis.
Industrial:			
Gifford-Hill & Co. Inc.[2]	Box 6615 Shreveport, LA 71136	do.	Miller.
Silica Products Co. Inc.	Box 29 Guion, AR 72540	do.	Izard.

See footnotes at end of table.

TABLE 4—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	Izard.
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.[3]	Box 15038 Houston, TX 77020	Mine and plant	Saline.
Vanadium:			
Strategic Minerals Corp.	Route 6, Box 943 Hot Spring, 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 construction sand and gravel in Ouachita County.
[3] Also produced slate.

THE MINERAL INDUSTRY OF CALIFORNIA

This chapter has been prepared under a Memorandum of Understanding between the 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 L. Burnett[3]

California ranked second among the States in the value of nonfuel minerals produced in 1989, about 8.8% of the U.S. total. The value of the commodities produced in 1989 increased nearly 6% to $2.85 billion, continuing the steady growth in the State's mineral industries since 1982. California led all States in the production of boron minerals, portland cement, diatomite, calcined gypsum, rare-earth concentrates, construction sand and gravel, and tungsten. It was second in the production of calcium chloride, feldspar, gold, magnesium compounds from brine, and sodium compounds.

Opposition by nearby residents to new mining permits continued to impede mining operations in the State when no-growth proponents opposed the issuance of new mining permits by local governments to sand and gravel quarries and to gold mining operations. Operations were shut down at several gold mines during the year.

TRENDS AND DEVELOPMENTS

Industrial minerals comprised 87% of the State's nonfuel mineral production value. In 1989, 35 mineral commodities, including 8 metals, were produced in California. The rising trend since 1982 continued, as the State continued it's economic expansion. The 6% rate of expansion was similar to that of 1988.

Gold production in California increased 7.6% from that of 1988 to 29,804 kilograms (958,199 troy ounces), retaining the State's ranking as the second largest State among U.S. gold producers. Gold was also the State's highest valued metal produced. Production was reported from 19 lode and 3 placer mines. Much of the increase in gold production resulted from expansion of the major disseminated, low-grade, open pit mines already operating in the State, despite shutdowns at several smaller gold mines during the year.

Construction sand and gravel, portland cement, boron, and gold were the State's most important mineral commodities in terms of value. Boron production decreased about 3% from that of 1988, continuing the 1988 decline. Portland cement posted a small gain, but the sand and gravel estimate reflected the slowdown in the State's construction industry and population growth from the previous year.

EMPLOYMENT

According to the California Department of Employment Development, approximately 9,300 workers were employed in nonfuel mining in California in 1989, down about 3% from that of 1988. Of these, 7,200 were employed in industrial minerals mining and 2,100 in metal mining.

REGULATORY ISSUES

The U.S. Bureau of Land Management's (BLM) new regulations regarding fees for recording or filing mining claims became effective in January. Under the new fee schedules, claimants were charged $10 per claim to record and $5 per claim for annual assessments. Mineral patent applications were increased from $25 to $250 for the first claim and $50 for each succeeding claim.

In 1989, 17,663 new claims were filed in California, an increase of almost 9% more than the previous year. More than 86,000 annual work assessments also were filed and 7 mineral patent applications were processed.

BLM began to require all mines on Federal lands in California using cyanide to report any bird or animal mortalities. They also instituted a monthly on-site inspection to verify compliance with agency-required environmental and safety protection measures.

EXPLORATION ACTIVITIES

Gold exploration continued in the State, although at a lesser pace than the previous year, as lower prices and new regulations dampened enthusiasm for precious-metals exploration. AMAX Gold Inc. and U.S. Gold Corp. investigated a gold deposit in Lassen County. Homestake Mining Co. began exploratory drilling near the Salton Sea in Imperial County. Exploratory drilling was undertaken near North Columbia in Nevada County by the San Juan Joint Venture. Exploration work continued at Golden Bell Mining Co.'s Pine Tree Mine in Mariposa County.

Exploration for sulfur was reported by American Sulfur Products Co. at the Crater Mine in the Last Chance Range of Inyo County. The property was explored for gypsum and sulfur deposits for agricultural uses.

LEGISLATION AND GOVERNMENT PROGRAMS

The passage of Assembly bill 1413 in November made the State Regional Water Quality Control Board the sole regulator of mining wastes. The bill reflected the recommendations of a mining waste study conducted by the University of California, Berkeley, that endorsed eliminating dual permitting and shifting of the regulatory authority on mining-waste matters from the Department of Health Services to the Water Board.

The Department of the Interior's Minerals Management Service reported

TABLE 1

NONFUEL MINERAL PRODUCTION IN CALIFORNIA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Boron minerals[2]	metric tons	625,051	$475,092	577,877	$429,667	562,311	$429,806
Cement:							
Masonry	thousand short tons	W	W	8	730	W	W
Portland	do.	9,937	593,859	10,423	601,152	10,911	642,020
Clays	metric tons	2,083,200	33,045	2,015,488	31,620	2,195,830	39,243
Gem stones		NA	3,367	NA	3,365	NA	2,982
Gold[3]	kilograms	18,743	269,937	22,442	316,246	29,804	366,595
Gypsum	thousand short tons	1,468	11,719	1,490	11,222	1,734	13,066
Lime	do.	465	25,745	r458	r20,242	395	24,503
Mercury	metric tons	(4)	(4)	W	W	W	W
Peat	thousand short tons	W	W	2	119	—	—
Pumice	thousand metric tons	38	1,539	32	1,245	79	4,612
Sand and gravel:							
Construction	thousand short tons	e141,600	e561,300	141,946	622,074	e138,300	e670,800
Industrial	do.	2,241	41,472	2,444	42,078	2,426	43,863
Silver[3]	metric tons	4	854	15	3,148	21	3,650
Stone:							
Crushed	thousand short tons	44,315	186,504	e49,100	e275,000	54,887	238,034
Dimension	short tons	33,335	4,554	e42,048	e5,991	28,829	5,564
Combined value of asbestos, barite (1987–88), calcium chloride (natural), copper (1988–89), diatomite, feldspar, diatomite, feldspar, iron ore (includes byproduct material, 1988–89), magnesium compounds, molybdenum, perlite, potassium salts, rare-earth metal concentrates, salt, sodium carbonate (natural), sodium sulfate (natural), talc and prophyllite, titanium concentrates ilmenite (1989), tungsten ore concentrates, wollastonite (1987), and values indicated by symbol W		XX	342,298	XX	334,755	XX	369,378
Total		XX	2,551,285	XX	2,698,654	XX	2,854,116

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Beginning with 1989 data reported in B_2O_3, 1987–88 data converted.
[3]Recoverable content of ores, etc.
[4]Less than 1/2 unit.

disbursement of $24,412,000 to California in 1989 for the State's share of bonuses, rents, and royalties associated with mineral leases on Federal lands within its borders.

The University of California received a $459,983 Mineral Institute grant from the Bureau of Mines for fiscal year 1989 under Public Law 98-409.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Asbestos.—California's 1989 asbestos production was slightly higher than that of 1988. KCAC Inc., at its San Benito County plant, was one of only two producers in the United States. Production was limited to short fiber chrysotile, one of six commercial varieties of asbestos. The ore was stripped and wet processing was used to beneficiate the fiber.

Boron Minerals.—California was the sole source of domestic boron mineral production. Sales of boron minerals valued at nearly $430 million were similar to those of 1988, although the quantity produced decreased from 578,000 metric tons in 1988 to 562,000 metric tons in 1989. Production was reported from three operations in 1989, principally in the form of sodium borate. Most of the boron production continued to be from Kern County, with the balance from San Bernardino County.

United States Borax and Chemical Corp., a subsidiary of RTZ Corp. PLC of London, United Kingdom, continued to be California's largest producer and the primary supplier of sodium borates. U.S. Borax mined and processed crude and refined borax products at its plant at Boron in Kern County. The company also used a proprietary process at a second plant at Boron to produce technical-grade boric acid from extensive kernite reserves. During 1989, U.S. Borax signed a 15-year

contract with Mojave Pipeline Co. for 100% of the natural gas used in its cogeneration operations. The majority of boron material was shipped to U.S. Borax's storage facility in Wilmington, which produced boric acid for glass manufacture and boron specialty chemicals. Other boron compounds were used in fertilizers, herbicides, and wood preservatives.

Kerr-McGee Chemical Corp. produced borax and boric acid products from mineral-rich lake brines at Searles Lake in San Bernardino County. The Trona plant used a differential evaporative process to produce pentahydrite borax and anhydrous borax and a solvent extraction process to produce boric acid. The Westend plant continued production of sodium borates by a carbonation process that also produced lime, sodium carbonate, and sodium sulfate.

Corona Corp. acquired 100% interest in the Fort Cady colemanite property in San Bernardino County and renamed the project Fort Cady Minerals Corp. Corona was in the process of negotiating for $85 million of financing for an 81,000-ton-per-year boric acid plant.

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.—Portland cement was California's second most valuable mineral commodity in 1989, with a reported value of more than $642 million. California's 10,911,000 short tons ranked first among the States in the production of finished portland cement, furnishing nearly 15% of the U.S. total, and first in clinker production, accounting for about 14% of the U.S. total from 11 active plants.

Los Angeles was the Nation's second largest recipient of imported cement, after Florida, receiving 2.2 million tons or 14% of the total. Because of the sustained level of construction activity in southern California, the State continued to lead all other regions of the country with an 8% increase in cement consumption.

Riverside Cement Co., a subsidiary of Gifford-Hill and Co., formed a joint venture with Korea's Ssangong Cement Industrial Co. to operate a bulk storage facility at the port of Stockton. Pluess-Staufer Inc. began an expansion program at its Lucerne Valley limestone plant in San Bernardino County. CBR Cement Corp. began integration of its recently acquired Monolith Portland Cement operation near Tehachapi with its Calaveras Cement Co. unit in Redding.

Nevada Cement Co. began discussions with the Port of Richmond over the possible development of an $11 million bulk cement distribution facility north of the Port's container terminal. The facility would use a high-capacity pneumatic unloading system and an underground piping network to remove cement from ships at the Port and transfer it to silos to await loading on ships and railcars.

Clays.—Clay production increased 9% from that of 1988 to 2.2 million metric tons (2.4 million short tons), valued at more than $39 million. Common clay and shale comprised the bulk of the clays produced with eight companies also reporting ball clay, bentonite, or kaolin production.

Diatomite.—California continued to lead all other States in diatomite production during 1989. As in previous years, the major producer was Manville Products Corp. from its operations near Lompoc in Santa Barbara County. Grefco Inc. was the second largest producer from its mine and plant near Burney in Shasta County.

Feldspar.—California ranked third nationally in the production of feldspar and second in the value of its production. The quantity of feldspar sold increased 48% over that of 1988. Production of feldspar-silica mixture was reported from three companies in Orange, San Bernardino, and San Diego Counties.

Gypsum.—The quantity of crude gypsum produced in 1989 increased 16% over the previous year's output to 1.73 million short tons valued at more than $13 million. California continued to be the number one producing State of calcined gypsum, but ranked only fifth in total mined output of crude gypsum. Calcined gypsum output from six plants was reported to be 1.96 million short tons valued at $32.4 million in 1989.

U.S. Gypsum Co.'s Plaster City Mine in Imperial County was the leading gypsum producer in the United States, and H. M. Holloway Inc.'s Lost Hill Mine in Kern County was also among the Nation's top 10 producers. The top 10 mines produced 41% of the total gypsum production reported by the Nation's 65 mines. Crude gypsum was mined at seven active mines in California.

Lime.—Lime production of 395,000 short tons was almost 14% lower than 1988's revised reported production of 458,000 short tons. However, value reported increased 21% to $24.5 million in response to higher lime prices. 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 Natividad plant.

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

Pumice.—California ranked second among the States in pumice production, more than doubling that of 1988 to 79,000 metric tons and jumping in value from $1,245,000 to $4,612,000, which, because of the increased prices for abrasive uses, ranked it first among the States in the reported value of production. Pumice was mined in Madera, Modoc, and Siskiyou Counties. Abrasives and building blocks were the principal uses, with minor amounts used in concrete aggregate, landscaping, and agriculture.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

California construction sand and gravel and crushed stone statistics are compiled by geographical districts as depicted in the principal mineral-producing localities map. At the request of the State, the number of districts was increased from 3 to 12, beginning in 1988.

CALIFORNIA

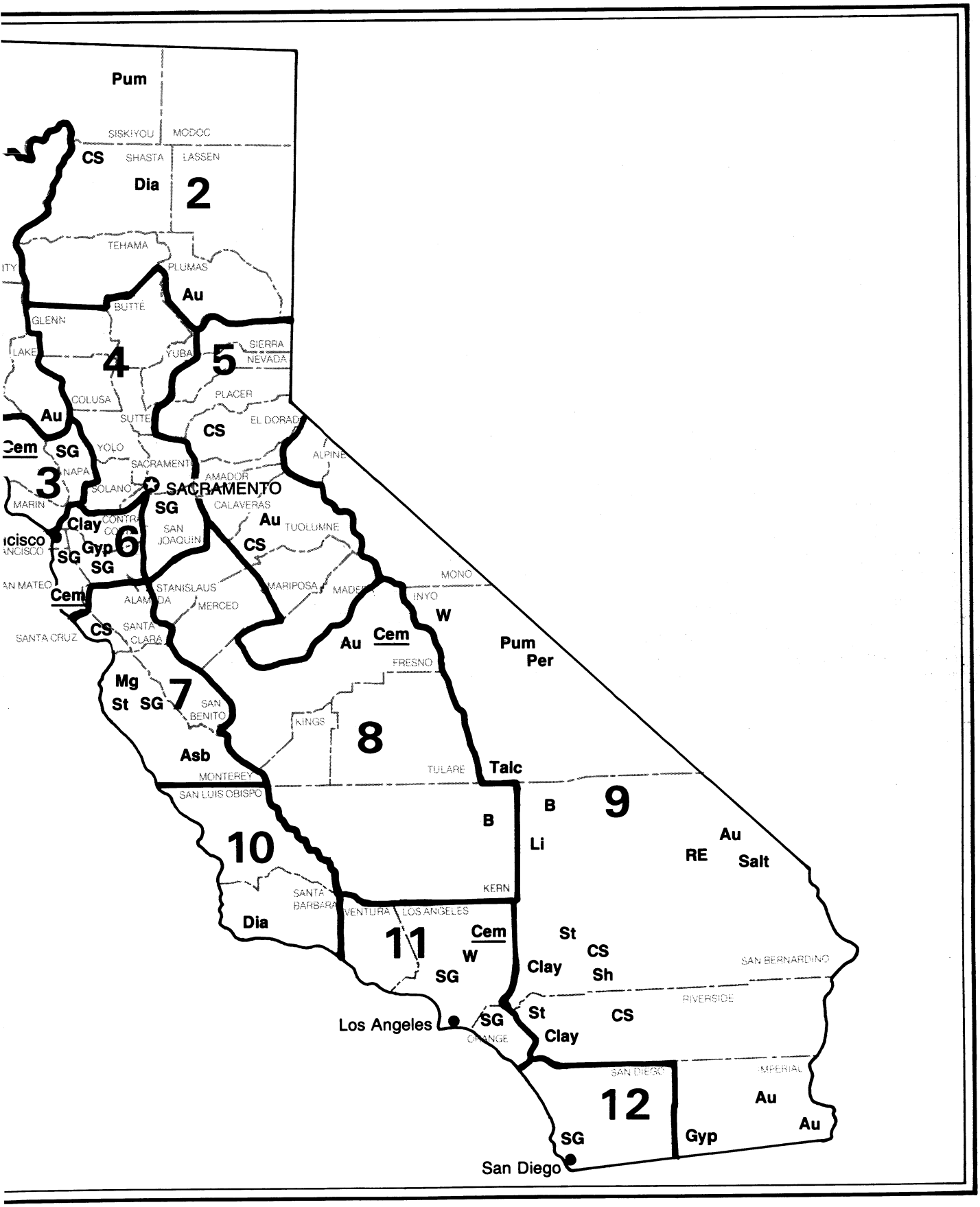
LEGEND

- 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


Pum
SISKIYOU
MODOC
CS
SHASTA
LASSEN
Dia
2
TEHAMA
PLUMAS
Au
BUTTE
GLENN
LAKE
4
YUBA
5
SIERRA
NEVADA
COLUSA
PLACER
Au
SUTTE
EL DORADO
CS
Cem
SG
YOLO
ALPINE
SACRAMENTO
NAPA
3
SOLANO
AMADOR
SG
CALAVERAS
MARIN
Clay
CONTRA
SAN
JOAQUIN
Au
TUOLUMNE
6
Gyp
CS
SG
SG
MONO
STANISLAUS
MARIPOSA
MADE
INYO
Cem
ALAMEDA
MERCED
W
CS
SANTA
CLARA
SANTA CRUZ
Au
Cem
Pum
Per
FRESNO
Mg
St
SG
7
SAN
BENITO
KINGS
8
Asb
TULARE
Talc
MONTEREY
SAN LUIS OBISPO
B
B
9
10
Li
Au
RE
Salt
KERN
SANTA
BARBARA
VENTURA
LOS ANGELES
Dia
11
Cem
St
W
CS
Clay
Sh
SAN BERNARDINO
SG
RIVERSIDE
Los Angeles
SG
St
CS
ORANGE
Clay
SAN DIEGO
IMPERIAL
12
Au
SG
Gyp
Au
San Diego

California remained the Nation's number one construction sand and gravel producing State, with 1989 production estimated at 138.3 million short tons. Construction sand and gravel, valued at more than $670 million, was California's leading commodity in terms of value, accounting for nearly 24% of the State's 1989 total nonfuel mineral production value. CalMat Co., California Portland Cement, and Beazer/USA-West were the State's largest producers among the 168 companies reporting construction sand and gravel production.

CalMat Co., of Los Angeles, formed a joint venture with Owl Rock Products Co. of Arcadia to acquire Kirst Construction Co. Inc., the owners and operators of Azusa Rock sand and gravel quarry in the San Gabriel Mountains. A special use permit was adopted by the Azusa City Council in May to allow the quarry to operate, despite opposition by nearby residents. The three Blue Diamond Materials gravel pit operations in Irwindale were sold to United Rock Products Corp. Granite Construction Co. reopened its Felton quarry in May after 6 months of reconstruction. Teichert Aggregates began mining gravel on two sites along Cache Creek in Yolo County.

ARC America Corp., of Newport Beach, a subsidiary of ARC Ltd. of Bristol, United Kingdom and one of the major sand and gravel and crushed stone producers in the United States, was acquired by Hanson Trust PLC of London, United Kingdom.

Industrial.—Industrial sand and gravel production in 1989 was slightly less than that of 1988, although value rose 4% to nearly $44 million. Industrial sand production of 2.4 million short tons was reported from 12 operations in 9 counties. Owens-Illinois Inc. was the State's largest producer. Industrial sand was used primarily in sandblasting, fiberglass manufacture, glass containers, and roofing granules. Owens-Illinois and Unimin Corp. were the largest producers of glass sand with major operations in Amador County and Contra Costa County, respectively. Corona Industrial Sand Co., Riverside County, supplied the majority of sand for the sandblasting industry.

After 46 years of production, the Monterey Sand Co. ceased activities at its Sand City and Marina beach locations in Monterey County after the Monterey City Council refused to renew mining permits for the beach operations.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

California's 1989 crushed stone production of almost 55 million short tons was 25% higher than the last reported production in 1987, but dimension stone output dropped 14% to just under 29,000 short tons. Beazer/USA, CalMat Co.'s California Portland Cement, and Hanson Industry Inc.'s Kaiser Cement Corp. were the largest of the 88 producers of crushed and broken stone throughout the State. Western Rock Products Inc. of New Mexico began construction of a crushing plant at the Ione quarry in Amador County for sale of commercial aggregate and railway ballast. Principal uses of crushed stone were for concrete and

TABLE 2

CALIFORNIA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregates (+1½ inch):		
Riprap and jetty stone	849	8,531
Filter stone	458	1,510
Coarse aggregate, graded:		
Concrete aggregate, coarse	1,294	5,655
Bituminous aggregate, coarse	3,527	16,565
Bituminous surface-treatment aggregate	152	577
Railroad ballast	247	1,199
Fine aggregate (-3/8 inch):		
Stone sand, concrete	868	4,418
Stone sand, bituminous mix or seal	682	2,565
Screening, undesignated	538	1,676
Coarse and fine aggregates:		
Graded road base or subbase	7,726	27,720
Unpaved road surfacing	215	846
Terrazzo and exposed aggregate	45	483
Crusher run or fill or waste	2,685	8,181
Other construction materials[2]	4,923	24,688
Agricultural: Agricultural limestone and poultry grit and mineral food	213	2,380
Chemical and metallurgical:		
Cement manufacture	17,550	58,662
Glass manufacture	217	2,609
Special: Other fillers or extenders	26	138
Other miscellaneous uses[3]	847	8,679
Unspecified:[4]		
Actual	8,717	49,533
Estimated	3,108	11,421
Total	54,887	[5]238,034

[1]Includes limestone, dolomite, granite, volcanic cinder and scoria, marble, slate, shell, and miscellaneous stone.
[2]Includes stone used in coarse aggregate (large), macadam, combination-coarse and fine aggregate, and other construction materials.
[3]Includes stone used in lime manufacture, sulfur oxide removal, whiting or whiting substitute, and roofing granules.
[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.

bituminous aggregate and road base, but other important uses were for riprap and jetty stone, filler stone, and cement manufacture.

Dimension stone was quarried by 12 operators from 17 granite, limestone, sandstone, quartzite, and slate quarries statewide. Total value of all dimension stone mined was more than $5 million. Cold Spring Granite Co. was the principal producer in terms of both quantity and value. Other important producers, in order of value, were National Quarries Inc., Bouquet Canyon Stone Co. Inc., Mariposa Flagstone Co., Donald L. Dingel Co., and G. Antolini & Son.

Other Industrial Minerals.—No barite production was reported in the State during 1989. Natural calcium chloride was produced from three operations in San Bernardino County. Two plants in Sacramento County produced synthetic graphite for cloth and fibers. Magnesium compounds were obtained from seawater magnesia operations in Monterey and San Mateo Counties.

Expanded perlite for use in plaster and concrete aggregates, acoustic tile, low-temperature insulation, fillers, and roof insulation was produced from six plants in Los Angeles, San Diego, and San Bernardino Counties. Kerr-McGee produced muriate of potash (60% K_2O) and sulfate of potash (50% K_2O) from plants in San Bernardino County. California ranked 7th among 11 States reporting talc and pyrophyllite production from 6 mines in 4 counties.

Byproduct sulfur was recovered at 15

TABLE 3

CALIFORNIA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(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 aggregate (+1½ inch)[1]	W	W	12	W	506	5,023	W	W
Coarse aggregate, graded[2]	W	W	63	330	1,002	7,602	W	W
Fine aggregate (-3/8 inch)[3]	W	W	W	W	349	955	W	W
Coarse and fine aggregates[4]	234	857	477	1,685	1,426	5,401	—	—
Other construction aggregates	35	116	194	797	—	—	2,340	14,608
Agricultural[5]	—	—	—	—	—	—	—	—
Chemical and metallurgical[6]	—	—	(7)	(7)	—	—	—	—
Special[8]	16	94	—	—	—	—	(7)	(7)
Other miscellaneous	—	—	808	3,846	—	—	14	25
Unspecified:								
Actual[9]	—	—	—	—	38	76	28	103
Estimated[10]	54	65	324	408	—	—	(11)	(11)
Total[12]	339	1,132	1,877	7,065	3,321	19,058	2,382	14,736

	District 5		District 6		District 7		District 8	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregate (+1½ inch)[1]	W	W	W	W	W	W	—	—
Coarse aggregate, graded[2]	—	—	1,352	6,462	2,492	7,428	—	—
Fine aggregate (-3/8 inch)[3]	—	—	263	1,043	W	W	—	—
Coarse and fine aggregates[4]	241	759	3,071	12,232	2,979	7,634	—	—
Other construction aggregates	99	306	116	720	1,568	4,378	—	—
Agricultural[5]	(7)	(7)	(7)	(7)	—	—	—	—
Chemical and metallurgical[6]	(7)	(7)	—	—	3,374	6,556	5,443	20,498
Special[8]	—	—	—	—	—	—	—	—
Other miscellaneous	385	3,454	33	229	—	—	—	—
Unspecified:								
Actual[9]	152	2,277	403	1,251	562	6,222	25	29
Estimated[10]	284	807	31	203	76	313	(11)	(11)
Total[12]	1,160	7,604	5,269	22,140	11,051	32,530	5,468	20,528

See footnotes at end of table.

TABLE 3—Continued

CALIFORNIA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(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 aggregate (+1½ inch)[1]	339	2,968	W	W	W	W	W	W
Coarse aggregate, graded[2]	W	W	W	W	W	W	W	W
Fine aggregate (-3/8 inch)[3]	137	1,282	W	W	W	W	—	—
Coarse and fine aggregates[4]	604	2,192	365	1,429	177	499	1,108	4,544
Other construction aggregates	213	1,195	465	2,019	1,293	6,185	690	3,965
Agricultural[5]	([7])	([7])	([7])	([7])	—	—	—	—
Chemical and metallurgical[7]	8,102	29,721	([7])	([7])	—	—	—	—
Special[8]	452	5,319	([7])	([7])	—	—	—	—
Other miscellaneous	142	1,417	85	1,310	—	—	—	—
Unspecified:								
Actual[9]	7,270	38,885	—	—	177	532	61	157
Estimated[10]	143	427	96	455	2,091	8,702	10	40
Total[12]	17,402	83,406	1,011	5,213	3,738	15,918	1,870	8,705

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

oil refineries in Contra Costa, Kern, Los Angeles, and Solano Counties. No peat or wollastonite production was reported in 1989.

Metals

Gold.—Gold production continued to increase in California during 1989, to 29,804 kilograms (958,199 troy ounces) valued at $366,595,000. This was a 33% increase in quantity and 16% increase in value from that of 1988. The two largest producers, the Mesquite Mine in Imperial County and the McLaughlin Mine in Napa County, accounted for more than 50% of the State's total gold production.

New gold mining operations at the American Girl Mining Corp.'s American Girl-Canyon project were approved by BLM, and construction began early in the year at the open pit mine adjacent to its Padre-Madre operation in Imperial County. The first gold from the Canyon open pit was poured in September. Mother Lode Goldmines Consolidated and Meridian Minerals began production in March at their Calaveras County Royal Mountain King Mine. AMAX Gold began development of a $73 million open pit gold project in Lassen County, which was named the Hayden Hill Mine.

Exploration continued at the Castle Mountain gold deposit owned by Viceroy Gold Corp. when plans to begin mining the company-estimated, 2-million-ounce gold ore body were delayed. Development of the Castle Mountain gold deposit in the Hart mining district of eastern San Bernardino County was opposed by California environmental groups. Approval of mining plans by BLM and San Bernardino County were postponed pending completion of new Environmental Impact Statements and proposed reclamation plans.

Gold Fields Mining Corp.'s Mesquite Mine in Imperial County was the State's largest gold producer in 1989. A revegetation program was initiated during the year as a first attempt at recovering lost vegetation on waste heaps and overburden.

Homestake Mining Co.'s McLaughlin Mine at the junction of Napa, Yolo, and Lake Counties, was the State's second largest producer. On March 28, the mine celebrated the pouring of its one millionth ounce of gold since production began in 1985. A $25 million expansion program at the McLaughlin Mine was completed in February with the installation of oxide-circuit equipment at its Lake County mill.

Sonora Mining Corp. began mining the upper oxide portions of the North Harvard Pit at its Jamestown Mine in Tuolumne County. Despite the lower grades and poorer recoveries encountered in this phase of mining, begun late in July, production for the year increased 14% from that of 1988.

Closures were reported at the Mokelumne gold mine northwest of Volcano in Amador County; the Carson Hill Gold Mine, 6 miles south of Angels

Camp in Calaveras County; the Brush Creek Mining and Development Co.'s Gardners Point Mine in Sierra County; and the Kanaka Creek Joint Venture Sixteen-to-One gold mine near Alleghany in Sierra County.

Glamis Gold Inc. proposed a new gold operation near Lake Tulloch in Calaveras County. The 90-acre Alto Project would be Calaveras County's third gold mine. Approval of a use permit and a reclamation plan was obtained in June. Glamis Gold and Amir Mines completed a 10,000-foot drilling program at the Indian Rose deposit near their Picacho Mine in Imperial County. Glamis Gold also explored its Alto gold mine project in Calaveras County.

Meridian Gold Co. explored the "Lincoln Mine" area in Amador County. The Long Valley prospect near Mammoth Lake in Mono County was drilled and sampled by Royal Gold Inc. American Gold Mineral Corp. drilled the massive sulfide deposit at the Siskon Mine in western Siskiyou County. The Grey Eagle Mine, also in Siskiyou County, was explored by Centurion Gold Ltd.

Rare-Earth Metal Concentrates.—Rare-earth concentrate production and value nearly doubled from that of 1988. California was the sole U.S. producer of rare earths from bastnasite ores and the world's principal supplier of rare-earth metal concentrates. Molycorp Inc.'s Mountain Pass bastnasite mine in San Bernardino County was the only domestic producer of rare-earth fluocarbonate-mineral bastnasite.

Weak foreign demand and increased international competition reportedly caused Molycorp's sales of rare earths to decrease slightly despite increased mine output. Molycorp completed an expansion of its separation facilities to produce additional quantities of dysprosium and neodymium oxides for the permanent magnet industry.

Silver.—Silver was produced from 13 California mines, principally as a byproduct of gold production. Output of 25 metric tons (675,165 troy ounces) was valued at $3,650,000, about 16% higher than 1988's value. Although production increased 40%, the value increase was only 16% higher than 1988's because of lower silver prices.

The Royal Mountain King Mine of Meridian Minerals and Mother Lode Gold Consolidated began production at their open pit gold operation in March. Byproduct silver was also produced in the form of gold and silver doré bars. CoCa Mines Inc.'s Cactus Mine in Kern County and Homestake's McLaughlin Mine in Napa County were the State's largest silver producers, both from byproduct gold mining. Additional important producers of byproduct silver from gold mining included the Mesquite Mine in Imperial County, the Keystone and Snowcaps Mines in Inyo County, the Standard Hill Mine in Kern County, the Morning Star and Colosseum Mines in San Bernardino County, and the Jamestown Mine in Tuolumne County.

Tungsten.—California was the sole U.S. producer of tungsten in 1989. U.S. Tungsten Corp., a subsidiary of Strategic Minerals Corp. (Stratcor), was the principal source from the Pine Creek plant near Bishop in Inyo County. Curtis Tungsten Inc.'s Andrew Mine in Los Angeles County began mining scheelite during the year with its mill startup announced in August.

Other Metals.—Byproduct copper recovery from U.S. Tungsten's Pine Creek tungsten operation in Inyo County accounted for most of California's limited copper production. All of the State's 1989 molybdenum production also was recovered as byproduct from the Pine Creek operation. Although small, iron ore production improved 14% from the previous year. No lead or zinc production was reported in 1989. Titanium, in the form of ilmenite, was produced in the State for the first time from an aggregate operation in Los Angeles County.

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[1]State Mineral Officer, Bureau of Mines, Reno, NV. He has covered the mineral activities in California for 9 years. Assistance in the preparation of the chapter was given by Mary Carico and Pat La Tour, editorial assistants.

[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.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Asbestos:			
Calveras 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	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. of America	Box 604 Norwalk, CA 90650	do.	Do.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
CalMat Co.[3]	3200 San Fernando Rd. Los Angeles, CA 90065	Plants	Various.
Kaiser Cement Corp. (Mitsubishi Mining & Cement Co.)	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., Riverside Cement Co.[5]	Box 832 Riverside, CA 92502	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.
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.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
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 Fernando Rd. Los Angeles, CA 90065	Pits	Various.
Beazer/USA-West	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/USA-West	Box 832 Riverside, CA 92502	Quarries	Various.
Talc and pyrophyllite:			
Pfizer Inc.[10]	Box 558 Lucerne Valley, CA 92356	Surface mine and plant	Inyo.
Western Source Inc.	Box 280 San Andreas, CA 95249	Surface mine and mill	Calaveras.
Tungsten ore and concentrate:			
U.S. Tungsten Corp., a subsidiary of Strategic Minerals Corp. (Stratcor)[11]	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 clays and wollastonite.
[11]Also molybdenum.

THE MINERAL INDUSTRY OF COLORADO

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

By Jane P. Ohl[1] and Mark W. Davis[2]

The value of nonfuel minerals produced in Colorado in 1989 was $454 million, a 25% increase from the value of production in 1988. This 25% rise in total value was due mainly to unit value increases for construction sand and gravel, molybdenum, and zinc and a substantial production increase for molybdenum. The State ranked 23d in the Nation in nonfuel mineral production and accounted for 1.4% of the total value. Colorado ranked 11th of 25 metal-producing States, accounting for slightly more than 2% of the Nation's total metals value. The principal minerals, in order of value, were molybdenum, construction sand and gravel, portland cement, and gold. Gold output, however, fell significantly.

By mid-November, the State's economy was seen by local economists as improving in all sectors except mining. Midway through the year, gold mining in Colorado underwent two unexpected closures and the forestallment of two other developing gold projects. Together, the closures and stalled projects reduced gold output 33% from that of 1988 and put about 250 people out of work. Molybdenum production, however, was increasing owing to world demand. Climax Molybdenum Co. added employees at its Henderson and Climax Mines and Henderson mill starting in mid-1988 and throughout much of 1989.

Because of the increase in the number of companies that have chosen to move their headquarters to Denver, the city's reputation as the "gold capital of the Nation" grew, encouraging the formation of The Denver Gold Group. The group organized a Western Gold Expo meeting, held in October to attract new investment capital to local gold-mining companies.

Mining can be expected to benefit from a modest improvement projected for the State's currently depressed construction industry. These two closely related industries were expected to benefit from the $241.7 million in bonds approved by the electors in November for streets and highways, city office buildings, convention buildings, and other public structures.

TABLE 1

NONFUEL MINERAL PRODUCTION IN COLORADO[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	264,944	$1,763	247,471	$1,890	265,435	$2,064
Copper[2]	do.	W	W	898	2,386	W	W
Gem stones		NA	100	NA	100	NA	240
Gold[2]	kilograms	5,561	80,091	5,126	72,237	3,448	42,411
Peat	thousand short tons	W	W	W	W	W	412
Sand and gravel (construction)	do.	e22,800	e84,300	21,566	69,882	e25,300	e104,000
Silver[2]	metric tons	27	6,033	27	5,588	W	W
Stone:							
Crushed	thousand short tons	8,045	33,465	e10,600	e42,400	[3]7,261	[3]32,435
Dimension	short tons	3,000	133	e3,450	e143	5,310	398
Combined value of cement, gypsum, lead, lime, mica (crude, 1989), molybdenum, perlite, pyrites (1987), sand and gravel (industrial), stone (crushed traprock, 1989), vanadium, zinc, and value indicated by symbol W		XX	167,104	XX	169,379	XX	272,030
Total		XX	372,989	XX	364,005	XX	453,990

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

EMPLOYMENT

The Colorado Department of Labor and Employment reported that unemployment fell from 6.5% in January to 5.6% in December. Counties with the highest unemployment rates included Costilla, Lake, Mineral, and Rio Grande, all metallic mineral-producing counties where projects had either slowed down, been terminated, or put on hold.

Mining employment, according to the Colorado Business and Economic Outlook Forum, was 7,400 in 1989, up about 10% from that of 1988. This figure excluded employment in the oil and gas sector. Coal and nonmetallics accounted for 3,800 workers, and metals, 3,600 workers.

According to the Colorado Department of Labor and Employment, wage statistics for 12 key industrial sectors showed that the biggest gainer was mining, where average pay was up 6.1% to $40,979 annually.

REGULATORY ISSUES

Colorado received $2 million in 1989 from Federal Abandoned Mine Reclamation funds to seal some of the State's 8,000 inactive mines. About 1,000, or 13%, of the 8,000 mines had been sealed by August 1989. The Federal program was scheduled to end in 1992, and many mines would remain unsealed if the current rate of closure was not increased.

The U.S. Bureau of Land Management (BLM) acted to fence off the inactive Lime Kiln quarry, near Del Norte, Rio Grande County. Stone from the historic 60-foot-deep quarry was used in the Colorado Governor's mansion and is not limestone but a welded volcanic tuff.

In November, U.S. House and Senate panels approved legislation authorizing the U.S. Bureau of Reclamation to let a construction contract for a $5 million water treatment plant in Lake County. The plant is planned to filter metals (including cadmium and lead) from water being discharged into the Arkansas River from the Leadville drainage tunnel. An appropriation of $4.5 million to begin construction was approved by Congress and the President. The total cost of the project, $10.5 million, included lining a section of the tunnel with concrete. Construction was to begin in May 1990 and take about 2 years.

The U.S. Forest Service planned to study the possible environmental impact of reopening the Conundrum Creek dark marble quarry in Pitkin County. The marble mining claims were within the Maroon Bells-Snowmass Wilderness Area.

BLM officials placed six mining operations on BLM lands in Gilpin County under investigation for possible violations of various regulations. The six sites were along State Highway 119 and North Clear Creek, east of Black Hawk. BLM cited the operators for having "excessive amounts of junk," including mine equipment and supplies and a mill located within the flood plain.[3]

AMAX Inc. spent $250,000 to plug the portal at its decommissioned Urad molybdenum mine in Clear Creek County.

In December, Denver Public School workers began excavating an elementary school yard in the Globeville area, near the ASARCO Incorporated smelter, to remove contaminated topsoil. Colorado Department of Health officials had found arsenic, cadmium, and lead metals in the soil, but at levels too low to pose any immediate threat. Blood tests in 1989 on 176 residents, including 60 schoolchildren, showed no elevated lead levels, but health officials warned of a possibility of increased cancers.

The mayor of Boulder and local citizens appealed to the mayor of Denver to boycott the taking of gravel for the new Denver airport from the Wesley D. Conda quarry in Boulder County. They complained that the quarry's mountain-front location was a visible eyesore.

Reclamation of inactive uranium and vanadium sites in Montrose County was an important income-producing activity on Colorado's Western Slope.

EXPLORATION ACTIVITIES

Metallic mineral exploration and some mine development continued in the State, particularly in mining districts in Boulder, Clear Creek, Gilpin, Ouray, and Teller Counties. A few gold mine shafts were being rebuilt and open pit and cyanide leaching operations were worked intermittently. Pikes Peak Mining Co. (the new manager of Cripple Creek & Victor Gold Mining Co.'s Carlton mill and Portland properties, formerly managed by Texasgulf Minerals and Metals Inc.) continued to explore for new and expandable deposits in the Cripple Creek and Victor area, Teller County.

Tenneco Minerals Co. of Lakewood, CO, continued into its third year of exploration drilling for silver in the Kate area, north of Silver Cliff, Custer County. Tenneco drilled more than 700 holes during 1987–89 and planned to drill at the same rate in 1990. A shallow open pit and a mill or a heap-leach pad were being proposed to process the ore, which graded 5 to 10 ounces of silver per ton. The mine, once in operation, was expected to have a life of 5 years and employ 20 to 30 people. Tenneco leased the project from CoCa Mines Inc. and other co-owners of the mineral rights.

LEGISLATION AND GOVERNMENT PROGRAMS

The Governor of Colorado signed into law two bills that affected mining; one additional bill became law without his signature. Senate Bill 72 established criteria for allowing underground miners and persons employed in underground workings to exceed a working period of 8 hours in 24 hours. A constitutional amendment had been passed previously by the electorate in November 1988 authorizing the General Assembly to make this exception to the 8-hour workday.

Senate Bill 181 established that the water quality panel of the Colorado Department of Health was to set standards for clean water; however, the State's Mined Land Reclamation Division and the Oil and Gas Commission would enforce the regulations. A key part of the bill allowed the mining and petroleum agencies to determine how far toxic substances are likely to be carried in ground water from the source of pollution. The bill also purportedly will simplify the reporting process, requiring operators to report to one agency rather than several.

Senate Bill 120 (which became law without the Governor's signature) re-

quired anyone extracting sand and gravel from an open pit to obtain a well permit if the pit penetrated the water table.

In 1989, The Rocky Mountain Regional Office of the National Park Service completed a study for the management and protection of the proposed Georgetown-Silver Plume National Historic District, making it available for public review in June. On November 21, electors in Georgetown, Silver Plume, and unincorporated areas in Clear Creek County voted against the Park Service proposal.

The Georgetown-Silver Plume Historic District was listed on the National Register of Historic Places, on November 13, 1966, thus recognizing these adjacent communities as a nationally significant cultural resource and/or nationally significant historic mining district. On the basis of this recognition, several restoration projects were completed—such as the Georgetown Historic Mining and Railroad Park—or, in 1989, were in the process of being completed—such as the Lebanon mill. According to the Park Service's draft report on designating the district a National Park, "Mining exploration and operations would continue, subject to existing regulations."[4]

Several county governments (Adams, Boulder, Douglas, El Paso, Garfield, Jefferson, Park, and Weld, for example) were confronted with protests from citizens about aggregate extraction. In Douglas County, a 1-year moratorium on mining permits was imposed in October to give county commissioners time to develop a mining and minerals extraction policy. Claiming the moratorium to be unconstitutional, a private firm brought suit in November to end it.

In El Paso County, members of the Governor's Commission on Mountain Scars (Scar Commission) planned to recommend legislation for consideration by the 1990 session of the General Assembly that would forestall mining and quarrying in any area exposed to public view.

In Dolores, Montezuma, and San Miguel Counties, construction firms in fast-growing areas, such as a new resort near the old mining town of Telluride, were applying pressure on county commissioners to approve the development of suitable aggregate sources. Increasingly, mining and quarrying permits were stipulating that visual quality must be maintained and wildlife not disturbed. Residential and ski-run construction were not required to meet these standards.

The Bureau of Mines investigated the mineral resource potential of wilderness study areas in Jackson, Moffat, and Montrose Counties and the San Isabel National Forest Service lands.[5]

Total royalties derived from Federal mineral leases in Colorado amounted to $57.9 million, up from $46.7 million in 1988. Operators paid royalties on oil, gas, coal, and carbon dioxide. The Federal Government (Minerals Management Service and BLM) distributed $32.6 million to the State of Colorado as its share of revenues collected.

The Advanced Materials Institute at the Colorado School of Mines was awarded a $329,000 subcontract by TRW Corp. of El Segundo, CA, to do research in superconducting materials, particularly in thin-film technology. The development of thin-film superconducting materials could result in smaller, faster computers and could affect the electronics and communications industries by speeding the storage, recording, and retrieval of information.[6]

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

The total value of metallic mineral output in Colorado soared 36% over that of 1988, despite the plunge in gold production and value—33% and 41%, respectively.

Cadmium.—Asarco produced more than 60,000 pounds per month of cadmium at its smelter in Globeville, northern Denver County. The plant employed 65 full-time workers, down from a peak of 180 in the 1950's and 1960's.[7]

Cadmium was used in batteries, coating and plating, pigments, plastics and synthetic products, and alloys and other uses. The tight supply of cadmium at yearend 1988 caused the price per pound to increase to as much as $8.50, up from a low in 1988 of $3.

Residents living near the 103-year-old smelter continued demanding that the Colorado Department of Health and mining company officials find ways to shield the residents, particularly children, from the plant's waste materials.

Copper.—Copper output and total value increased significantly. The State's copper output was the second highest since 1977, when output was 1,721 metric tons. Seven mines reported copper production, including the London Mine whose closure at midyear did not significantly affect the State's 1989 output. The average value of copper per metric ton ($2,887) rose nearly 9% above that of 1988.

Gold.—The total gold output in the State plummeted 33% from that of 1988, chiefly because of shutdowns for repairs or because of financial realignments.

The London Mine, Park County, was closed June 9 and the mill on July 12, both having been in production for a little more than 1 year. The Summitville surface mine, Rio Grande County, was closed just 1 month into the production period when a crack was discovered in the leach pad embankment on June 13.

These two closures meant the loss of about 250 jobs for the remainder of 1989. Summitville had been the State's largest gold producer each year from 1986 through 1988. Despite the shutdown of its outdoor operations, ore processing indoors continued through the winter, and exploration for new resources nearby also continued. Production at Summitville was planned for 1 or 2 more years. Summitville ranked second in gold output in Colorado in 1989; Pikes Peak Mining ranked first.

Two other gold mining projects were stalled by either lack of managerial agreement or lack of permitting and local citizens' support. The two stalled projects were those being planned for the Empire and San Luis areas. Nevada Goldfields Corp. and its partners, joint-venture owners of the Empire project in Clear Creek County, did not begin surface preparation in the fall as planned. A new partnership was created in December, bringing Noranda Exploration Inc. into the joint venture. The Empire property was reported to have proven and probable reserves of 505,000 short tons, grading 0.127 ounce of gold per ton (485,000 metric tons, grading 3.95 grams per ton) in one of two major mineralized gold-bearing zones.

At the delayed San Luis project in

Costilla County, Battle Mountain Gold Co.'s expectations of producing 60,000 troy ounces of gold annually met with a citizens' lawsuit to protect the environment, and development and mining plans were delayed. Local courts also must decide on a water permit issue.

Several small mining and milling operators continued development or reconstruction work and some ore extraction in Boulder, Clear Creek, Gilpin, and some western counties. In Clear Creek County, the Broken Handle Mining Corp. brought ore down from its mine on McClellan Mountain; the Stevens Mine in Stevens Gulch and the Grizzly Mine, south of Bakerville, also were active in the county. In Gilpin County, the Bates-Hunter Mine in Central City, the Franklin Mine in Gilson Gulch, and the Perserverance Mine were active. The Two Brothers Mine (also called the Bald Eagle Mine) received approval from Gilpin County commissioners in October to transport ore from the mine in Virginia Canyon (Clear Creek County) to the Boodle mill, above Central City (Gilpin County). The approval, however, limited work to certain days and hours during the June-September tourist season. Besides the Boodle mill, the Marion mill in the Sugarloaf area of Boulder County reported activity.[8]

The Bessie G. Mine in La Plata County was operated until April by Gold Star Mining Co., a subsidiary of Energy Fuels Corp., Denver. From that date, the Bessie G. was operated by Petro-Global Inc. of Denver, CO, and Scottsdale, AZ, or by a lessee.

The price of gold in January 1989 was just more than $400 per ounce. By December, the price was $416 per ounce, and the State's gold explorationists were encouraged. In 1989, 13 gold-mining permits were applied for at the Colorado Mined Land Reclamation Division. The applications were for lands in Gilpin, La Plata, Lake, Mesa, Otero, Park, San Miguel, and Teller Counties.

Iron and Steel.—CF&I Steel Corp. of Pueblo had a unionized production and maintenance work force of 1,600 persons. The mill produced oil country tubular goods for the petroleum industry and other steel products for the agricultural, construction, and transportation industries. CF&I was one of the Nation's two manufacturers of rails; the other was in Pennsylvania.

No iron ore mine in Colorado has reported production for the past 4 years. Output of iron and steel slags dropped significantly in 1989 from that of 1988.

Lead.—Lead output and total value decreased nearly 15% and 10%, respectively, continuing a 3-year downtrend. On the basis of smelter feed reports, Asarco's Leadville Unit was the Nation's 12th ranking of 25 lead-producing mines. Other reporting lead mines were 13th ranking Sunnyside Mine at Silverton, Great Eastern in Park County, Camp Bird in Ouray County, and Gold King in Silverton. Except for Sunnyside, these four mines were not significant lead producers.

Molybdenum.—The molybdenum mining and milling operations of the AMAX subsidiary, Climax Molybdenum, were on the upswing, principally because of the rise in price of molybdic oxide to $3.44 per pound in 1988 from $2.90 in 1987. Between mid-1988 and the fall of 1989, this production upswing resulted in an increase in employment to about 340 employees at the Henderson Mine and 230 employees at the mill, up from a combined total of 345 employees in July 1988. The firm raised output of molybdenum in concentrate to about 36 million pounds annually. This output was up from about 27 million pounds in 1987 but still well below the 50 million pounds produced annually in the early and mid-1980's and the record 102 million pounds produced from both the Henderson Mine (Clear Creek County) and the Climax Mine (Lake County) in 1980.

In a continuing cleanup and reclamation operation at the closed Climax Mine, 1 million short tons of mined and milled molybdenum ore, grading 0.376% MoS_2, was shipped from inventory. The block-caved underground portion of the mine at Climax has been exhausted; but, if the site were to be reactivated, the remainder of the ore body could be more economically mined from the surface, according to company officials.

At the end of December, Climax Molybdenum announced plans to cut production at the Henderson Mine by 15%, beginning the first week in January 1990. The cut came as a result of lower marketplace demand. The effect on employment was negligible. Climax Molybdenum officials predicted that demand for molybdenum in the Western World would decline about 10% in 1990 from its 1989 level. At yearend 1989, reserves at Henderson amounted to 206 million tons of 0.37% MoS_2; at the Climax open pit, 137 million tons of 0.32% MoS_2.

The underground Henderson Mine supplied about one-fifth of the world's demand for molybdenum.

Palladium, Platinum, and Rhodium.—Catalyst Resources Inc. bought used automobile and industrial plant catalytic converters as the source from which it extracted palladium, platinum, and rhodium at its Denver processing plant. The plant covered 20,000 square feet and employed 20 persons. At full capacity, the plant could process 100 tons per month of scrapped catalysts. From this, 32 ounces per ton of platinum, 3.5 ounces of palladium, and 3 ounces of rhodium could be recovered.[9]

Silver.—Silver production decreased slightly, and total value fell more steeply. The average price of silver declined from $6.54 per troy ounce in 1988 to $5.50 in 1989. A total of 10 mines reported silver output.

Vanadium.—The State had 51 active uranium-vanadium mines during 1989 according to the Colorado Mined Land Reclamation Division, bringing production up to about 60% of historical output. Environmental concerns about nuclear powerplants lowered the demand for the uranium fuel to operate those plants and, since uranium and vanadium were coproducts in Colorado ores, constituted an inhibition on production of vanadium as well as uranium. Vanadium, a metal, was used to toughen and strengthen steel; it also had chemical and ceramic uses. With an increase in vanadium prices to more than $4 per pound in 1988 from below $2 in the mid-1980's and the reopening of dozens of Western Slope mines, vanadium production took a turn for the better in early 1989. According to the Colorado Mining Association, Colorado uranium-vanadium mines produced an estimated 1 million pounds of U_3O_8 and 5 million pounds of V_2O_5 in 1989.

Between early 1989 and July 1989, the price of vanadium pentoxide decreased by 50%. All ore was trucked to the White Mesa mill near Blanding, UT, which had been reopened in the fall of 1988, employing 150 persons. The mill was a joint operation between Umetco Minerals Corp. (a subsidiary of Union Carbide Corp.) and Energy Fuels Nuclear Inc. The mill's time was split between processing Umetco Mineral's uranium-vanadium ore and Energy Fuels' uranium ore.[10]

At yearend, Umetco Minerals announced a cutback in its uranium-vanadium mining and milling activities in western Colorado and eastern Utah, resulting in the layoff of 59 employees.

Zinc.—Zinc production in Colorado increased slightly over that of 1988. Total value, however, ballooned 40% as the average price of zinc rose from 60 cents to 82 cents per pound in 1989.

Industrial Minerals

Cement.—Portland cement output in Colorado rose more than 5%; however, total value fell nearly 10% from that of 1988. Portland cement was produced by Ideal Basic Industries Inc. at its plants in Fremont and Larimer Counties and by Southwestern Portland Cement Co. in Boulder County.

Directors of Ideal Basic voted December 18 to merge with its Swiss-owned parent company, Holnam Inc. Ideal Basic had begun operations in 1899 and was incorporated as a Colorado corporation in 1924. Holnam, a Delaware corporation, formerly known as HOFI North America Inc., was an 89%-owned subsidiary of Holderbank Financiere Glaris Ltd. of Switzerland, the world's largest cement producer. Operations in Fremont and Larimer Counties and the headquarters office in Denver employed about 290 persons in Colorado in 1989.

Reconstruction of the "Mousetrap," the busiest highway interchange in Colorado, where I-25 and I-70 cross near central Denver, began in July and was scheduled for completion in June 1991. This large construction job and several others, including the new Denver airport, were expected to consume large quantities of cement.

Masonry cement was produced at two plants in Colorado. Output was unchanged, but total value plunged 43%, average price per short ton having fallen nearly 40%.

In early 1989, Ideal Basic and Lone Star Industries Inc. (a Texas cement producer) both began offering a quick-drying cement called "Pyrament." Pyrament cures in about 4 hours, compared with 4 days for cement, and has an unconfined compressive strength of 3,000 to 4,000 pounds per square inch (206.7 to 275.6 bars).

Clays.—Colorado clay producers mined bentonite, common clay and shale, fire clay, and kaolin. Except for the reduction in bentonite output (down from 3,600 metric tons in 1988 to 272 metric tons in 1989), the output of Colorado clays was up 7%.

A very light-colored, white-burning clay with a "very wide vitrification zone" (so called by G. W. Parfet Estate Inc. officials) has been mined as fire clay for generations in Jefferson County. The clay, from the G. W. Parfet Estate Inc. pits near Golden, fired at 2,100 degrees Fahrenheit, and was used by Denver Brick Co. for brick products it had sold for Denver-area housing and municipal buildings since the 1880's.[11] Expansion of the city of Golden continued to encroach on the clay deposit.

Gypsum.—Crude gypsum output rose more than 19% from that of 1988. Its average value was $6.76 per short ton. Calcined gypsum averaged $15.17 per short ton.

An $11 million structure to house the Orleman wallboard plant of Eagle-Gypsum Products was being built at Gypsum, Eagle County. The plant planned to utilize gypsum from a nearby mine owned by one of the firm's partners, Eagle-Gypsum Ltd. Another participant in the project was Eagle Investment Group Ltd. Partners. Production at the mine was to be increased in the spring of 1990 to accommodate outside customers. Between 70 and 90 workers were to be hired at the plant, which was to begin operation in the fall of 1990.

Lime.—The State's three lime plants produced slightly less of the product in 1989 than they did in 1988 and received about one-quarter less for it. The average value of lime per short ton decreased 23%. Western Sugar Co. produced from its plants in Morgan and Weld Counties. Calco Inc. operated a quarry and plant in Chaffee County.

Peat.—Peat production reported from four counties rose about 5%, but average unit value plunged 40% from $20 to $12 per short ton.

The Park County Council on Environmental Quality was in the process of developing a policy on peat extraction and other wetland concerns. Nevertheless, the county's Board of Adjustment unanimously approved a request for a 3-year extension of a conditional use permit for extracting peat moss near Fairplay. The operation was owned by the Windmill Restaurant in the town of Salida.

Perlite.—No significant change from 1988 was reported for crude perlite output. Colorado output was the smallest of six producing States. Two plants in the State expanded perlite ore. The average price per short ton of expanded perlite sold or used in Colorado decreased 46% from 1988 to 1989. Nationwide, the average price decreased 8%.

Persolite Products Inc. received perlite ore from Grefco Inc.'s pit near Antonito, in Conejos County, and its own Rosita pit in Fremont County. Output at Persolite's expanding plant in Florence has been trending downward for the past several years, according to the owner-manager.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Six of 138 companies or highway departments in Colorado each produced more than 1 million tons of sand and gravel in 1988, the last year a canvass was made by the Bureau of Mines. The largest producer, Western Mobile Inc. and its subsidiary, Mobile Premix Co., operated 46 pits in Adams, Douglas, Eagle, Garfield, Jefferson, Larimer, Moffat, Routt, and Weld Counties. The other 4 top producers were Castle Concrete Co. (3 pits), Grand County Highway Department (5), Albert Frei and Sons (5), and Flatiron Sand and Gravel Co. (10).

COLORADO

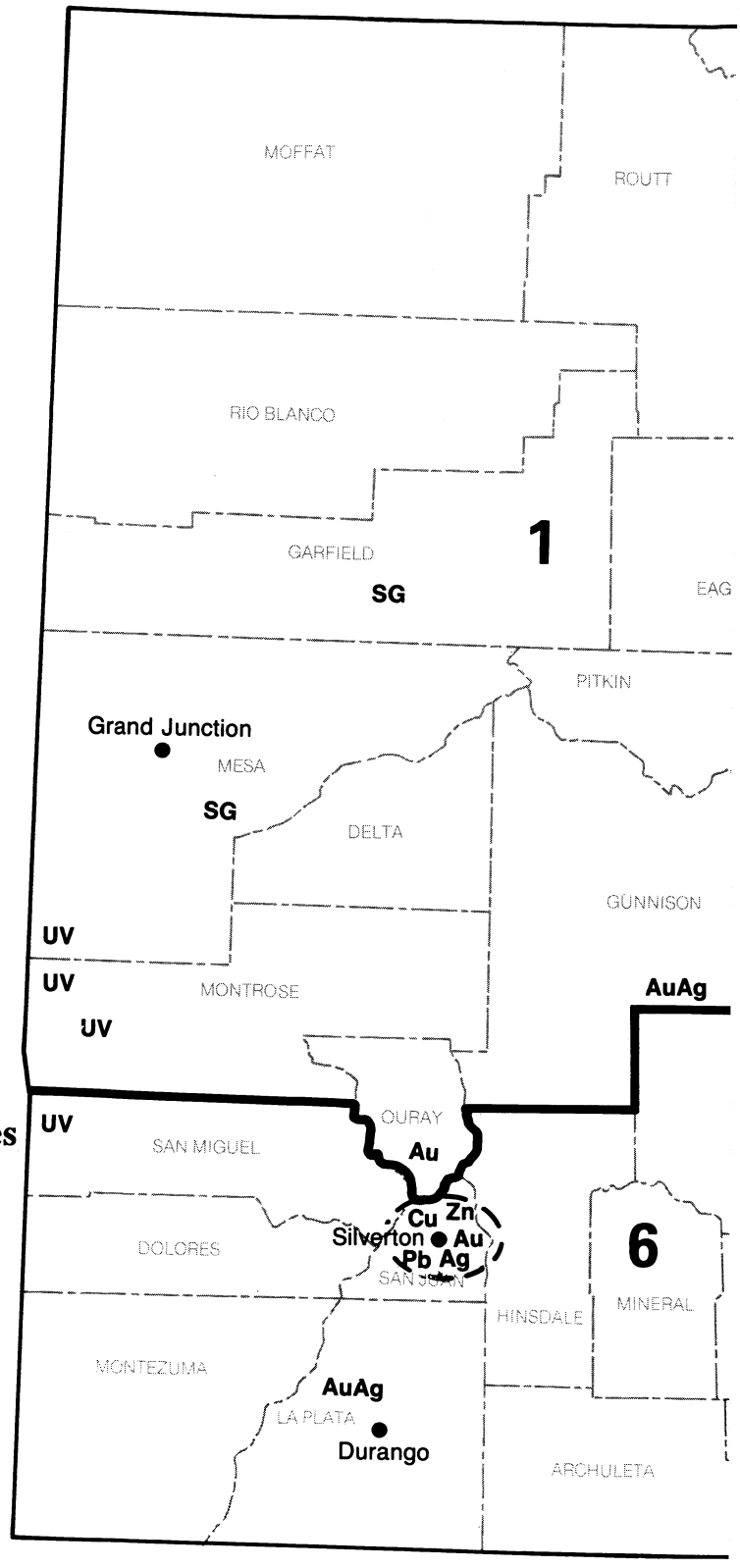
LEGEND

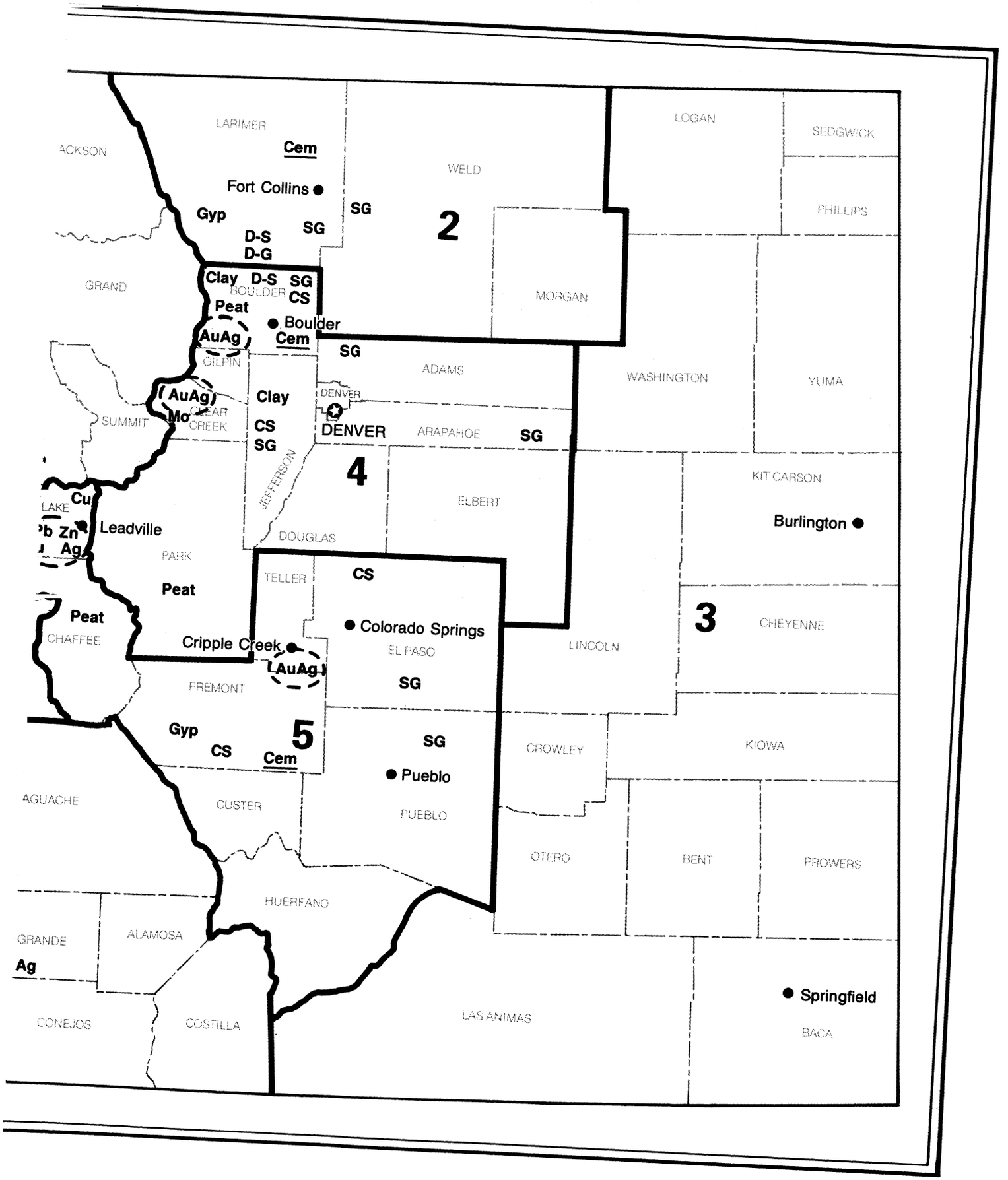
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

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




LARIMER
Cem
Fort Collins
Gyp
SG
D-S
D-G
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2
WELD
LOGAN
SEDGWICK
PHILLIPS
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GRAND
Clay
D-S
SG
BOULDER
CS
Peat
Boulder
AuAg
Cem
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GILPIN
ADAMS
WASHINGTON
YUMA
AuAg
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DENVER
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ARAPAHOE
SG
4
JEFFERSON
ELBERT
KIT CARSON
LAKE
Cu
Leadville
Zn
Ag
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CHEYENNE
Colorado Springs
CHAFFEE
Cripple Creek
EL PASO
LINCOLN
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FREMONT
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5
SG
CROWLEY
KIOWA
Pueblo
AGUACHE
CUSTER
PUEBLO
OTERO
BENT
PROWERS
HUERFANO
GRANDE
ALAMOSA
Ag
Springfield
CONEJOS
COSTILLA
LAS ANIMAS
BACA

Of Colorado's 63 counties, only 11 lacked construction sand and gravel pits or quarries. Flatiron Paving Co. of Longmont and three of its seven affiliated Flatiron companies were acquired by Western-Mobile, a Denver-based construction materials firm. Western-Mobile was a subsidiary of Redland PLC, of Reigate, Surrey, England.

Some local opposition to expansion of the Wesley D. Conda quarry on State land in Boulder County continued on the grounds that it would produce a scar on Eldorado Mountain that would be visible from Eldorado State Park. The Conda quarry's permit allowed an output of 70,000 short tons per year.

In November 1989, after three decades of open pit mining, Cooley Gravel Co. dismantled its South Santa Fe Drive plant in Arapahoe County and converted the last 40 acres into a natural area seeded with native grasses that were attracting heron, deer, and other desirable wildlife.

Cooley Gravel also received an award from the Colorado Mined Land Reclamation Board for the effective restoration of its Thornton South sand and gravel facility, in Adams County, for "river stabilization and aquatic habitat enhancement."

Industrial.—Colorado Lien Co. of Laporte, Larimer County, planned to mine sand from a site 14 miles northwest of Laporte. The proposed mine site was on private land owned by the firm and would be in operation for about 20 years. The sand was to be used for glass bottlemaking by the Adolph Coors Co., a brewer, in Jefferson County.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimated data for 1988.

Crushed.—Crushed stone production in 1989 fell to 7.3 million short tons. Production in 1987 had been nearly 10% higher, at 8 million tons. The Colorado Business and Economic Outlook Forum estimated total 1989 construction value in Colorado at $2.6 billion or a 5% decline from that of 1988. Crushed stone production can be expected to parallel construction activity.

More than one-half of the Colorado crushed stone output was limestone and about one-quarter, granite—a reversal in the relative demand for these two rock types since the last canvass in 1987. In lesser amounts, producers also quarried sandstone, volcanic cinder, and andesite. One-fifth of the crushed stone was limestone used in the manufacture of cement. Among other uses, in decreasing order of demand, were concrete aggregate, graded road base, and bituminous aggregate. The average value per short ton for all types of crushed stone was $4.46. A much higher value, $15.43 per ton, was placed on volcanic cinder, commonly used as construction aggregate.

The largest proportion of crushed stone was moved by truck (50%); the remainder was moved by other modes (11%), or not transported (38%). Of the 15 counties that were sources of crushed stone, 7 were along the Front Range corridor, close to Colorado's largest cities.

During a 5- to 6-year construction period, the new Denver airport was projected to consume about 11 million short tons of sand and gravel, crushed stone, and clays to build runways, parking areas, aprons, and other structures. On September 28, the mayor of Denver accepted a check for $60 million from the Federal Aviation Administration for land acquisition, design work on the terminal building, and site preparation. Clearing and stripping work began on the same day. The airport was expected to cost between $1.7 billion and $2.3 billion when completed about 1995. At yearend, discussions were underway to scale down the new airport to match reduced airline passenger activity in 1989.

Jefferson County citizens and the county planning commission continued to debate the permitting of 320 acres of private land from which the landowner wished to extract crushed stone. Plans for the site, near scenic Clear Creek Canyon, called for removal of about 100 million tons of rock during the next 75 years.

The Denver metropolitan area and nearby counties were scheduling and completing other construction projects. The newest proposal, a $246 million highway tunnel under Berthoud Pass between Clear Creek and Grand Counties, was voted on favorably by residents of Winter Park, a ski town, on October 3. Enough construction material to build a two-lane highway through the 4.1-mile-long tunnel would be required.

The combined values of sand and gravel and crushed stone produced in Colorado exceeded by more than three times the value of gold produced in the State in 1989.

Dimension.—Granite, quartzite, and sandstone were quarried for use as dimension stone by three firms along the Front Range of the Rocky Mountains. Among the types of dimension stone cut were those to be used as rough blocks, cut, or veneer; stone; sawed stone; and flagging stones. The average value per short ton of the combined types of cuts was $74.97.

Gunnison County commissioners gave preliminary approval for Colorado Yule Marble Co. to reopen the area's historic white marble quarries and to build a $3.5 million marble cutting and shaping plant in 1990. The quarries were leased from the Vermont Marble Co. Annual production would be about 150 short tons. About 10 people would be employed at the plant to produce marble wall and floor tiles. Fewer mammoth slabs such as those used in past years' construction of the Lincoln Memorial, the Tomb of the Unknown Soldier, the Denver Post Office building, and other buildings and monuments were planned. The proposed plant site was adjacent to the National Historic Site on which the ruins of the old marble plant, closed in 1941, still stand. The quarry was being reopened in response to a rapidly increasing demand for marble—an increase of 850% in the past 8 years. About 90% of the marble used recently in the United States has been imported, principally from European countries.

About $100,000 in Federal money was allocated to appraise the Conundrum Creek "black" marble deposit in Pitkin County. The mineral rights owner's patented mining claims, on a 472-acre site within the Maroon Bells-Snowmass Wilderness area, were on national forest land. Therefore, opponents of the mining plan requested the U.S. Forest Service to undertake an environmental study of the plan, despite the fact that, under the 1872 Mining Law, a Federal permit to mine

TABLE 2

COLORADO: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch): Riprap and jetty stone	236	1,063
Coarse aggregate, graded: Concrete aggregate, coarse	573	3,076
Coarse and fine aggregates:		
Graded road base or subbase	434	1,364
Unpaved road surfacing	138	321
Crusher run or fill or waste	67	170
Other construction materials[2]	1,210	5,278
Chemical and metallurgical: Cement manufacture	1,479	4,838
Other miscellaneous[3]	139	1,126
Unspecified:[4] Actual	2,986	15,199
Total	[5]7,261	32,435

[1] Includes limestone, granite, quartzite, marl, and slate; traprock withheld to avoid disclosing company proprietary data.
[2] Includes stone used in filter stone, bituminous aggregate (coarse), bituminous surface-treatment aggregate, railroad ballast, stone sand (concrete and bituminous mix or seal), screening (undesignated), and other coarse and fine aggregates.
[3] Includes stone used in agricultural limestone, poultry grit and mineral food, lime manufacture, flux stone, sulfur oxide removal, mine dusting or acid water treatment, and asphalt and other fillers or extenders.
[4] Includes production reported without a breakdown by end use.
[5] Data do not add to total shown because of independent rounding.

the claims was not needed. The Colorado Geological Survey (CGS) conducted a valuation of the mineral estate as one part of that appraisal. CGS concluded that the marble could be extracted by a combination of surface and underground mining methods, during 5 months of the year, and that the marble could be quarried at a profit, although at a low production rate. In July, the owner was notified that he would receive a mining permit from the Colorado Mined Land Reclamation Division as soon as he applied for a Pitkin County special use permit. The complete appraisal, of which the valuation was only a part, had not been made public by yearend 1989.

Sulfur.—Apache Pyrite Joint Venture, which was extracting pyrite from tailings piles south of Leadville in Lake County, closed and entered foreclosure proceedings in April. The pyrite was used in making amber glass bottles and for other industrial purposes.

Vermiculite (Exfoliated).—W. R. Grace & Co. exfoliated vermiculite from out-of-State sources at its Denver plant. Output fell an estimated 7% from that of 1988. Exfoliated vermiculite was sold for use as block insulation, concrete aggregates, fireproofing, loose fill, plaster aggregates, and soil conditioning.

[1] State Mineral Officer, Bureau of Mines, Denver, CO. She has covered the mineral activities in Colorado for 5 years. Assistance in the preparation of the chapter was given by Pat La Tour, editorial assistant.

[2] Chief, Minerals and Mineral Fuels Resources, Colorado Geological Survey, Denver, CO.

[3] Paystreak, The Newsletter of the Clear Creek County Metal Mining Association. Oct. 1989, pp. 1–2; Dec. 1989, p. 1.

[4] The Clear Creek Cournat. Summary of the National Park Service's Draft Study of Alternatives for the Georgetown/Silver Plume District. V. 16, No. 47, July 5, 1989, 12 pp.

[5] Korzeb, S. L. Mineral Investigation of the Willow Creek (CO-010-002) and Skull Creek (CO-010-003) Wilderness Study Areas, Moffat County, CO. BuMines MLA 27-89, 1989, 16 pp.

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[6] Fallen, G. Mines Gets Major Grant for Superconductor Study. The Denver Post, Feb. 12, 1989.

[7] Obmascik, M. Plant Cranks Out Jobs, Tons of Toxic Wastes. The Denver Post, July 27, 1989, p. 10A.

[8] Paystreak, The Newsletter of the Clear Creek County Metal Mining Association. Oct. 1989, p. 3.

[9] McEachern, S. Utah Discovery Fuses Potential of Tiny Catalyst Resources Inc. The Denver Bus. J., v. 40, No. 31, Apr. 24, 1989, pp. 1 and 16.

[10] The Miner's News. Vanadium Producer Survives Hard Times of Mid-1980's; Ends Decade With Fairly Stable Operations. Oct.-Nov. 1989, p. 6B.

[11] Scott, J. Clay Mining and Golden History Go Hand In Hand. The Golden Transcript, Sept. 6, 1990, pp. 1 and 3.

TABLE 3

COLORADO:[1] CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[2]	—	—	—	—	—	—
Coarse aggregate, graded[3]	W	W	—	—	—	—
Fine aggregate (−3/8 inch)[4]	—	—	—	—	—	—
Coarse and fine aggregates[5]	W	W	—	—	—	—
Other construction aggregates	28	92	—	—	—	—
Agricultural[6]	—	—	(7)	(7)	—	—
Chemical and metallurgical[8]	—	—	(7)	(7)	—	—
Special[9]	(7)	(7)	—	—	—	—
Other miscellaneous	48	240	108	969	—	—
Unspecified: Actual[10]	226	1,430	341	1,720	—	—
Total[11]	302	1,762	448	2,689	—	—

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[2]	W	W	W	W	—	—
Coarse aggregate, graded[3]	W	W	—	—	—	—
Fine aggregate (−3/8 inch)[4]	W	W	—	—	W	W
Coarse and fine aggregates[5]	527	1,569	100	250	W	W
Other construction aggregates	1,833	8,513	112	379	57	470
Agricultural[6]	—	—	(7)	(7)	—	—
Chemical and metallurgical[8]	(7)	(7)	(7)	(7)	(7)	(7)
Special[9]	—	—	(7)	(7)	—	—
Other miscellaneous	640	1,956	812	2,770	10	30
Unspecified: Actual[10]	803	4,233	1,137	3,563	11	2,192
Total[11]	3,803	16,271	2,162	6,962	78	2,692

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[1] Excludes 468,311 short tons valued at $2,060,568 not reported by county.
[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 fine aggregate (screening-undesignated).
[5] Includes crushed stone for graded road base or subbase, unpaved road surfacing, crusher run or fill or waste, and other coarse and fine aggregates.
[6] Includes agricultural limestone and poultry grit and mineral food.
[7] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[8] Includes crushed stone for cement manufacture, lime manufacture, flux stone, and sulfur oxide removal.
[9] Includes crushed stone for mine dusting or acid water treatment, asphalt fillers or extenders, and other fillers or extenders.
[10] Includes production reported without a breakdown by end use.
[11] Data may not add to totals shown because of independent rounding.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Ideal Basic Industries 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.
Pikes Peak 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:			
Domtar Gypsum	1173 State Hwy. 120 Florence, CO 81226	Mine and plant	Fremont.
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	do.	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.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Castle Concrete Co.[1]	Box 2379 Colorado Springs, CO 80901	Pits and plants	El Paso and Pueblo.
Cooley Gravel Co. (J. L. Shiely Co.)[1]	Box 5485 Terminal Annex Denver, CO 80217	do.	Adams, El Paso, Jefferson.
Albert Frei & Sons Associates	11521 Brighton Rd. Henderson, CO 80640	do.	Adams, Clear Creek, Garfield, Weld.
Mobile Premix Co.[1]	Box 5183TA Denver, CO 80217	Pits	Various counties (9).
Western-Mobile Inc.	1400 West 64th Ave. Denver, CO 80221	Pits and plants	Boulder, El Paso, Larimer, Pueblo, Weld.
Stone:			
Asphalt Paving Co.	14802 West 44th Ave. Golden, CO 80401	Quarries	Jefferson.
Associated Aggregates	33501 Highway 6 Idaho Springs, CO 80452	do.	Various.

[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 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]

Connecticut's 1989 nonfuel mineral production value was $113 million, a $5 million decrease from that of 1988. Crushed stone and construction sand and gravel, the two leading mineral commodities produced, accounted for 91% of the State's total mineral production value. Other commodities produced included clay, dimension stone, feldspar, industrial sand, and mica.

TRENDS AND DEVELOPMENTS

One of the most economically troubled industries in Connecticut in 1989 was the mineral-dependent construction industry. Employment in this industry was down 4,000 jobs, from 81,500 in 1988 to 77,500 in 1989. A comparison of the total number of construction contract awards in 1989 with those of 1988 showed dramatic declines in all categories in 1989. Decreases were reported for nonbuilding, nonresidential, and residential contracts. The largest decline was in the total number of residential housing starts, which declined 41% in 1989 after declining 28% in 1988.[3] However, on the bright side for the construction and mineral industries was the continuing $7.1 billion, 10-year Transportation Infrastructure Renewal Program initiated in 1984. The infrastructure improvements in the program included street paving and repairs to the roads, bridges, sewers, and water systems of the State. During the first three quarters of 1989, 183 projects were set in motion representing $350 million. The Infrastructure Program was financed by the Special Transportation Fund (STF) set up in 1984. The STF is funded from the State motor fuel tax, motor vehicle receipts, and transportation-related licenses and permits.[4]

Although deposits of construction minerals are generally considered to be abundant and widespread, land use conflicts and environmental protection regulations were often cited in news accounts as the primary reason for blocking development of local deposits. Mining is primarily regulated at the town level in Connecticut. Because individual towns usually exercised control over surface mining through zoning and bylaws, many potential aggregate developers were prohibited or strictly regulated near urban areas, where demand was often the greatest. Because most aggregate has a low unit value, the market price is sensitive to transportation costs that can often double or triple the f.o.b. price of the material.

EMPLOYMENT

Although there were only about 1,200 workers engaged in mining in the State in 1989, nearly 77,500 persons worked in the mineral-dependent construction industry. Stone, clay, and glass product employees totaled 5,200, while employees working in primary

TABLE 1

NONFUEL MINERAL PRODUCTION IN CONNECTICUT[1]

Mineral	1987		1988		1989	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones	NA	$2	NA	$2	NA	$2
Sand and gravel (construction) thousand short tons	e8,400	e37,000	8,275	32,102	e5,800	e24,700
Stone:						
Crushed do.	11,412	76,668	e11,400	e76,900	2 11,480	2 78,734
Dimension short tons	18,140	1,646	e19,718	e1,914	W	W
Combined value of clays (common), feldspar, mica (scrap, 1987–88), sand and gravel (industrial), stone (crushed granite, 1989), and value indicated by symbol W	XX	6,959	XX	7,198	XX	9,780
Total	XX	122,275	XX	118,116	XX	113,216

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

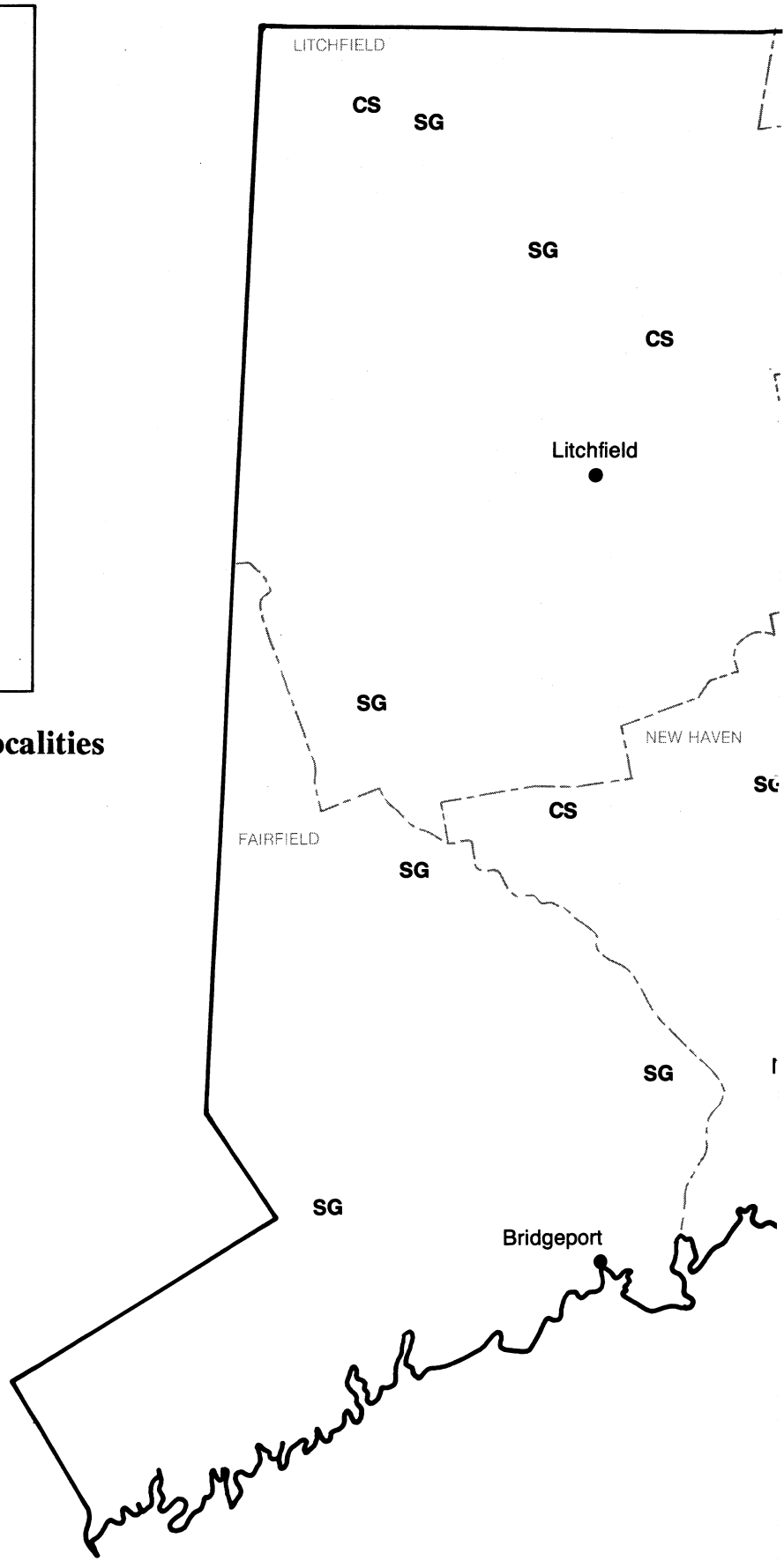
LEGEND

- 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



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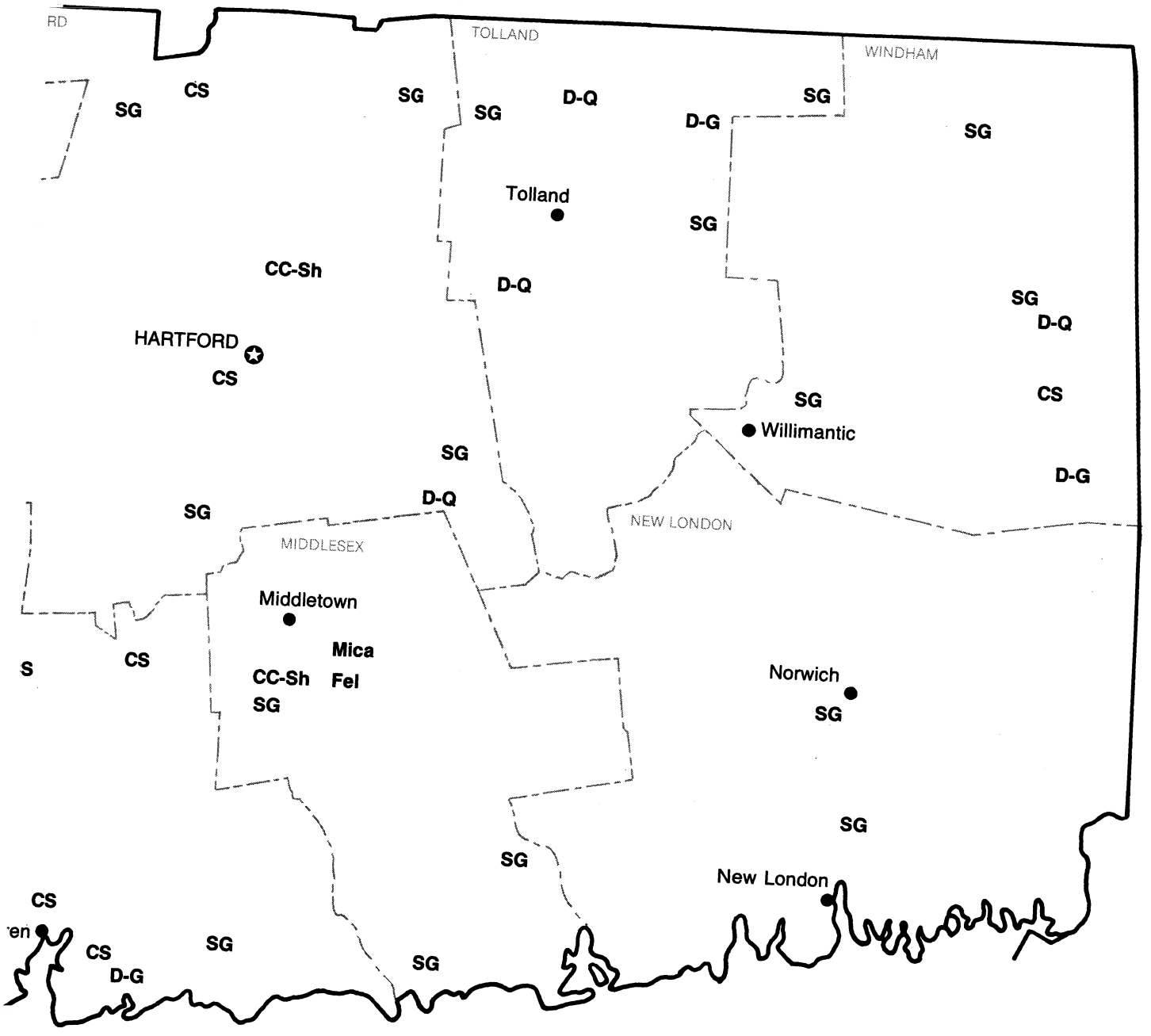
RD
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HARTFORD
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NEW LONDON
MIDDLESEX
Middletown
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and fabricated metal products numbered more than 56,000.

LEGISLATION AND GOVERNMENT PROGRAMS

During 1989, the State General Assembly approved $462 million in funding for the STF highway and bridge projects. The monies were allocated for interstate and intrastate highways, bridge repair, resurfacing, and special projects.[5]

The Engineering Research Institute (ERI), under the direction of the School of Engineering at the University of Connecticut, was attempting to find a use for the 600,000 tons of ash produced annually by the five trash incinerators in the State. If the ash can be used, the State was expected to save $50 million per year in disposal costs. ERI is studying the toxicity of the ash and its possible use as a road base, in sidewalk construction, or as an additive in concrete block manufacture. Use of ash of the "fly ash variety" is presently allowed in concrete.[6]

The Connecticut Geological & Natural History Survey (CGNHS) continued the collection, interpretation, and distribution of information about the State's natural resources. CGNHS staff focused on a number of efforts that included the planning and preparation for 1990 low- and high-altitude air photo flights of the entire State. Statewide topographic coverage continued to be updated, and the development of a 1:100,000 scale base map of Long Island Sound showing adjacent coasts took place in cooperation with the U.S. Geological Survey (USGS). During the year, data on the State's surficial and bedrock geology, and on soils, as well as biological data, were entered into the Department's computerized Geographic Information System (GIS).

Bedrock and surficial geologic mapping was pursued through a cooperative program with the USGS Geologic Division and through a separately funded State program.[7] A significant collection of rock core, primarily of Connecticut's Mesozoic sedimentary and volcanic rocks of the Newark Supergroup, was obtained by the Survey from the U.S. Army Corps of Engineers. Another cooperative program with the USGS involved marine geologic investigations in Long Island Sound. Seismic reflection profiling in Long Island Sound was conducted using funds from the Minerals Management Service.

Work continued on a cooperative effort with the Soil Conservation Service to rectify, reclassify, and digitize detailed soil maps for use in the GIS.

Through a cooperative effort with the USGS Water Resources Division, basic data was collected by monitoring the quantity and quality of surface and ground water, as well as water use. Precipitation was monitored through a cooperative program with the National Oceanographic and Atmospheric Administration (NOAA). Hydrogeological data, including saturated thicknesses and areas of contribution to wells for stratified drift aquifers, was provided for Statewide legislative action to protect aquifers.

A directory of active bedrock mines and quarries was compiled, and an active quarry location map was prepared using the GIS.[8] Work on a Connecticut mining display for the National Mining Museum and Hall of Fame in Leadville, CO, was under way. Also in the area of mining, development of model mining guidelines for towns began, in cooperation with the Water Management Bureau of the Department of Environmental Protection.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Clays.—Two companies mined common clay and shale for use in manufacturing common and face brick. K-F Brick Co. mined Pleistocene glacial lake clay near South Windsor and quarried Jurassic age shale near Suffield, both in Hartford County. The Michael Kane Brick Co., the State's other producer, operated an open pit mine in glacial lake clay in Middlesex County.

Feldspar.—Connecticut ranked second nationally of the seven States that produced feldspar in 1989. The Feldspar Corp. operated three open pit pegmatite quarries and a froth-flotation plant in the old Middletown pegmatite district in Portland and Middletown, Middlesex County. The processed feldspar was shipped by truck to markets in New England, New Jersey, and New York and was used principally as a flux by the glass and ceramics industries.

In November, the Portland Planning and Zoning Commission granted a 2-year mining permit renewal to The Feldspar Corporation to continue blasting and quarrying feldspar. The company also received approval for mining from the Inland-Wetlands Agency (IWA), a State agency that regulates mining near wetlands. Earlier in the year, residents had asked the Commission to limit the mining permit to 1 year, fearing the effects of blasting on their house foundations and noise and traffic problems from the trucks hauling the ore to the Middletown plant. The permit, which expires on November 16, 1991, allows the company to remove up to 120,000 tons of pegmatite per year.

Gem Stones.—Individual collectors and mineral clubs recovered an abundance of gem stones 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 sites for gem collecting.

Iodine.—Crude iodine was shipped to Connecticut and processed by Uniroyal Chemical Co. Inc. at a plant near Middlebury, New Haven County. The crude iodine was used primarily to manufacture rubber, anti-oxidants, and organic chemical compounds.

Mica.—The Feldspar Corp. recovered scrap mica as a byproduct of feldspar mining operations in Middletown, Middlesex County. The mica was sold as a filler and as an additive for well-drilling mud.

Peat.—There was no recorded peat production in Connecticut in 1989. However, a proposal to excavate 22,000 cubic yards of peat on a private developer's property in Mansfield was submitted to the Mansfield Planning and Zoning Commission near yearend. The Mansfield Conservation Committee, as well as the State Inland-Wetlands Agency, both rejected the plan to mine the peat. Had the proposal been approved, the peat was to be sold to landscape and nursery firms.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

In terms of value, construction sand and gravel has historically been the second leading mineral commodity produced. Estimated production in 1989 was 5.8 million short tons valued at $24.7 million. This represents a decrease of 30% and 23% in output and value, respectively, from those of 1988. The primary reason for the decline was the decrease in total contract construction during the year. Major uses are for construction and roadbuilding.

By a large percentage, voters in Glastonbury rejected a proposition that would have restricted mining of sand and gravel in that town to 100,000 cubic yards annually. The proposed ordinance was the result of a petition drive by some Glastonbury residents who objected to truck traffic to and from the sand and gravel mining areas. At yearend, excavation permits that allowed mining companies to dig as much as 3.5 million cubic yards of material from sites within the town's jurisdiction were in effect. A pending permit to mine another 22-acre site within the town limits by the Balf Co. would raise that amount to 5 million cubic yards.[9]

Industrial.—Two companies produced industrial sand in the State in 1989. U.S. Silica Co. of Connecticut operated a quarry near North Stonington, New London County, and The Feldspar Corp. processed industrial sand as a byproduct of feldspar refining in Middletown, Middlesex County. Principal uses were for roofing granules, glass products, and filtration.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Crushed stone continued to be the State's leading mineral commodity produced, accounting for nearly 70% of the State's total mineral value. Crushed stone production (predominantly Jurassic-age basalt, which is commonly called traprock) remained essentially the same as 1988. Limestone and granite were also quarried in the State. Crushed stone was mined in five of the State's eight counties. Leading counties in order of output were New Haven, Hartford, Litchfield, Middlesex, and Windham.

The crushed stone industry may face an attempt by environmental groups to restrict or eliminate quarrying of stone in Connecticut's basalt ridges. The Department of Environmental Protection was drafting revised regulations, under the "Environment 2000" program, to protect such habitats as wetlands and the basalt regions.[10]

After a 2-year legal battle, the State Appellate Court declined to hear a quarry owner's appeal of an earlier State Supreme Court ruling limiting that quarry's operations. The owners of the Bolton Notch Quarry in Bolton had sought to overturn the Supreme Court ruling. The Supreme Court had sided with the local zoning board's ruling, which limited the mining on the 10.9-acre parcel to the 2.2 acres zoned for industrial purposes; the remainder is zoned for residential property. The owners of the quarry claimed that, because the quarry was in existence for about a century before zoning regulations were adopted, it should be exempt. They also argued that the town's zoning commission approved plans in 1983, 1984, and 1985 that showed that the entire parcel ultimately would be quarried.

Dimension.—Dimension granite was quarried in New Haven County, and dimension granite and quartzite were quarried in Tolland and Windham Counties. The stone was sold as irregular-shaped stone, rough blocks, and cut stone.

TABLE 2

CONNECTICUT: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate, graded: Concrete aggregate, coarse	209	1,225
Coarse and fine aggregates: Other construction materials[2]	996	7,086
Unspecified:[3]		
Actual	5,403	40,838
Estimated	4,872	29,585
Total	11,480	78,734

[1] Includes limestone and traprock; granite withheld to avoid disclosing company proprietary data.
[2] Includes stone used in bituminous aggregate, coarse, riprap and jetty stone, and a small amount of agricultural limestone.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in Connecticut for 4 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.

[3] New England Business. The Unperceived Star. V. 12, No. 2, Feb. 1990, pp. 49–53.

[4] State of Connecticut Department of Transportation. Governor's Transportation Infrastructure Renewal Program, 1984–94. Report of Progress, The First 5 Years, 1984–89, 11 pp.

[5] Connecticut Construction Industries Association Inc. 1989 Annual Report. pp. 3–4.

[6] ——. CCIA Highlights of the Week, Dec. 15, 1989, p. 2.

[7] London, D. Bedrock Geology of the Moodus Seismic Area, South-Central Connecticut With Map. Conn. Geol. and Nat. Hist. Surv. Report of Investigations No. 11, 1989, 25 pp., map (1:12,000 scale).

[8] Altamura, R. J. Directory of Active Bedrock Quarries of Connecticut. Conn. Geol. and Nat. Hist. Surv., 1989, 19 pp.

——. Active Bedrock Quarries of Connecticut. Conn. Geol. and Nat. Hist. Surv. GIS Map, 1989, 1:250,000 scale.

[9] Hartford Courant. Council Rejects Proposal. Aug. 30, 1989, p. 1.

[10] Rock Products. Forecast 1990. V. 92, No. 12, Dec. 1989, p. 36.

TABLE 3

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	Mine and plant	Hartford.
Feldspar:			
The Feldspar Corp.[1]	Box 99 Spruce Pine, NC 28777	Mines and plant	Middlesex.
Sand and gravel (1988):			
Construction:			
Bakerville Lumber & Construction Co.	321 Maple Hollow Rd. New Hartford, CT 06057	Pit	Litchfield.
Connecticut Sand & Stone Corp.	7 West Main St. Plainville, CT 06062	Pit and plants	Hartford and Litchfield.
The Elm Construction Co.	400 North Frontage Rd. New Haven, CT 06473	Plant	New Haven.
O&G Industries Inc.	23 Casson Ave. Box 907 Torrington, CT 06790	Pit	Do.
R. A. Rawson Sand & 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 06018	Quarry	Litchfield.
Edward Balf Co.	Box 11190 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	do.	Hartford, New Haven, Windham.
York Hill Trap Rock Quarry Co.	Westfield Rd. Meriden, CT 06450	do.	New Haven.
Dimension:			
Castellucci & Sons Inc.	West River St. Providence, RI 02904	do.	Do.
R. B. Marriott & Sons Co.	Box 67 Oneco, CT 06373	do.	Windham.
Wayne C. Williams General Construction Inc.	R.F.D. 1, Conklin Rd. Stafford Springs, CT 06076	do.	Tolland.

[1] Also crude mica and industrial sand.

THE MINERAL INDUSTRY OF DELAWARE

This chapter has been prepared under a Memorandum of Understanding between the 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]

The value of nonfuel mineral production in Delaware in 1989 was $6.2 million. Sand and gravel and magnesium compounds were the major commodities produced. The chemicals and construction industries were the most significant users of minerals, many of which were shipped into Delaware through the Port of Wilmington.

TRENDS AND DEVELOPMENTS

Construction projects for a bypass around Dover and other infrastructure improvements were expected to result in contracts valued at $500 million. Before the construction work, scheduled to start in 1990, BTO Limited Partnership proposed building stone depots along rail lines in Camden, Felton, and other sites. The crushed stone was expected to be shipped from Pennsylvania. Rezoning and local government approval for the depots were pending at yearend. The proposed bypass was expected to relieve traffic congestion for motorists heading to beach areas in southern Delaware.

Large quantities of minerals were transported into the State from other domestic sources and also were imported from overseas. Most of the imported minerals were received at the Port of Wilmington and included 330,000 short tons of crude gypsum, 209,000 tons of salt, 200,000 tons of steel, and 48,000 tons of magnesite ore.[2]

Most of the steel imported at the Port was produced in Brazil, Europe, and the Far East.

For the first time in more than 5 years, steel was exported from the Port of Wilmington. Shipments in the 5,000- to 10,000-ton range were sent to Italy and India from steelmakers in Pennsylvania and Delaware.[3]

LEGISLATION AND GOVERNMENT PROGRAMS

A dispute about the hiring of former steelworkers triggered the introduction of legislation that proposed closing Delaware's only steel mill. In February 1989, CitiSteel USA Inc., an agency of the Chinese government, reopened the mill in Claymont. The mill had been closed since 1986 and was formerly owned by Phoenix Steel Corp. In June, the State Senate passed a bill on the last day of the legislative session that would revoke CitiSteel's permit to operate because the firm allegedly refused to hire former Phoenix Steel workers. CitiSteel officials maintained a position that no such hiring agreement had been made. Legislative action on the Senate bill was expected in the House during the 1990 session if the dispute is not resolved.

Legislation to regulate sand and gravel borrow pits was introduced in the Delaware General Assembly through House Bill (H.B.) 368. This legislation would require borrow pit owners-operators to obtain operating permits; reclaim abandoned pits; and secure the premises from illegal dumping, disposal of waste, or vandalism. The Department of Natural Resources and Environmental Control would have the authority to carry out and enforce the regulations. H.B. 368 was carried over for consideration during the 1990 legislative session.

The Delaware Geological Survey (DGS) at Newark is the "point of contact" for the Bureau of Mines, U.S. Geological Survey (USGS), and Mineral Management Service (MMS). All three of these agencies are in the Department of the Interior and are in-

TABLE 1

NONFUEL MINERAL PRODUCTION IN DELAWARE[1]

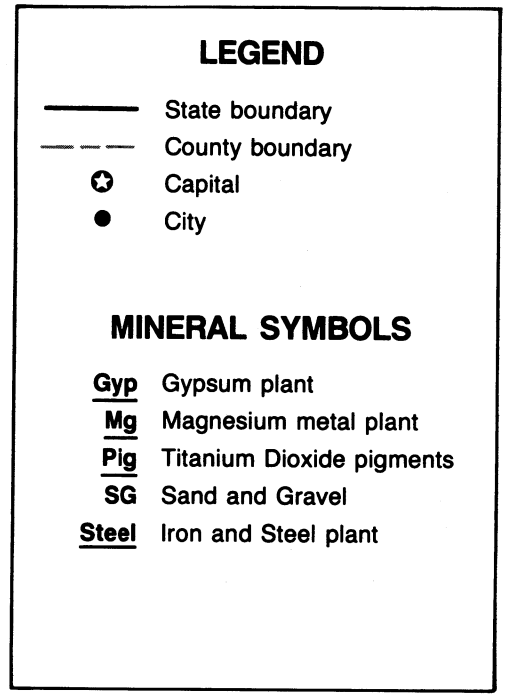
Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	$1	NA	$1	NA	$1
Marl (greensand)	short tons	W	W	750	10	—	—
Sand and gravel (construction)	thousand short tons	e2,300	e6,400	1,933	5,988	e1,900	e6,200
Total[2]		XX	6,401	XX	5,999	XX	6,201

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. XX Not applicable.

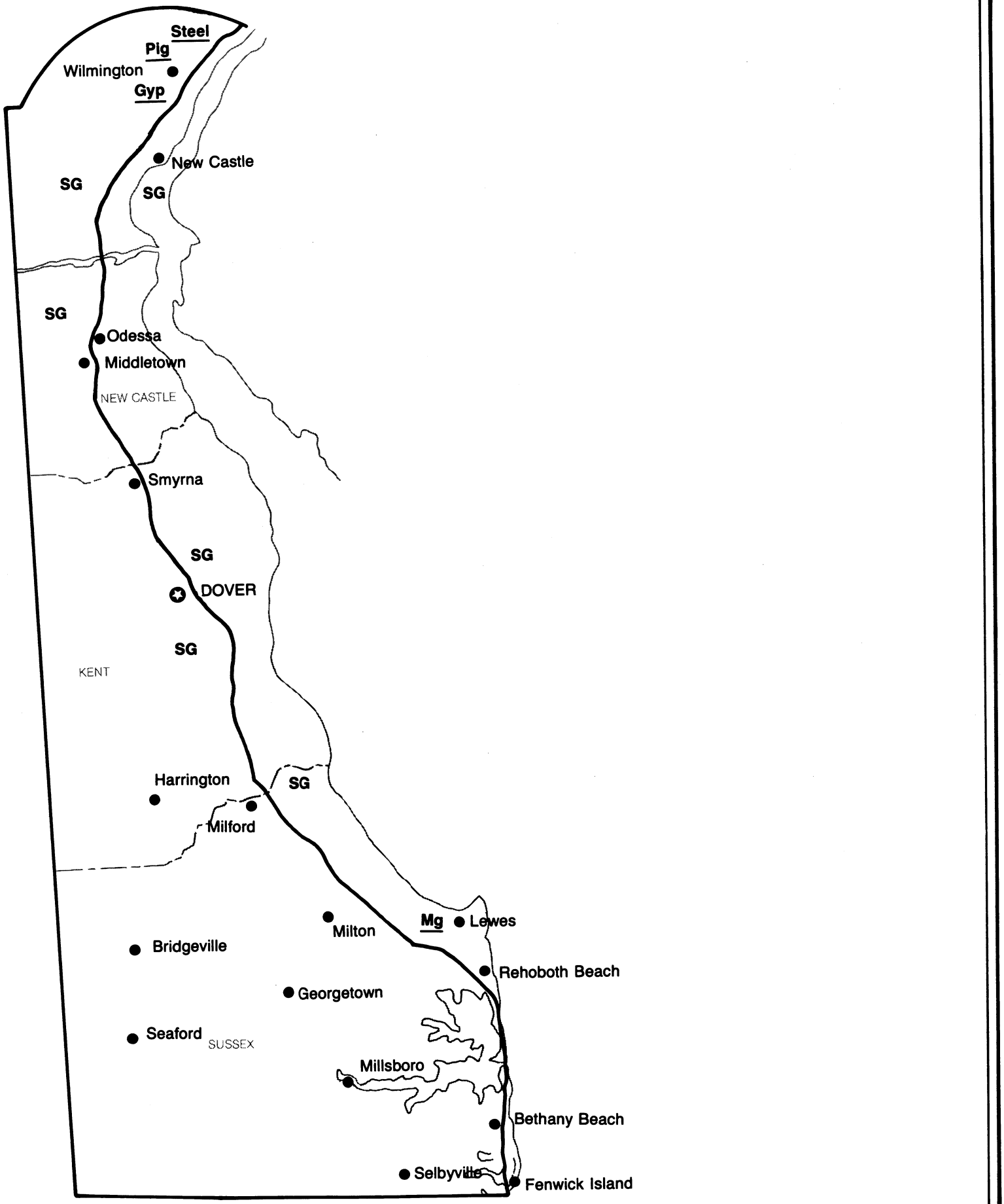
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Partial total, excludes values which must be concealed to avoid disclosing company proprietary data.

DELAWARE



Principal Mineral-Producing Localities


Steel
Pig
Wilmington
Gyp
New Castle
SG
SG
SG
Odessa
Middletown
NEW CASTLE
Smyrna
SG
DOVER
SG
KENT
Harrington
SG
Milford
Milton
Mg
Lewes
Bridgeville
Rehoboth Beach
Georgetown
Seaford
SUSSEX
Millsboro
Bethany Beach
Selbyville
Fenwick Island

volved in conservation and natural resources programs. In 1989, the DGS continued to aid the Bureau of Mines in preparation of the Minerals Yearbook by providing information on the State's mineral industry. The DGS and USGS continued a mapping project to completely review all of Delaware's 7.5-minute topographic maps.

In cooperation with the MMS through the Association of American State Geologists and the University of Texas, the DGS was involved in research to further knowledge and understanding of the geology and resource potential of the U.S. continental margins. In Delaware, studies focused on deeper subsurface geology and hydrocarbon resource potential.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Greensand.—No greensand production was reported in 1989. Contractors Sand & Gravel Co. Inc. began mining greensand as a coproduct at its sand and gravel pit near Middletown in 1984.

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 1989 remained about the same as that of the previous year. Magnesium and aluminum hydroxides are used in the manufacture of antacid products and other pharmaceuticals.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

In 1989, an estimated 1.9 million short tons of construction sand and gravel were mined in Delaware. During the decade of the 1980's, a total of nearly 15 million tons of sand and gravel was produced in the State with a value of about $45 million. In the last 10 years, output ranged from a low of 1.0 million tons in 1984 to a high of 2.3 million tons in 1987.

In addition to the production of construction sand and gravel reported to the Bureau of Mines, the State, through a contract, dredged about 900,000 tons of sand. That sand was used to replace sand eroded from Bethany Beach in Sussex County. Delaware's Department of Natural Resources and Environmental Control, Division of Soil and Water Conservation, began the beach nourishment project in 1988. The project was started because of the negative effect of shoreline erosion on the State's tourism industry.

Metals

Steel.—CitiSteel USA Inc. reopened the former Phoenix Steel Corp. plant in Claymont. Production began at the 400,000-short-ton-per-year-capacity facility in March.

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 1989, about 207,000 short tons of municipal solid waste was processed at the facility. Recovered materials included 6,150 tons of ferrous metals, 785 tons of nonferrous metals (primarily aluminum), 1,100 tons of glass, and 745 tons of sand. Paper waste was processed for use as a fuel and mixed with sludge for application as a mulch or fertilizer.

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[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in Delaware for 5 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2] Port of Wilmington Delaware Newsletter. Monthly Tonnage Report, June 1989, p. 3.

[3] Port of Wilmington Delaware Newsletter. Port Handles First Export Steel Shipments, Spring 1989, p. 2.

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.
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 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 1989, Florida mineral producers reported production and sales valued at $1.6 billion, an increase of $22 million over that reported in 1988. The higher value was due to increased sales of portland cement, clays, construction sand and gravel, crushed stone, and phosphate rock. This reflected the strength of the construction industry and an unexpected foreign demand for phosphate rock products.

Florida continued to rank 4th nationally in total mineral value, 2d in industrial mineral production, and 19th in metal value. The State again led the Nation in heavy mineral and phosphate rock output and ranked in the top three nationally in crushed stone, masonry cement, and peat production.

TRENDS AND DEVELOPMENTS

During the 10-year period from 1980 to 1989, mineral production in Florida was valued at $14.4 billion and provided thousands of jobs, both directly and indirectly, for the State's citizens. This was a period of fluctuating demand and sales for the State's mineral producers.

Phosphate sales historically have accounted for approximately one-half of the State's mineral value. The demand for phosphate rock and phosphate rock products has been the determining factor on whether Florida's mineral value increased or decreased.

The record for mineral value was established in 1981 when sales reached $1.7 billion. This was followed by a decline of $500 million in 1982, when the nationwide recession reduced demand throughout Florida's mineral industry. Sales and value rebounded in the 1983–85 period, but fell again in 1986. This decline was due primarily to a reduction in fertilizer demand brought on by (1) a Federal agricultural acreage reduction program, (2) foreign competition, and (3) a world-wide reduction in demand. The 1987–88 period witnessed the slow recovery of Florida's economy and saw renewed demand for the State's mineral commodities. In 1989, however, mineral value remained $117 million below the 1981 record. One highlight of the year was an increase in orders for diammonium phosphate by India.

TABLE 1

NONFUEL MINERAL PRODUCTION IN FLORIDA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	390	$24,069	411	$25,892	477	$31,231
Portland	do.	3,565	165,944	3,682	168,719	4,357	207,857
Clays	metric tons	541,760	39,496	536,922	44,423	[2]563,687	[2]46,941
Peat	thousand short tons	363	6,068	266	5,091	235	4,515
Sand and gravel:							
Construction	do.	[e]30,000	[e]74,900	18,654	53,083	[e]17,900	[e]55,500
Industrial	do.	1,884	19,713	636	6,928	681	7,768
Stone (crushed)	do.	[3]78,992	[3]350,537	[e][3]83,200	[e][3]374,400	83,995	341,397
Combined value of clays (common), gem stones, magnesium compounds (1988–89), phosphate rock, rare-earth metal concentrates, staurolite, stone (crushed marl 1987–88), titanium concentrates (ilmenite and rutile), and zircon concentrates		XX	665,510	XX	713,345	XX	913,054
Total		XX	1,346,237	XX	1,391,881	XX	1,608,263

[e] Estimated. 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.

Historically, cement value has been an important contributor to the State's total mineral value. Although Florida continued to rank third nationally in cement consumption, the State's six cement plants operated at a fraction of capacity, and imported cement accounted for almost 49% of the tonnage used instate. This trend of importing rather than producing has been a long-term phenomenon, and industry personnel agree that the import trend will continue into the foreseeable future.

Developments in the mineral industry during 1989 included the opening of a new limestone mine in Citrus County in northern Florida to supply a south Alabama cement plant and the announcement of a new heavy minerals mine in north-central Florida scheduled to begin operation in 1992. One of the State's phosphate companies was purchased by a Chinese firm, and one phosphate mine that supplied feed to a Mississippi fertilizer plant closed.

REGULATORY ISSUES

Byproduct gypsum resulting from the processing of phosphate rock continued to be a major problem for industry, State officials, and local citizens. Many gypsum "mounds," some 200 feet high and covering several hundred acres, were said to be ". . . leaking heavy metals, sulfates, radioactive particles, and other pollutants into the ground water. . . ."[3]

In September, IMC Fertilizer Inc. (IMCF) signed an agreement with the Department of Environmental Regulation (DER) to determine the extent of contamination at the New Wales plant. IMCF announced plans for a new 4- to 5-acre gypsum stack. Environmental safeguards for the new stack were projected to cost $52 million.

At yearend, State and regional officials were working with Consolidated Minerals Inc. to develop procedures to review the company's plans for a huge phosphate mine and industrial complex in western De Soto County. The $1-billion project includes a 4-million-ton-per-year phosphate rock mine, a 2.5-million-ton-per-year cement plant, a 600-megawatt electrical power plant, a gypsum decomposition plant, and a 1.2 million-ton-per-year phosphoric acid plant.[4]

Royster Phosphates Inc.'s plans to construct a $50 million sulfuric acid plant was deferred when DER requested additional information on the project before issuing the necessary permits. The new facility would replace the Piney Point sulfuric acid plant.[5]

LEGISLATION AND GOVERNMENT PROGRAMS

In October, the head of the Florida DER met with county and city environmental agency directors and others to seek help in drafting new legislation and researching duplicate responsibilities between local and State government. This action resulted from a law passed in 1967 that required local governments to establish their own pollution control programs and to submit their plans to the State for approval. Although the law required enforcement of the statute, its wording was so vague that it was routinely ignored by the DER.

The Florida Geological Survey continued compiling data on the geology and the mineral resources of the State. The Mineral Resource Investigations and Environmental Geology Section compiled and published mineral resource maps on Flagler, Jefferson, Putnam, and St. Johns Counties. Projects in progress at yearend included mineral resources maps of several other counties, compilation of a statewide mineral resources map, and two environmental geology studies on the Ocala and Gainesville areas. An updated version of Florida's oil and gas production and exploration statistics were well underway.

The Geological Investigations Section published a geologic study on Sumter County, a guide map to geologic and paleontological sites in the State, and geologic descriptions of selected exposures. At yearend several projects were underway, including a new geologic map of the State, a report on uranium in peat lands, and a reconnaissance of offshore heavy mineral sands from Cape Canaveral to the Jacksonville area.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Industrial mineral value exceeded $1 billion for the 12th consecutive year. Thirteen industrial mineral commodities were mined or manufactured by the State's mineral industry.

Cement.—The combined value of portland and masonry cement, $239 million, was 15% of Florida's mineral value. The State maintained its first-place ranking in masonry cement output and its sixth-place ranking in portland cement production. The industry produced 477,000 short tons of masonry cement valued at $31 million and 4.4 million tons of portland cement valued at $208 million.

The State's cement industry consisted of six companies with plants at Bradenton, Brooksville (two), Ft. Pierce, Hialeah, Miami, and Tampa. Three of the companies produced masonry cement, and all six produced portland cement. No clinker was produced; the Bradenton and Tampa plants ground clinker, most of which was imported from Mexico, Spain, or France. The other four companies used locally mined clay and limestone for clinker manufacture. One firm used waste limestone fines obtained from its aggregate production operation. Requirements for alumina and iron oxide in the clinker were met by the use of fly ash, bag house dust, and mill scale. Gypsum, used in the finish grinding step, was obtained from Spain. The industry operated eight kilns; five used the dry process, and three used the wet.

Clays.—Florida ranked second in value among the 44 states with clay production. Clay sales, $47 million, ranked sixth among the 13 industrial minerals produced in 1989. Production, 564,000 metric tons, was 27,000 metric tons above that reported by the clay producers in 1988; value also increased $2.5 million over that reported for 1988.

Six firms reported common clay, fuller's earth, and kaolin production. Common clay, defined as a clay or clay-like material that is sufficiently plastic to permit ready molding and that usually vitrifies below 1,100 degrees Celsius, was produced by several companies with mines principally in Escambia and Lake counties. The principal uses were for cement (clinker), brick, and lightweight aggregate.

Fuller's earth, a clay with absorbent properties, occurs in an area extending from the north Florida panhandle into

southwestern Georgia. In Florida four companies, Engelhard Co., Floridin Co., Mid-Florida Mining Co., and Milwhite Co., produced fuller's earth from six mines in Gadsden and Marion Counties. The raw clay was trucked to a preparation plant where it was dried, ground, fired in a rotary kiln, screened, and stored for shipment, either in bags or bulk. Sales were to the (1) pet waste, (2) oil and grease absorbent, (3) fertilizer, (4) pesticide carrier, and (5) saltwater drilling mud industries. Output exceeded the 1988 level reported by the four companies by almost 24,500 tons; value increased $3.6 million.

Kaolin, a white mineral with a specific gravity of 2.6 and a fusion point of 1,785° C, was produced by the Feldspar Corp. from a mine in Putnam County. A kaolin-sand mixture was produced by dredge. The sand was recovered and separated into industrial-construction fractions, and the clay slurry was solidified, extruded into "noodles," and dried. Approximately 90% was ground and shipped bulk or in 50-pound bags. Principal customers, both in the United States and overseas, were the whiteware, wall tile, and electric porcelain industries. Production totaled 42,600 metric tons valued at $3.9 million.

Peat.—Nationally, Florida dropped to second in the production of peat; Michigan moved into first place. The State's peat producers harvested 235,000 short tons valued at $4.5 million. This was a 31,000-short-ton and $576,000 decrease from that reported in 1988. Ten companies harvested both reed-sedge and humus peat in a six-county area. Lake County accounted for almost 51% of the tonnage harvested. Horticultural establishments provided the principal market.

An agreement was reportedly reached between Florida Power Corp. and General Peat Resources LP for the utility to purchase power from three peat-fueled plants to be built in central Florida. The action paved the way for General Peat of St. Petersburg to build three 52-megawatt generating units near Lake Placid at an estimated cost of $300 million. General Peat will harvest peat in the immediate area, where bogs contain a 50-year supply of the fuel. At full capacity, the powerplants would require more than 1 million dry tons of peat annually, more than double current U.S. peat output.[6]

Phosphate Rock.—The value of phosphate rock production accounted for over 50% of the State's 1989 mineral value. Production, as reported by the Florida Phosphate Institute, totaled 38.2 million metric tons, 1.9 million metric tons more than in 1988. The Institute does not collect marketing data, that is, phosphate rock value. The Bureau of Mines combines phosphate rock production and value data for Florida and North Carolina to protect information supplied by the single North Carolina producer. Therefore, value data reflecting Florida production are not published.

Enhanced technology and economic necessity have lead to more efficient phosphate operations over the past 10 years. In 1980, 43 million metric tons of phosphate rock was mined with a work force of 14,620. In 1989, 38.2 million metric tons of phosphate rock was produced by 9,783 workers; 89% of the tonnage was produced with 67% of the work force. Output in 1989, 10% higher than in 1988, was produced with 14 fewer workers.

During the year, 10 companies operated 17 mines in the Polk, Hardee, Manatee, and Hillsborough contiguous-county area of west-central Florida. Approximately 90% of the production was from Polk County. In north-central Florida three companies recovered low-fluorine, soft phosphate rock from hard rock tailings ponds.

In 1989, Beeker Phosphate Corp. was purchased by New West Industries Inc., and Hopewell Land Co.'s phosphate holdings were purchased by IMC Fertilizer Inc. The IMC Lonesome Mine in Hillsborough County and Mobil Mining & Minerals Co.'s Big Four Mine in Polk County were idle; IMC's Haynsworth Mine in Polk County was closed.

Export and domestic shipments were transported by rail from the beneficiation plants to shipping terminals at Hillsborough Bay, Jacksonville, and Tampa. Florida ports exported an estimated 15.4 metric tons of phosphate rock and related products during the year. Among the countries importing Florida phosphate rock or phosphate rock products were China, India, Japan, the Republic of Korea, and the Netherlands. Phosrock, a trade association, estimated that the State's exports were worth about $2.17 billion, a $270 million increase over 1988.[7]

Sand and Gravel.—Florida ranked 15th among the 50 states producing construction sand and gravel and 15th among the 38 states producing industrial sand and gravel. The value of both construction and industrial output accounted for about 4% of the State's mineral value.

Construction.—Construction sand and gravel is surveyed by the Bureau of Mines for even number of years only; data for odd-numbered years are based on annual company estimates. This chapter contains actual data for 1988 and estimates for 1987 and 1989.

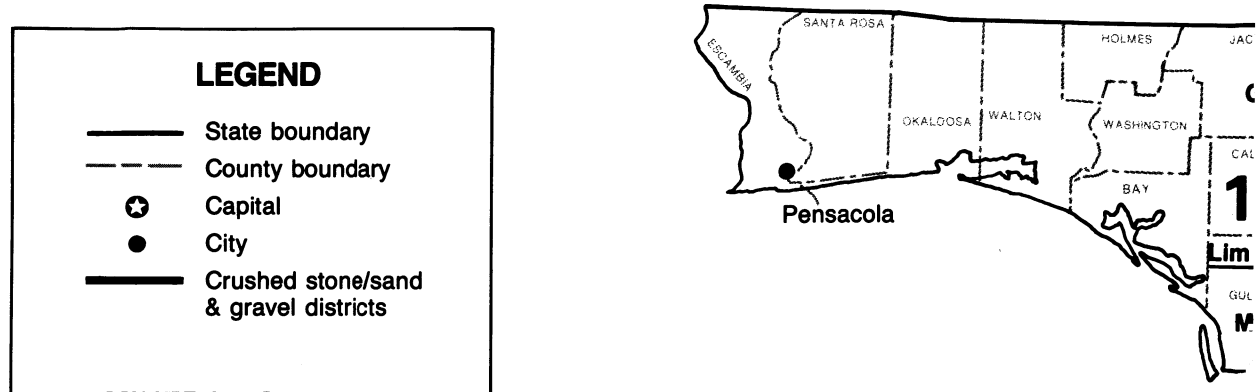
The estimated production fell below that reported in 1988 by about 750,000 short tons. Value, however, exceeded the 1988 level by almost $2.4 million, reflecting an increase in the unit price.

In 1988, the last year that full-year company data were reported to the Bureau of Mines, 29 companies operated 48 mines in 20 counties. The leading counties, by tonnage, were Broward, Hendry, Lake, Marion, and Polk. These five accounted for approximately 73% of the State's total.

Industrial.—Industrial sand was produced by six companies operating nine mines in six counties. One firm produced both industrial sand and industrial gravel as a coproduct of kaolin mining. The three leading counties were Glades, Polk, and Putnam, which accounted for about 90% of the production. The end use for more than 50% of the tonnage reported was unspecified. Of the tonnage for which an end use was reported, more than 60% was used for manufacturing glass containers. Sand for filtration, blasting, ground filler, molding and cores, and traction uses accounted for the remainder. Unit values were reported as follows: blasting, $23.75; ground fillers, $20.99; molding and cores, $9.73; traction, $8.50; glass containers, $8.25; and filtration, $5.50.

One firm reported production of 1,213 tons of industrial gravel. The average unit price was $13.50. Sales were to several industries, including those producing roofing and aquarium gravel.

Staurolite.—E. I. du Pont de Nemours and Co. Inc. recovered a staurolite concentrate as a byproduct of heavy mineral processing in Clay County. Sales were to the foundry, sandblasting,



LEGEND

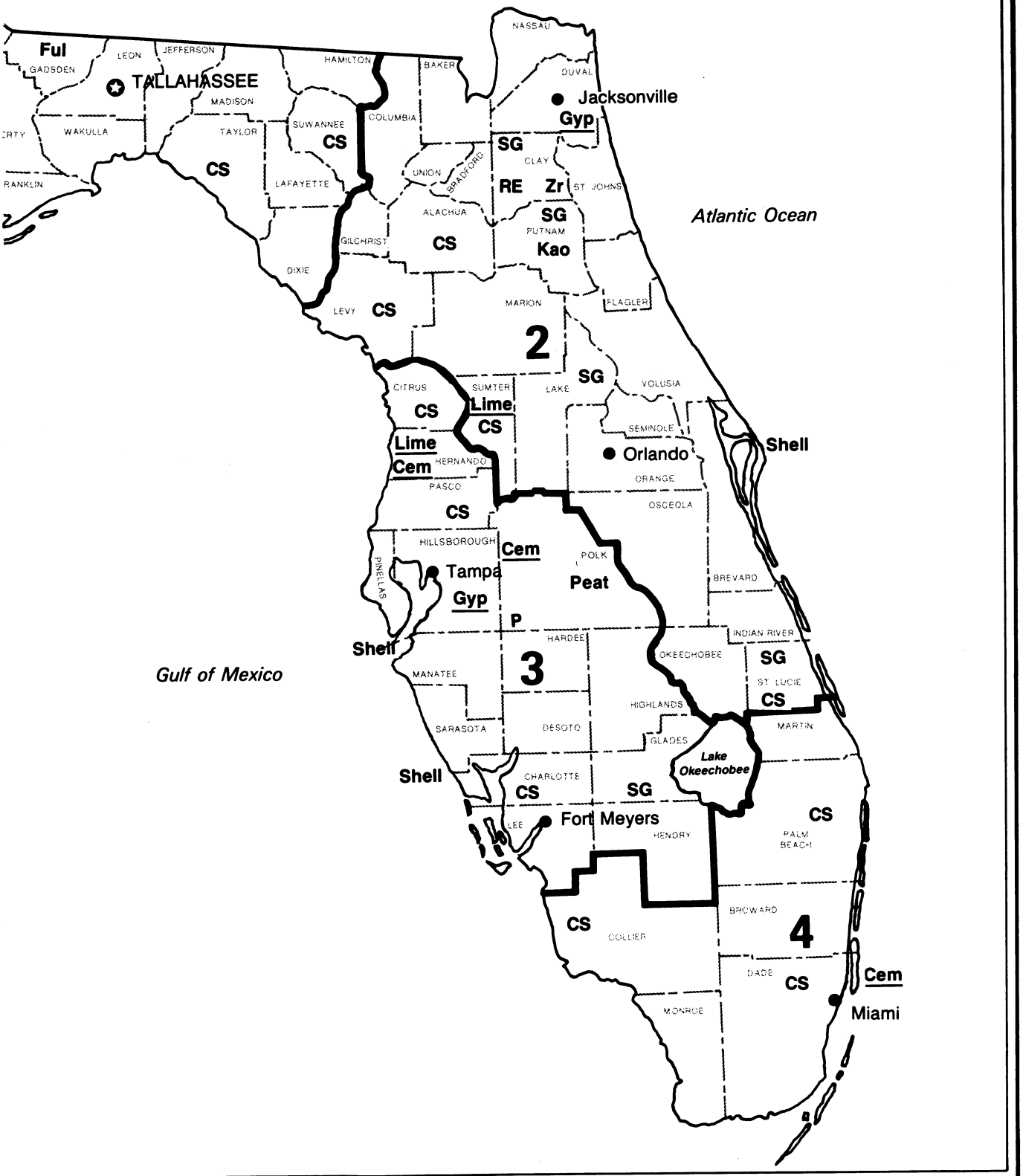
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Cem	Cement plant
CS	Crushed Stone
Ful	Fuller's earth
Gyp	Gypsum plant
Kao	Kaolin
Lime	Lime plant
Mg	Magnesium
P	Phosphate rock
Peat	Peat
RE	Rare-earths
SG	Sand and Gravel
Shell	Shell
Zr	Zircon
	Concentration of mineral operations

Principal Mineral-Producing Localities

DA


NASSAU
Ful
LEON
JEFFERSON
GADSDEN
TALLAHASSEE
HAMILTON
BAKER
DUVAL
Jacksonville
Gyp
MADISON
SUWANNEE
COLUMBIA
WAKULLA
TAYLOR
CS
SG
CLAY
UNION
BRADFORD
RE
Zr
ST JOHNS
LAFAYETTE
ALACHUA
SG
Atlantic Ocean
GILCHRIST
CS
PUTNAM
Kao
DIXIE
LEVY
CS
MARION
FLAGLER
2
SG
CITRUS
SUMTER
LAKE
VOLUSIA
CS
Lime
CS
SEMINOLE
Shell
Lime
Orlando
Cem
HERNANDO
ORANGE
PASCO
CS
OSCEOLA
HILLSBOROUGH
Cem
POLK
PINELLAS
Tampa
Peat
BREVARD
Gyp
P
INDIAN RIVER
Shell
HARDEE
OKEECHOBEE
SG
Gulf of Mexico
3
MANATEE
ST LUCIE
CS
HIGHLANDS
SARASOTA
DESOTO
MARTIN
GLADES
Lake Okeechobee
Shell
CHARLOTTE
CS
SG
CS
LEE
Fort Meyers
HENDRY
PALM BEACH
CS
BROWARD
COLLIER
4
DADE
CS
Cem
MONROE
Miami

and cement industries. Production decreased slightly, but value increased by about $200,000.

Stone.—Stone production is surveyed by the Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1988 and actual data for 1987 and 1989.

The Bureau of Mines compiles crushed stone statistics by districts for some States. Table 3 presents end-use data for crushed stone produced in the four Florida districts depicted on the State map.

Florida again ranked second behind Pennsylvania among the 48 states with stone production. The Keystone State's output exceeded that of Florida by about 9 million short tons. Florida's $341 million stone value accounted for 21% of the State's total mineral value and ranked second behind phosphate rock. Production reported by the stone sector of the mineral industry in 1989 was about 800,000 short tons above that estimated for 1988. Value, however, was $33 million below that estimated for 1988. When compared with the actual 1987 data reported by the stone industry, production increased 5 million short tons, while value slumped $9 million.

Production-value reports were received from 84 companies operating 130 mines in a 29-county area. The five leading counties were Dade, Broward, Hernando, Lee, and Sumter, which accounted for more than 70% of the State's crushed stone output.

Florida's stone production consisted of mined and crushed limestone (87%), oyster shell (5%), dolomite (2%), marl (.2%), and stone type unspecified (less than 6%). Limestone output, valued at $306 million, was $23 million lower than in 1987. Production was from 102 quarries, 8 fewer than in 1987. Limestone was produced by 68 companies with operations in 25 counties; the Broward-Collier-Dade-Lee contiguous county area in the southern part of the State and Hernando County in east-central Florida were the five leading counties.

The five principal end uses, in terms of tonnage for both limestone and dolomite, were for graded road base (26%), concrete aggregate (25%), fine screening (10%), concrete stone sand (9%), and crusher run fill (6%). Unspecified uses accounted for 10% of production reported by industry.

Shell was mined by nine companies operating nine quarries, two more than in 1987. Production, 3.5 million short tons, increased 120,000 short tons over the 1987 level. Value, however, fell from $10.2 million to $9.9 million, a decrease in unit value from $3.00 per ton to $2.82 per ton. Most of the production was reported from paleo-shell zones onshore in the Hillsborough-Manatee-Sarasota contiguous county area of west-central Florida. Shell recovery was also reported from the Atlantic-coast counties of Indian River and Palm Beach, and from Orange County near Orlando. The major end uses were graded road base (37%), crusher run fill (production withheld), and unpaved road surface (6%). End uses were unspecified for almost 30% of the shell produced.

Dolomite, a high-magnesium limestone, was mined by five companies operating nine quarries in Jackson, Suwannee, and Taylor Counties in Florida's panhandle and in Citrus County on the Gulf Coast in central Florida.

Production increased from 1.1 million short tons (1987) to 1.6 million short tons (1989). Despite a total value increase from $7.5 million in 1987 to $8.1 million in 1989, unit value fell from $6.63 per ton (1987) to $5.19 per ton. Principal end uses were reported with limestone.

Marl production was reported by three firms operating three quarries in Collier and Lee Counties in southwestern Flor-

TABLE 2

FLORIDA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	425	1,215
Filter stone	491	2,494
Coarse aggregate, graded:		
Concrete aggregate, coarse	18,165	100,335
Bituminous aggregate, course	4,599	21,918
Bituminous surface-treatment aggregate	202	914
Railroad ballast	419	1,579
Fine aggregate (−3/8 inch):		
Stone sand, concrete	6,736	32,844
Stone sand, bituminous mix or seal	2,232	10,316
Screening, undesignated	7,348	32,018
Coarse and fine aggregates:		
Graded road base or subbase	21,956	65,040
Unpaved road surfacing	882	2,956
Crusher run or fill or waste	4,844	10,373
Other construction materials[2]	3,974	7,623
Agricultural:		
Agricultural limestone	605	3,576
Poultry grit and mineral food	803	3,216
Other miscellaneous uses[3]	2,195	9,788
Other unspecified:[4]		
Actual	4,002	21,264
Estimated	4,120	13,929
Total[5]	83,995	341,397

[1] Includes limestone, dolomite, shell, and miscellaneous stone.
[2] Includes stone used in coarse and fine aggregates.
[3] Includes stone used in cement manufacture, sulfur oxide removal, and asphalt and other fillers or extenders.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

TABLE 3

FLORIDA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(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 aggregate (+1 1/2 inch)[1]	W	W	W	W	85	432	1,730	5,094
Coarse aggregate, graded[2]	W	W	W	W	7,211	44,269	15,252	74,381
Fine aggregate (−3/8 inch)[3]	W	W	W	W	3,435	15,879	12,613	58,024
Coarse and fine aggregates[4]	855	2,858	8,577	26,253	4,297	9,511	14,030	39,929
Other construction aggregates	479	2,407	714	5,011	193	945	2,798	4,633
Agricultural[5]	315	1,375	(6)	(6)	(6)	(6)	—	—
Chemical and metallurgical[7]	—	—	(6)	(6)	—	-	(6)	(6)
Special[8]	—	—	(6)	(6)	(6)	(6)	—	—
Other miscellaneous	—	—	436	1,438	889	4,791	1,963	8,973
Unspecified:								
Actual[9]	1,014	6,109	384	1,312	64	261	2,539	13,582
Estimated[10]	395	1,655	283	1,155	1,283	3,799	2,159	7,320
Total[11]	3,058	14,404	10,394	35,170	17,459	79,888	53,084	211,935

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[1] Includes 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), and fine aggregate (screening-undesignated).
[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[5] Includes agricultural limestone and poultry grit and mineral food.
[6] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[7] Includes crushed stone for cement manufacture and sulfur oxide removal.
[8] Includes crushed stone for asphalt fillers or extenders and other fillers or extenders.
[9] Includes production reported without a breakdown by end use.
[10] Includes estimates for nonrespondents.
[11] Data may not add to totals shown because of independent rounding.

ida and from Indian River County on the south-central Atlantic coast. The three firms produced 266,000 short tons valued at $800,000. The only end use reported was graded road base.

Approximately 5.6 million short tons of stone was unidentified as to stone type. The value of this stone category was reported at $16.6 million. Major uses included graded road base, bituminous aggregate, and concrete aggregate.

Sulfur.—Sulfur was recovered from natural gas at Exxon Corp.'s desulfurization plant in Santa Rosa County. The company produced and shipped 67,000 metric tons, a slight decrease from the reported 1988 output.

Other Industrial Minerals.—Six firms produced fluosilicic acid as a byproduct of wet-process phosphoric acid manufacture. The acid was sold for several industrial applications, including water purification.

Both byproduct and imported gypsum were recovered and/or used by several companies during 1989. Imported gypsum, calcined at three plants in Duval and Hillsborough Counties, was used in wallboard manufacture. The South Florida Gypsum Company began construction of a wallboard plant in Miami. The announced completion date was 1991. The plant would use crude gypsum imported from Spain.

Nitrogen was recovered at a Pace Junction plant by Air Products and Chemicals Inc. The nitrogen was used in an anhydrous ammonia process. Anhydrous ammonia was also produced by Jones Chemical Inc. at a facility in Fort Lauderdale. Nitric acid was produced by Nitram Inc. at a plant in Tampa.

Four firms, W. R. Grace & Co., Chemrock Inc., World Industries, Inc., and Airlite Processing Corp., expanded perlite at plants in Broward, Duval, Escambia, and Indian River Counties. Ore was purchased from mining firms in western States. Sales to the horticultural, insulation, and plaster aggregate industries comprised 31% of the 23,084-short-ton output. Other sales were to the tile, oil-water absorbent, concrete aggregate, and filter aid industries.

Vermiculite was exfoliated by W.R. Grace at a plant in Broward County and by Verlite Co. at a Hillsborough County plant. Crude vermiculite was obtained from mines in South Carolina, Virginia, and Montana. Concrete aggregate, horticulture, and insulation industries were the principal markets.

Metals

The State continued as one of the important metal-producing States in the Southeast and was the only State with a mineral sands mining industry. Nationally, Florida ranked 19th in metals output.

Iron and Steel.—Florida Steel Corp. operated minimills at Jacksonville and Tampa. The two mills were equipped with three electric furnaces with an aggregate capacity of 603,000-net-ton-per-year capacity. The mills housed one 4-strand and two 2-strand continuous casters.

Florida Steel and seven sponsors worked with Carnegie Mellon's Center for Materials Production, Pittsburgh, PA, to develop a system to determine the cost effectiveness of the CONSTEEL process for the continuous feeding, preheating, melting, and refining of steel scrap in the electric arc furnace.

Mineral Sands.—Two companies, Associated Minerals (USA) Inc. at Green Cove Springs and Du Pont at Trail Ridge, recovered mineral sands by dredging. Both companies operated dredges that produced a 2% to 4% ore, which was upgraded to approximately 80% mineral content at a wet mill located at the dredge site. The concentrate was trucked to a dry mill where the final mineral separation was made using electrostatic and magnetic separation technology.

Rare Earths.—Associated Minerals recovered a monazite concentrate at its Green Cove Springs operation in Clay County. The operation also recovered titanium and zirconium concentrates. The monazite concentrate was processed in La Rochelle, France, by Rhone-Poulence. A portion of the rare earths extracted at the French operation was imported by a Texas operation.

Titanium Concentrates.—Rutile, ilmenite, and leucoxene, titanium minerals of various compositions, were recovered as concentrates by Associated Minerals and Du Pont. Associated Minerals recovered three separate concentrates. A rutile concentrate was sold to Kemira Oy's titanium dioxide plant in Savannah, GA. An ilmenite concentrate was sold to Du Pont's titanium dioxide pigment plants in Tennessee and Delaware. A leucoxene concentrate was sold to Kerr McGee's synthetic rutile plant in Mobile, AL.

The Du Pont dry mill produced a concentrate containing all three minerals that was used by the company's titanium dioxide pigment plants in Tennessee and Delaware. Du Pont ordered a new dredge for the deposit near Maxville. Delivery was scheduled for late 1991, and mining for 1992.

Zirconia Concentrates.—Both Associated Minerals and Du Pont recovered a zircon concentrate. Associated Minerals' concentrate was sold to grinding plants in South Carolina and New York. The grinding facilities marketed the milled zircon to the ceramic, refractory, and foundry industries. Four grades of zirconium concentrate recovered at the Du Pont plant were sold to the ceramics and foundry industries.

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[1] State Mineral Officer, U.S. Bureau of Mines, Tuscaloosa, AL. He has 29 years of 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] Sarasota Herald-Tribune. DER Tries to Contain Gypsum Contamination. June 15, 1990.

[4] Chemical Engineering. Integration is the Key to Mega Phosphoric Acid Plant. May 1990, p. 25.

[5] Sarasota Herald-Tribune. Sulfuric Acid Plant on Hold. Jan. 3, 1990.

[6] Engineering News Record. McGraw Hill. Jan. 18, 1990, p. 38.

[7] Mining Engineering. U.S. Phosphate Producers Are Beginning Their Comeback. July 1990.

TABLE 4

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.	Box 187 Berkeley Springs, WV 25411	do.	Gadsden.
Mid-Florida Mining Co.	Box 68-F Lowell, FL 32663	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.
Lime:			
Dixie Lime & Stone Co.[2]	Drawer 217 Sumterville, FL 33585	do.	Sumter.
Peat:			
Hyponex Corp.	14111 Scottslawn Rd. Marysville, OH 43041	do.	Lake.
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	do.	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.
CF Industries Inc.	Box 1549 Wauchula, FL 33873	do.	Hardee.
Estech Inc.	Box 208 Bartow, FL 33830	do.	Polk.
Gardinier Inc.	8813 Hwy. 415 Riverview, FL 33524	do.	Do.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Phosphate rock—Continued			
IMC Fertilizer Inc.	Box 867 Bartow, FL 33830	Mine(s) and plant complex	Polk.
Mobil Mining and Minerals Co.	Box 311 Nichols, FL 33863	do.	Do.
Occidental Chemical Agricultural Products Inc.	White Springs, FL 32096	do.	Hamilton.
Seminole Fertilizer Corp.	Box 471 Bartow, FL 33830	do.	Polk.
USS Agri-Chemicals Inc.	Box 867 Fort Meade, FL 33841	do.	Do.
Sand and gravel:			
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.
Staurolite:			
Associated Minerals (USA) Ltd. Inc.[4]	Green Cove Springs, FL 32043	Mine and plant	Clay.
E. I. du Pont de Nemours & Co. Inc.[4]	Du Pont Bldg. D-10084 Wilmington, DE 19898	Mines and plants	Do.
Stone:			
Florida Rock Industries Inc.	Box 4667 Jacksonville, FL 32201	Quarries and plant	Alachua, Collier, Hernando, Lee, Levy, St. Lucie, Taylor.
Rinker Southeastern Materials Inc.	Box 5230 Hialeah, FL 33014	do.	Dade.
Tarmac Florida Inc.	Box 8648 Deerfield Beach, FL 33441	Quarry and plant	Do.
Vecellio & Grogan Inc.	Box 15065 West Palm Beach, FL 33416	do.	Do.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	Quarries and plant	Broward and Dade.

[1] Also construction and industrial sand and gravel.
[2] Also crushed stone.
[3] Also exfoliated vermiculite.
[4] Also titanium concentrates.

THE MINERAL INDUSTRY OF GEORGIA

This chapter has been prepared under a Memorandum of Understanding between the 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]

The value of mineral commodities produced in Georgia in 1989 increased only 1.0% over that of 1988, but still attained an alltime high of $1.4 billion. The State's leading commodity, clay, increased 10.6% in value, although the volume of clay produced decreased 4.9% to 9.8 million metric tons. The increase in value was attributable largely to kaolin, which increased 9.7% to $944.9 million and accounted for 68.1% of the total value of minerals produced in Georgia. Fuller's earth also showed significant increases, both in value and volume produced. The decrease in clay volume resulted entirely from a 29% decrease in common clay. The value of common clay decreased only 14.8%.

Georgia, the Nation's leading clay producer, ranked first in both the value and volume of kaolin and fuller's earth. It also led the Nation in the value and volume of synthetic mullite and in the value of barite and iron oxide pigments produced. Overall, Georgia ranked third, behind California and Florida, in the value of industrial minerals produced and eighth in the value of all minerals produced.

TRENDS AND DEVELOPMENTS

The year 1989 marked the seventh consecutive year that Georgia's mineral production increased, the past 6 years setting record highs. However, the increase represented the smallest percentage gain in the past 7 years. This follows a trend typical of most of the southeastern States during the decade of the eighties. The decade started with an upward trend carrying over from the 1970's. However, the nationwide recession that began in 1981 caused a decline in the value of minerals produced in Georgia in 1982. Recovery from the recession in 1983 marked the beginning of an upward spiral that continued through 1989.

The 1989 increase may be attributed, at least in part, to record exports by the U.S. paper industry that totaled more than 18.5 million tons in 1989. This helped to increase kaolin sales and offset losses in sales to the paint and plastic markets caused by a general weakening of the national economy.

The most significant developments in Georgia during the year were related mainly to company buyouts and plant expansions. A Chicago banking concern, First Chicago Corp., purchased Georgia Marble Co. from Kohlberg, Kravis, Roberts and Co. (KKR) for

TABLE 1

NONFUEL MINERAL PRODUCTION IN GEORGIA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	9,484,392	$756,093	10,274,358	$908,771	9,768,312	$1,004,954
Gem stones		NA	20	NA	20	NA	21
Sand and gravel:							
Construction	thousand short tons	e9,000	e26,900	9,526	30,185	e6,100	e18,900
Industrial	do.	W	W	W	W	537	7,013
Stone:							
Crushed	thousand short tons	60,834	318,903	e57,400	e317,200	50,417	262,805
Dimension	short tons	179,207	21,683	e190,472	e27,768	2145,545	212,087
Talc and pyrophyllite	do.	20,100	286	26,000	260	W	W
Combined value of barite, bauxite, cement, feldspar, iron oxide pigments (crude), mica (scrap), peat, stone (dimension marble, 1989), and values indicated by symbol W		XX	88,485	XX	89,621	XX	81,515
Total		XX	1,212,370	XX	1,373,825	XX	1,387,295

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

more than $325 million in a leveraged buyout. Previously, First Chicago was involved in KKR's acquisition of Georgia Marble's parent company, the Jim Walter Co., which is now Hillsborough Holdings Corp. (HHC). Proceeds from the Georgia Marble sales were expected to pay HHC's debt from the buyout. Later in the year, First Chicago sold the aggregate division, Georgia Marble Aggregates Corp. (GMA), to Blue Circle Holdings Inc., the U.S. subsidiary of Blue Circle Industries PLC (BCI) of the United Kingdom. The purchase price was $148.5 million. GMA had eight quarries, seven within 50 miles of Atlanta, and proven reserves listed[3] at more than 700 million tons. The acquisition was BCI's first major move into the construction aggregate business in the United States. When added to its existing asphalt, cement, and ready-mix concrete interests, it gives them a fully integrated business in the Atlanta area.

Combustion Engineering Inc., the parent company of Georgia Kaolin Corp. Inc. and the Mullite Corp. of America, was purchased by Asea, Brown, Boveri (ABB), a Swiss company reputed to be the world's largest heavy-engineering group. At yearend, both Georgia companies were reported to be for sale.

Georgia Kaolin Corp. expanded into the precipitated calcium carbonate (PCC) market by purchasing the assets and technology for PCC production from Continental Lime Ltd., parent of Continental Lime Inc. A new division, GK Carbonates, was formed to operate the new business.

Hecla Mining Co. purchased all of the kaolin assets of Cyprus Industrial Minerals Co. (CIM) in Georgia and South Carolina. The sale, which was announced in 1988, was delayed by an antitrust investigation by the Federal Trade Commission (FTC). The FTC disallowed inclusion of CIM's ball clay operations in Tennessee and Mississippi in the sale. The kaolin operations, to be managed by Hecla's subsidiary, Kentucky-Tennessee Clay Co., enabled it to offer consumers ceramic grades of kaolin, complementing its ball clay products.

New Riverside Ochre Co. (NRO), Cartersville, purchased Baroid Corp.'s, formerly NL Baroid, barite properties and reserves in the Sweetwater, TN, area. Jigged ore mined from the properties was to be processed at NRO's facilities in Cartersville.

Evans Clay Co. purchased the air-float kaolin business of J.M. Huber Corp.'s kaolin division. The purchase included approximately 1 million tons of crude clay reserves and the rights to the trade names and production of four of Huber's air-float kaolin products. No employees or plant equipment were involved in the transaction. Huber indicated that it will continue to produce its other lines of air-float kaolin products at its Langley, SC, operation and its water-washed kaolin products at its Huber and Wrens, GA, facilities.

Huber was also a leader in plant expansion, installing a second high-gradient magnetic separator (HGMS) which was claimed to be the world's largest superconducting magnetic separator, at its Huber, GA, plant. The first HGMS, installed at its Wrens' operation, was the first commercial superconducting magnetic separator. A third HGMS unit was scheduled for installation in 1990. The HGMS units were part of a $100 million expansion, most of which was completed in 1989.

Evans Clay also completed a major expansion in 1989 that more than doubled its storage capacity. Installation of additional loading, packaging, and mining equipment was expected to increase its production from 240,000 tons per year to more than 300,000 tons per year during the first half of 1990.

Wilkinson Kaolin Associates Ltd. completed expansion of its Gordon, GA, air-float operation early in the year. The expansion was scheduled to triple production capacity to more than 250,000 tons per year.

Englehard Minerals and Chemicals Corp. announced an initial investment of $2.5 million to improve its attapulgite operations near Attapulgus, GA. Improvements scheduled to be completed during the first quarter of 1990 included initiation of a statistical process control program, addition of packaging and mining equipment, and centralization of warehouse facilities. These represent the first of a series of improvements designed to increase reliability and efficiency.

EMPLOYMENT

Georgia's mining employment decreased from 8,900 in 1988 to 8,700 in 1989 according to the Bureau of Labor Statistics, U.S. Department of Labor. This contrasted to a 2.3% increase in nonagricultural employment within the State during the same period.

REGULATORY ISSUES

Opposition to proposed mining operations led to several precedents being set that affect mining activity. One resulted from submission of an air dispersion computer model to predict emission from quarry activity by opponents of a proposed crushed stone quarry in White County. The model indicated that dust emissions from the quarry would not be in compliance with Georgia Environmental Protection Division (EPD) standards. The EPD, which had fought the use of computer modeling as a condition for issuance of air quality permits, delayed issuance of the permit to give the applicant time to modify its emission controls and submit a model showing it to be in compliance. The applicant submitted a model indicating that alterations to the original plan of operation would bring the quarry into compliance with State standards. The opposition group countered by soliciting a letter from a U.S. Environmental Protection Agency (EPA) official to the effect that EPD guidelines for preparation of the applicant's model were less stringent than the EPA's and that the new model would not meet EPA standards. As the year ended, differences between the EPD and EPA had not been resolved and the permit had not been issued. The EPD, however, did indicate that in the future it would require computer modeling for new quarry sites and for significant alterations within a plant. Mining industry officials contended[4] that both models grossly exaggerate emissions from quarry operations, perhaps overestimating actual emmissions by as much as 4 to 10 times.

The EPD also began a program to identify and plug farm drainage wells that have the potential to pollute the underground water supply in southern Georgian and adjacent Florida. The wells were drilled in the early 1900's to drain water from swamps into limestone cavities 100 to 300 feet below the surface. These cavities are an integral part of the Florida aquifer, which supplies drinking

water for much of the area. Field runoff, potentially containing herbicides, pesticides, and fertilizer, is delivered directly to the aquifer via the drainage wells. In limited testing, no contamination had been discovered in Georgia; however, the EPD initiated the program to identify and plug the wells because of the potential for pollution.

In a legal decision, Georgia's minerals lapse statute was upheld in Federal court. The law gave mineral rights to the surface owner if the minerals rights owner does not work the property during a 7-year period. The court decision clarified how the 7-year time-lapse period should be determined.

EXPLORATION ACTIVITIES

Most of the mineral exploration done in the State was conducted by the Georgia Geologic Survey (GGS). Commercially, some of the companies exploring for heavy minerals in ancient beach sands occurring along the Fall Line and in the Coastal Plain extended the search into Georgia from the center of activity in southern Virginia and northern North Carolina. A limited amount of exploration for gold and other metals was carried out in the Piedmont and Blue Ridge Provinces. No announcements of potential discoveries of either heavy metals or minerals were made.

Exploration by the GGS was conducted under the Accelerated Economic Minerals Program (AEMP), which successfully identified several areas favorable for mining exploration. The Construction Materials Project identified 21 areas with high to moderate potential for production of construction aggregate on the Coastal Plain. The Pegmatite Project identified two areas with high to moderate potential for development as a resource for strategic materials, fillers, and rare-earth minerals. The Heavy Minerals Project identified two areas of potential interest to industry for further exploration. The Sulfides Project also identified areas with high concentrations of silver.

With a grant from the Minerals Management Service (MMS), the Survey continued studying the phosphate and heavy-mineral resources of coastal Georgia, including the Continental Shelf. Offshore drilling of potential phosphate deposits near Tybee Island was scheduled for 1990.

LEGISLATION AND GOVERNMENT PROGRAMS

The only law passed by the Georgia legislature affecting the mining industry in 1989 was a bill mandating counties to implement land use management programs and State Erosion and Sedimentation Act amendments. This law implementing land use management was expected to require any mining company applying for surface mining, water, and air discharge permits to first get approval from the local land use planning authority before any applications would be considered. The effects of such legislation were dramatized by a large increase in local challenges to requests to open or enlarge quarries and surface mines. Especially affected was the construction aggregate industry, which applied for a greater-than-normal number of permits in north-central Georgia. This was the result of the Department of Transportation announcement of plans to construct a second perimeter highway system around Atlanta and speculation that a second major airport would be built in the outlying Atlanta area. The outer perimeter highway would be approximately 40 miles outside the existing perimeter, I-270.

At least 13 applications for land use permits to allow mining filed by 9 companies in 10 counties were strongly contested by local residents and environmentalists. Five applications were approved, three were denied, and the rest were pending as the year ended. Eight lawsuits were filed in attempts to override decisions or force decisions favorable to the plaintiffs. One existing operation was forced to close by county authorities.

Amendments to the Erosion and Sedimentation Act affected the mining industry by imposing more stringent performance criteria for control measures. Small mining operations could be affected by a reduction in the number of land use activities exempted from regulation and a reduction in the size of operations requiring regulation from 5 acres to 1.1 acres.

The GGS conducted investigations of the economic and framework geology of the State. Emphasis was on economic geology, with the Accelerated Economic Minerals Program being the centerpiece. Most of the studies conducted are discussed in the Exploration section of this chapter. The Survey published 22 reports on technical investigations of Georgia's geology and mineral and water resources during the year. Organization and updating of the Survey's repository of geological core and cuttings continued. Additions to the repository were donated by the Bureau of Mines, as well as other private and government organizations.

The Bureau of Mines participated in the MMS and GGS study of phosphate and heavy-mineral resources of coastal Georgia discussed in the Exploration section. The Salt Lake City Research Center was to evaluate samples from drilling scheduled for 1990. The Bureau also provided funding for the Minerals Research Institute (MRI), which granted the Georgia Institute of Technology $138,000 for the 1989 fiscal year. Since 1978, Georgia Tech has received $1,780,906 in funding from MRI. The monies were used to encourage the training of mining engineers and other scientists involved in mineral-related studies and to continue research in mineral exploration, mining, processing, utilization, and conservation.

The EPD established new environmental protection goals during 1989 under a 5-year strategy plan. Major goals included eliminating toxic chemicals in the environment, controlling nonpoint water pollution, and meeting air quality standards in metropolitan Atlanta. The EPD distributed $7.5 million under the Environmental Facilities Grants program during the year to help 130 communities build or improve environmental facilities. During the year, the EPD regulated 142 permitted mining operations, 83 of which were active stone quarries.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Fifteen industrial minerals were mined in Georgia in 1989. Eight additional in-

dustrial mineral commodities were produced from raw materials mined within the State, shipped from other States, or imported. These 23 commodities accounted for all of the value of minerals produced because no metal production was reported for Georgia in 1989.

Barite.—Georgia continued to lead the Nation in the value of barite produced, although it lagged far behind Nevada in volume. All of the barite was produced by two companies in the Cartersville area. Cyprus Industrial Minerals, Barite Div., produced a flotation product primarily for extenders and fillers in the paint, plastic, and rubber markets. New Riverside Ochre Co. (NRO) produced both flotation and jigged barite, primarily for internal consumption, at the barite chemical manufacturing plant of its sister company, Chemical Products Corp. (CPC), also in Cartersville.

NRO moved its barite mining operation to Emerson, approximately 5 miles south of its previous operation. A four-log washer and jigging plant purchased from a defunct barite mining operation in Missouri was rebuilt and modified to meet NRO's needs. Water for the operation is pumped approximately 1 mile from the Etowah River. A 5-mile pipeline carries tailings from the plant to an existing tailings pond near Cartersville. Jigged ore is hauled by truck to NRO's flotation plant at Cartersville for additional processing before being trucked to CPC's chemical plant. NRO is also processing barite ore at the Cartersville facilities from properties purchased from Baroid Corp. near Sweetwater, TN.

NRO discontinued barite mining operations at its mining site in Cartersville. Much of the mined area has been reclaimed and is the site of a new shopping center and several other businesses. This reclamation won the annual award given by the Georgia Mining Association for the best reclamation effort in the State. It marked the only time the award has been won by a company that did not mine kaolin.

Bauxite.—In the Coastal Plain Province of Georgia, bauxite occurs as lenses within flat-lying beds of kaolinic clay of Eocene age. Commercial clays, consisting of bauxite, bauxitic kaolin, and kaolin, occurred in a northwest-southeast trending belt approximately 14 miles long and 7 to 8 miles wide across portions of Macon, Schley, and Sumter Counties. The bauxitic kaolin occurred as halos enveloping the bauxite lenses. The ore zone, which is overlain by sands and clays of early Tertiary age, is generally 20 to 30 feet thick. Overburden averages 40 feet, but may exceed 100 feet locally. Mining operators strive for a maximum stripping ratio of 3.5 cubic yards overburden to 1 ton of clay.

The ore was mined by two companies, American Cyanamid Co. and Mullite Corp. of America (Mulcoa). The ore consisted predominantly of kaolin and bauxitic kaolin, with bauxite comprising less than 5% of the total; therefore, operations of these companies are discussed in the kaolin subsection.

Clays.—Georgia broke the $1 billion barrier in clay sales and once again led the Nation in both volume and value. The $1 billion in total clay sales represented 66.3% of all the clay sold in the United States. Clay production, listed in descending order of value, consisted of kaolin, fuller's earth, and common clay. A total of 32 companies reported clay production from 46 operations and 78 pits in 19 of Georgia's 100 counties. Georgia's EPD had issued mining permits to 38 companies for 161 pits in 26 counties.

Common Clay and/or Shale.—Although the value of all clays produced in Georgia rose to an alltime high, the value of common clays produced decreased by $1.2 million; production decreased from 2.3 to 1.6 million metric tons. As a result of the decreases, Georgia's national ranking dropped from fourth to sixth in both volume and value.

Common clay was reported by 9 companies from 13 operations and 14 pits in 8 counties. The leading producers in terms of volume were Cherokee Brick and Tile Co., Boral Bricks Inc., Blue Circle Inc., General Shale Products Corp., and Bickerstaff Clay Products Co. Each of the preceeding produced more than 200,000 metric tons of common clay in 1989.

Fuller's Earth.—Clays included in the fuller's earth category included attapulgite mined by Englehard Corp. and Milwhite Co. Inc. in Decatur County and by Oil Dri Corp. of America and Waverly Minerals Products Co. in Thomas County. Also included are clays classified as montmorillonite mined by Medusa Cement Co. in Houston County and the Georgia Tennessee Mining and Chemical Co. in Jefferson County.

The volume of fuller's earth produced increased from 583,356 metric tons in 1988 to 667,244 metric tons in 1989, while the value increased from $39.4 million to $53.2 million. Georgia produced 35.5% of the volume and 32.1% of the value of all the fuller's earth produced in the United States during the year.

Principal uses of fuller's earth included pet waste absorbents, oil and grease absorbents, and pesticide carriers, all of which accounted for more than 80% of the volume produced. Other uses included fertilizers; drilling mud; cement; paint; filtering, clarifying, and decolorizing agents; and as a catalyst in oil refining.

Kaolin.—Kaolin production in Georgia increased only slightly from that of 1988, 7.43 million metric tons to 7.49 million metric tons; however, the value increased from $861 million to $945

TABLE 2

GEORGIA: FULLER'S EARTH SOLD OR USED BY PRODUCERS, BY KIND

(Thousand metric tons and thousand dollars)

Kind	1987		1988		1989	
	Quantity	Value	Quantity	Value	Quantity	Value
Attapulgite	337	22,770	393	26,931	472	40,191
Montmorillonite	199	12,433	190	12,472	195	13,057
Total	536	35,203	583	39,403	667	53,248

million. The increase in value resulted from major plant expansions, designed to shift sales emphasis from high-volume low-value products to lower volume high-value products, that were completed by many of the kaolin producers. Increased sales of high-value filler-grade kaolin to paper producers also contributed to the increased value.

Industrial kaolin production was reported by 15 companies operating 52 pits in 7 counties during 1989. Unprocessed kaolin was reported by six companies from seven pits in six counties.

Bauxitic kaolin is mined by two companies, American Cyanmide Co. and Mulcoa, in the Andersonville area in Sumter County. American Cyanamid Co. mined from one pit and processed the ore at a plant approximately 5 miles north of Andersonville. All of the ore was used to produce chemical-grade alum. About 70% of the production was sold to the paper industry where it was used in sizing operations. Conversion from acid to alkaline sizing by paper companies reduced the demand for alum. The remaining 30% of the alum production was used in water purification systems where it acts as a deflocculant.

Mulcoa mined from several locations and operated two plants south of Andersonville. Ore mined from properties near Eufaula, AL, was also hauled to Andersonville for processing. The ore is sintered to produce three grades of synthetic mullite: Mulcoa 47 containing 47% alumina produced from the kaolin component of the ore, Mulcoa 60 containing 60% alumina produced from the bauxitic kaolin, and Mulcoa 70 containing 70% alumina produced from the bauxite lenses. The two plants had a total capacity of 600,000 short tons per year. Mulcoa has experienced steady growth since the recession of the early eighties, with all seven of its kilns in operation during the year in contrast to only one kiln operating in 1981 and five kilns operating in 1985. The mullite was used as investment castings and moldings and sold to the refractories industry for use as raw material to make refractory bricks. Approximately one-half of the production was exported through the Port of Savannah.

Tables 3 and 4 summarize the kinds of kaolin and the principal uses of kaolin sold or produced in Georgia.

TABLE 3

GEORGIA: KAOLIN SOLD OR USED BY PRODUCERS, BY COUNTY

Country	1988			1989		
	No. of mines	Quantity (thousand metric tons)	Value (thousands)	No. of mines	Quantity (thousand metric tons)	Value (thousands)
Jefferson	1	W	W	1	W	W
Richmond[1]	3	399	$2,102	3	407	$23,071
Twiggs	6	1,465	173,279	6	1,865	263,104
Washington	5	2,536	265,091	5	2,494	292,285
Wilkinson	5	1,028	145,081	5	965	176,656
Other[2]	8	1,999	275,785	6	1,263	115,634
Total[3]	28	7,428	861,338	26	6,994	870,750

W Withheld to avoid disclosing company proprietary data; included in "Other."
[1] Includes Jefferson County.
[2] Includes Columbia, Houston, Sumter, and Warren Counties and data indicated by symbol W.
[3] Data may not add to totals shown because of independent rounding.

Georgia's four leading kaolin companies, Englehard Corp., Georgia Kaolin Corp. Inc., Anglo American Clays Subsidiary of ECC America Inc., and J.M. Huber Corp., accounted for 56.6% of the volume and 77.6% of the value of kaolin produced in 1989. This was down from 63.1% in volume and up from 70.3% in value in 1988. This dramatically illustrates the trend for larger companies to increase their share of the higher value, low-volume end products, leaving the smaller companies to supply the market for lower value, high-volume products.

Several companies announced that major plant expansions were started or continued during the year. J.M. Huber Corp. completed the following projects as part of its $100 million expansion. At its Wrens plant, a facility to chemically restructure kaolin to produce a kaolin-base structured pigment for the paper industry was completed. Other improvements at the Wrens plant included installation of a new spray dryer, a new pumping system, automation control equipment, and expansion of filtering capacity. At its Huber plant, Huber installed the HGMS system discussed under Trends and Developments. The new system reportedly[5] exceeded expectation in terms of both production capacity and ease of operation. Although its capacity is twice that of the first HGMS installed at Huber's Wrens plant in 1986, its cost was only slightly higher. Energy costs were also only slightly higher because electrical power is needed only briefly at the start of each batch cycle. Liquid helium in a closed-loop system cools the niobium-titanium coils of the magnet to -269° C. At this temperature, the conductors have no resistance to electrical current and consequently require no power to generate the magnetic field. When it is shut down, the magnet returns about one-half the power it used during start-up. When started, the magnet can attain full power of 20,000 gauss in 60 seconds. This produced an additional cost savings by reducing the time needed between process batches.

Anglo American Clays completed construction of its research laboratory building, the final phase of the company's largest expansion program.

Englehard Corp. also completed a facility to produce a new kaolin-based pigment structured to improve the printability and optical properties of lightweight coated paper.

A new warehouse installed at Evans Clay Co.'s McIntyre plant expanded storage space from 8,000 to 17,000 square feet and doubled storage capacity to 1,000 tons of unitized kaolin. The new facility has five truck-loading stations and automatic filling machinery for oversized bags ranging from 500 pounds to 1 ton capacity.

Wilkinson Kaolin Associates Ltd. completed an expansion program that tripled its production capacity. Included in the improvements were installation of state-of-the-art air-float grinding equipment, a new warehouse, enhanced crude ore storage facilities, and new concrete-finished product silos.

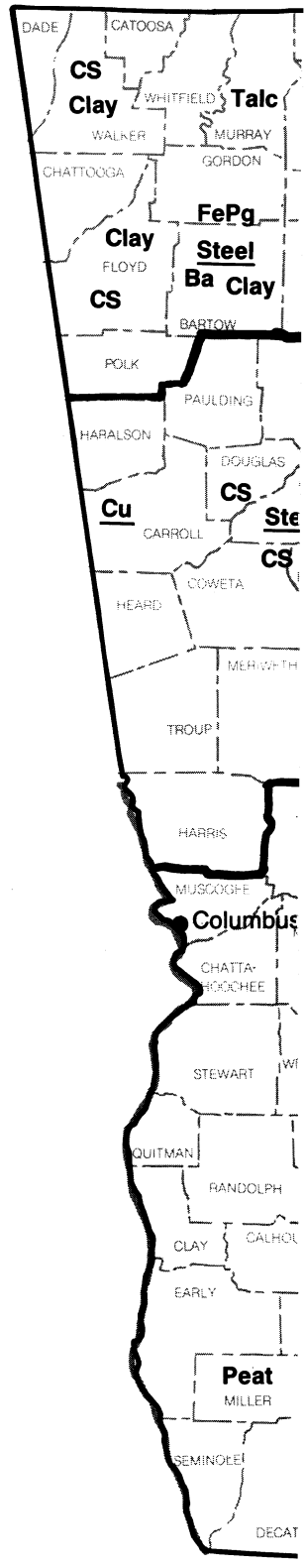
GEORGIA

LEGEND

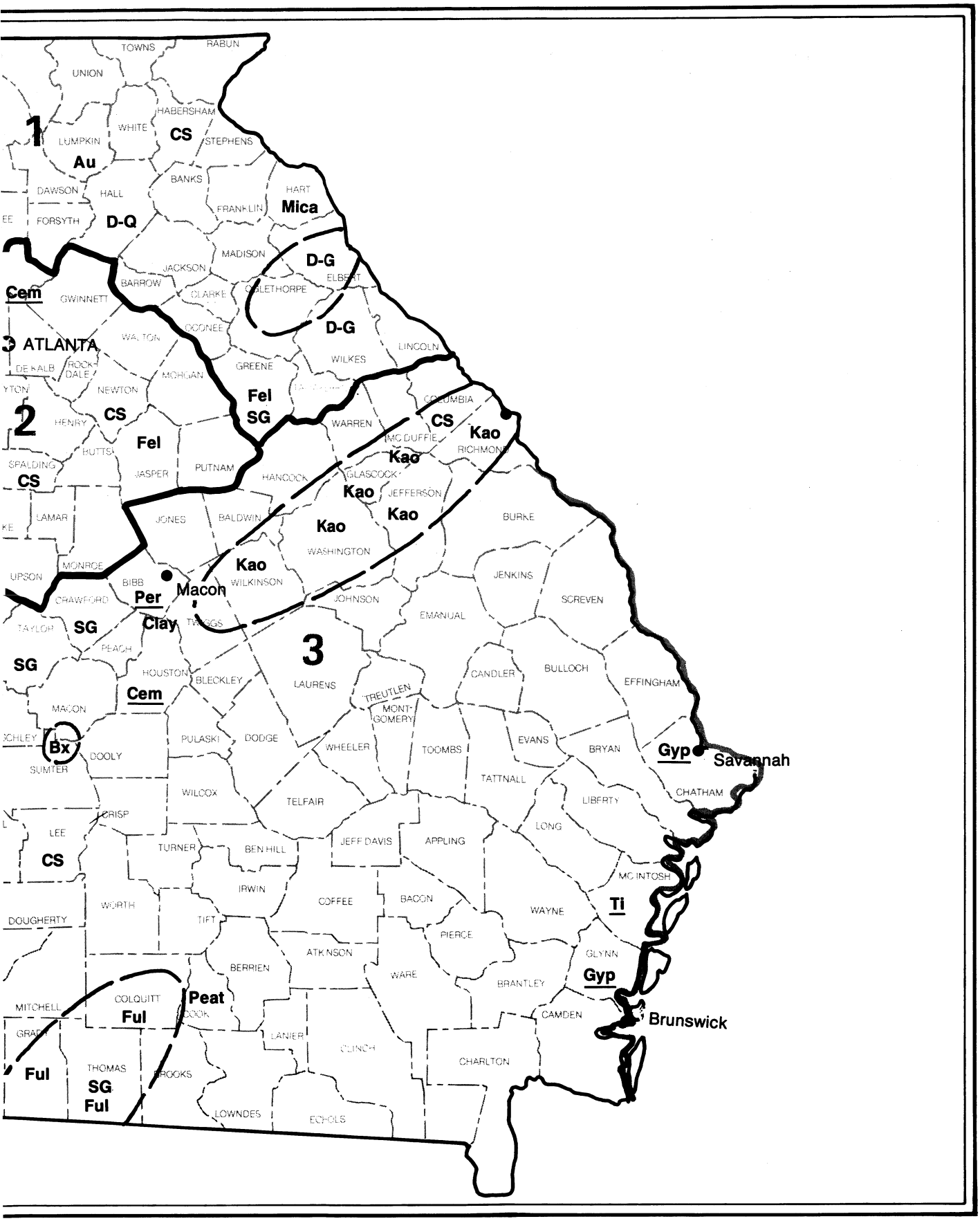
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

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
Ti	Titanium plant
	Concentration of mineral operations



Principal Mineral-Producing Localities


TOWNS
RABUN
UNION
HABERSHAM
WHITE
CS
STEPHENS
1
LUMPKIN
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BANKS
DAWSON
HALL
HART
FRANKLIN
Mica
FORSYTH
D-Q
MADISON
D-G
JACKSON
BARROW
ELBERT
Cem
GWINNETT
CLARKE
OGLETHORPE
D-G
OCONEE
ATLANTA
WALTON
LINCOLN
DE KALB
ROCK DALE
GREENE
WILKES
MORGAN
NEWTON
Fel
SG
COLUMBIA
2
HENRY
CS
WARREN
CS
Kao
Fel
MC DUFFIE
RICHMOND
Kao
BUTTS
SPALDING
PUTNAM
JASPER
HANCOCK
GLASCOCK
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Kao
JEFFERSON
LAMAR
JONES
BALDWIN
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Kao
BURKE
WASHINGTON
MONROE
Kao
UPSON
BIBB
Macon
WILKINSON
JENKINS
CRAWFORD
Per
JOHNSON
SCREVEN
Clay
EMANUAL
TAYLOR
SG
TWIGGS
3
PEACH
SG
HOUSTON
BLECKLEY
LAURENS
CANDLER
BULLOCH
EFFINGHAM
Cem
TREUTLEN
MONT-GOMERY
MACON
Bx
PULASKI
DODGE
WHEELER
TOOMBS
EVANS
BRYAN
Gyp
Savannah
DOOLY
SUMTER
TATTNALL
WILCOX
TELFAIR
CHATHAM
LIBERTY
CRISP
LEE
LONG
CS
TURNER
BEN HILL
JEFF DAVIS
APPLING
MC INTOSH
IRWIN
COFFEE
BACON
Ti
WORTH
WAYNE
DOUGHERTY
TIFT
PIERCE
ATKINSON
GLYNN
BERRIEN
WARE
Gyp
BRANTLEY
MITCHELL
COLQUITT
Peat
COOK
CAMDEN
Brunswick
Ful
LANIER
CLINCH
GRADY
CHARLTON
Ful
THOMAS
BROOKS
SG
Ful
LOWNDES
ECHOLS

TABLE 4

GEORGIA: KAOLIN SOLD OR USED BY PRODUCERS, BY USE

(Metric tons)

Use	1988				1989			
	Air-float	Unprocessed[1]	Water-washed[2]	Total[3]	Air-float	Unprocessed[1]	Water-washed[2]	Total[3]
Domestic:								
Adhesives	13,552	—	26,346	39,898	9,220	—	17,139	26,359
Aluminum sulfate and other chemicals	4,536	136,078	—	140,614	6,560	167,104	—	173,664
Asphalt tile and linoleum	28,503	—	58	28,561	3,425	—	—	3,425
Catalysts (oil-refining)	17,121	—	49,670	66,791	11,858	—	40,670	52,528
Face brick	—	12,710	—	12,710	—	—	—	—
Fiberglass and mineral wool	227,219	—	56,408	283,627	249,899	—	43,124	293,023
Fine china and dinnerware; crockery and earthenware	42,300	—	143	42,444	22,462	—	—	22,462
Firebrick, blocks and shapes	27,216	4,754	85	32,054	27,267	4,536	—	31,803
Grogs and calcines, refractory	36,518	387,368	479	424,365	36,495	390,027	424	426,946
Medical, pharmaceutical, cosmetic	—	—	1,181	1,181	369	—	420	789
Paint	20,559	—	236,457	257,015	18,757	—	199,649	218,406
Paper coating	—	—	2,483,325	2,483,325	—	—	2,568,846	2,568,846
Paper filling	202,895	—	1,253,892	1,456,787	229,758	—	1,312,644	1,542,402
Plastics	370	—	47,133	47,503	370	—	40,177	40,547
Pottery	25,217	—	1,190	26,407	26,324	—	—	26,324
Refractories[4]	12,697	6,350	5,254	24,302	12,707	6,350	5,741	24,798
Roofing granules	9,706	—	—	9,706	10,143	—	—	10,143
Rubber	31,943	—	16,464	48,406	77,630	—	19,556	97,186
Sanitary ware	22,348	—	—	22,348	33,018	—	—	33,018
Miscellaneous, air-float:								
Common brick, fertilizers, gypsum products, pesticides and related products, roofing and structural tile, other uses not specified	194,572	—	—	194,572	172,726	—	—	172,726
Miscellaneous, unprocessed:								
Fertilizers, pesticides and related products, other uses not specified	—	39,426	—	39,426	—	37,624	—	37,624
Miscellaneous, water-washed:								
Gypsum products, ink, pesticides and related products,waterproofing and sealing, fertilizers, other uses not specified	—	—	189,779	189,779	—	—	147,516	147,516
Total[3]	917,270	586,686	4,367,865	5,871,821	948,988	605,641	4,395,906	5,950,535
Exports:								
Paint	—	—	31,293	31,293	—	—	27,115	27,115
Paper coating	22,696	—	1,073,315	1,096,011	20,650	—	1,074,973	1,095,623
Paper filling	28,268	—	267,065	295,333	32,479	—	262,155	294,634
Refractories	—	29,937	—	29,937	—	32,540	—	32,540
Rubber	9,072	—	22,221	31,293	—	—	17,451	17,451
Undistributed	22,700	—	49,251	71,951	21,629	—	54,995	76,624
Total[3]	82,735	29,937	1,443,146	1,555,819	74,758	32,540	1,436,689	1,543,987
Grand total[3]	1,000,005	616,623	5,811,012	7,427,640	1,023,746	638,181	5,832,595	7,494,522

[1] Includes high-temperature calcined.
[2] Includes low-temperature calcined and delaminated.
[3] Data may not add to totals shown because of independent rounding.
[4] Includes electrical porcelain; floor and wall tile, ceramic; flue linings; glazes, glass, and enamels; high-alumina brick and specialties; kiln furniture; refractory mortar and cement.

Feldspar.—The Feldspar Corp., a subsidiary of Zemex Corp., operated Georgia's only feldspar mines near Shady Dale in Jasper County and near Siloam in Greene County. Ore from the two mines is blended and processed at its processing facility near Monticello, Jasper County. The plant increased grinding capacity to 50,000 short tons per year,[6] anticipating additional demand from the ceramic industry. However, production of potash feldspar for the glass and ceramic industries remained virtually unchanged from that of 1988.

Iron Oxide Pigments.—Georgia continued to lead the Nation in the value of iron oxide pigments produced, although it ranked third of seven States in volume mined. The State's only producer, New Riverside Ochre, introduced a new more finely ground ochre pigment, NRO Nirox 600, designed to compete with Spanish imports and synthetic pigments. New Riverside claimed the new product was more consistent than most natural pigments being marketed and, because of its excellent tinting strength, was more economical to use than synthetically produced pigments.

Mica.—Franklin Mineral Products Div. of the Mearl Corp. produced flake muscovite from micaceous granite saprolite. It had a mine and wet-grinding plant one-half 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 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 estimates for 1987 and 1989.

Based on estimated construction sand and gravel production, both the volume and the value decreased significantly from that of 1988. The decrease was thought to have resulted from a combination of a general slowdown in the area's economy coupled with failure of the State legislature to pass a fuel tax increase to finance an accelerated highway improvement program. If the legislature had passed such a tax, industry officials felt[7] its effects would have begun to be experienced during the last quarter of the year.

Industrial.—Production decreased from that of 1988, although two of the three companies producing industrial sand and gravel reported higher sales. 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 Quaternary alluvial sand 1 mile west of Mount Vernon, Montgomery County. The company, under the name Montgomery Sand Co., also produced construction sand at the same location. Approximately 6% of its total production was industrial sand.

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 configurations. The fusion of silica at temperatures above 1723° C converts the crystalline silica into an amorphous glass that possesses entirely different properties. High purity, high resistance to thermal shock, and low thermal conductivity are among the most desirable. The high purity promotes the material's use as an inert filler and extender in resins used in the electronics industry. Resistance to thermal shock makes the material suitable for use in furnaces where extremes in temperature are experienced, and low thermal conductivity allows it to be used as a heat insulator in the form of tiles and bricks.

PPG Industries' completion of its eighth flat glass plant at Perry late in the year was expected to have a positive effect on industrial sand production in Georgia beginning in 1990.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Georgia stone statistics are compiled by geographical districts as depicted in the State map. Table 6 presents end-use statistics for Georgia's three districts.

Crushed.—Crushed stone was the second most valuable mineral commodity produced in Georgia. Its value of $262.8 million accounted for almost 19% of the total value of all minerals mined. Twenty-one companies operated 77 quarries in 47 of Georgia's 100 counties.

Although the number of quarries increased from 69 in 1987 to 77 in 1989, both the quantity and total value decreased significantly while the unit price remained almost constant. Forty-three quarries produced granite and accounted for 64.6% of the volume and 64.3% of the value of crushed stone produced. Sixteen quarries produced limestone; 15 produced marble and quartzite; marl and slate were each produced from 1 quarry.

The principal uses, each accounting for more than 1 million tons of crushed stone production, were concrete aggregate, crusher-run fill, graded road base, bituminous aggregate, fine screenings, railroad ballast, other construction and maintenance uses, and concrete sand.

Companies producing over 1 million short tons of crushed stone included: Vulcan Materials Co. with 16 quarries in 15 counties; Beazer, USA (Davidson Mineral Properties and Stoneman Inc.), 15 quarries in 12 counties; Georgia Marble Co., 16 quarries in 11 counties; Martin-Marietta Aggregates Inc., 7 quarries in 6 counties; Florida Rock Industries Inc., 5 quarries in 5 counties; and RMC Holdings USA Ltd., 2 quarries in 2 counties.

Dimension.—Georgia continued to lead the Nation in the production of dimension stone from marble while ranking second in volume and third in

TABLE 5

GEORGIA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch): Riprap and jetty stone	561	3,835
Coarse aggregate, graded:		
Concrete aggregate, coarse	9,577	51,803
Bituminous aggregate, coarse	4,193	23,397
Bituminous surface treatment aggregate	267	1,373
Railroad ballast	2,190	10,009
Fine aggregate (-3/8 inch):		
Stone sand, concrete	1,590	9,832
Stone sand, bituminous mix or seal	819	4,623
Screening, undesignated	3,575	18,258
Coarse and fine aggregates:		
Graded road base or subbase	4,678	23,204
Unpaved road surfacing	264	772
Crusher run or fill or waste	6,035	30,814
Other construction materials[2]	2,099	13,148
Agricultural: Agricultural limestone	254	1,213
Other miscellaneous uses[3]	1,018	3,354
Unspecified:[4]		
Actual	13,195	66,699
Estimated	103	472
Total[5]	50,417	262,805

[1] Includes limestone, dolomite, granite, volcanic cinder and scoria, traprock, sandstone, miscellaneous stone, and quartzite.
[2] Includes stone used in macadam, filter stone, and lightweight aggregate.
[3] Includes stone used in cement manufacture and asphalt fillers or extenders.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

value of all dimension stone produced. All of the marble dimension stone was produced by Georgia Marble Co. from its Tate quarry in Pickens County.

The Elberton granite district retained its position as the world's leading producer of granite monuments, although production reported to the Bureau of Mines decreased substantially from the last reported figures in 1987 and from 1988 estimated production.

Major expansions were completed by Georgia-Carolina Quarries Inc., Coggins Granite Inc., T & C Quarries Inc., and Smith Brothers Memorials. Georgia-Carolina added two new heavy-duty mobile cranes and a track drill and developed a new quarry near its main quarry in Oglethorpe County 18 miles southwest of Elberton. Coggins added two new 90-ton capacity mobile cranes and a 150-ton capacity crawler crane, one of the largest mobile cranes in use in the district. T & C opened two new quarry sites adjoining the firm's No. 1 quarry in Oglethorpe County. Smith Brothers installed a new stiff-leg-type stationary derrick with a 100-foot boom at its quarry approximately 15 miles south of Elberton in Oglethorpe County.

Talc.—Southern Talc Co., a subsidiary of United Catalysts Inc., increased production at the Earnest Mine in the Chatsworth talc district. Two other underground mines, Lindsey and Rock Cliff, remained idle. Southern Talc continued an exploration and reevaluation program of the talc deposits on its properties on Fort Mountain and indicated a second underground mine would be reopened in the future.

The company also completed a modernization and expansion of its processing plant in Chatsworth, Murray County. The new plant featured state-of-the-art dry grinding and froth flotation equipment producing talc pigments and pitch control additives for the paint, paper, plastics, rubber, adhesives, ceramics, and cosmetic markets. A large portion of the talc processed at the plant was shipped in from Montana.

Other Industrial Minerals.—Georgia remained a minor producer of gem stones, ranking 32d of the 50 States reporting production. The major producer was Dan Quillan Co., which operates an amethyst mine about 10 miles northwest of Greensboro in Greene County. Peat was produced by the Hyponex Corp. 2.5 miles west of Adel, Cook County, and by Colonial Peat Co. in Screven County. Sales were mainly to the horticultural market with 98% of the sales packaged.

Numerous industrial minerals were produced as byproducts or from commodities mined within the State, shipped in from other States, or imported. Brucite was ground for use in fire retardant by Filler Products Co. of Chatsworth, Murray County. The company also ground dolomite marble mined in the Tate area for carpet backing. High-brightness marble was shipped by ECCA Calcium Products Inc., a subsidiary of ECC America Inc., from its quarries in Alabama to a plant in Cartersville, Bartow County. The marble was finely ground to produce extenders, fillers, and pigments for the paint, plastic, paper, and rubber markets. In December, ECC announced plans to close the plant by October 1990. The plant, originally built by Thompson Weinman and Co., was acquired by ECC from Cyprus Industrial Minerals Co. in 1988. Georgia Marble Co. also manufactured similar calcium carbonate products at its Tate plant from marble mined primarily from the underground New York Mine adjacent to the plant. TAC Industries, a division of Franklin Limestone Co., ground limestone shipped in from Tennessee for carpet backing at its Dalton, Whitfield County, plant.

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.

Blue Circle Inc. in Atlanta and Medusa Cement Co. in Clinchfield produced both portland and masonry cement from clay and limestone mined in-State. Production of both decreased substantially from those of 1988 be-

TABLE 6

GEORGIA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	180	1,005	W	W	W	W
Coarse aggregate, graded[2]	2,904	15,521	7,627	42,835	5,695	28,226
Fine aggregate (−3/8 inch)[3]	1,566	8,763	W	W	W	W
Coarse and fine aggregates[4]	2,321	11,178	6,673	33,812	1,984	9,800
Other construction aggregates[5]	583	5,436	3,988	23,532	2,327	10,960
Agricultural[6]	(7)	(7)	—	—	(7)	(7)
Chemical and metallurgical[8]	—	—	—	—	(7)	(7)
Special[9]	(7)	(7)	—	—	—	—
Other miscellaneous	367	1,842	—	—	905	2,725
Unspecified:						
Actual[10]	6,478	33,371	6,081	29,737	636	3,590
Estimated[11]	99	459	4	13	—	—
Total[12]	14,497	77,575	24,374	129,930	11,546	55,300

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[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 crushed stone for graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[5] Includes lightweight aggregate.
[6] Includes agricultural limestone.
[7] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[8] Includes crushed stone for cement manufacture.
[9] Includes crushed stone for asphalt fillers or extenders.
[10] Includes production reported without a breakdown by end use.
[11] Includes estimates for nonrespondents.
[12] Data may not add to totals shown because of independent rounding.

cause of a slowdown in the economy and the resultant decline in construction activity in the Atlanta area. Medusa had been part of the Crane Corp. but was spun off as an independent company during the year.

Byproduct gypsum was produced by Kemira Inc. at its Savannah titanium dioxide pigment manufacturing plant. It imported titanium-rich slag from Canada, rutile from Australia and Florida for raw material, and aragonite from the Bahamas for acid neutralization. Calcined gypsum was produced for the manufacture of wallboard and gypsum plaster by Building Products Div., Georgia-Pacific Corp., Brunswick, and by Gold Bond Building Products Div., National Gypsum Co., Garden City, from crude gypsum imported from Nova Scotia and Newfoundland. Georgia-Pacific also produced gypsum plaster at a plant in Marietta. Domtar Inc. completed conversion of the wallboard plant in Savannah that it acquired from Genstar Corp. in 1987 to byproduct gypsum.

Various iodine chemicals valued at $331,000 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.

Perlite imported from Greece was expanded by Armstrong World Industries Co. in Macon. Slag from Atlantic Steel Co. plants in Atlanta and Cartersville was sold as construction aggregate by International Mill Service Corp. 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

No metals were mined in Georgia. Bauxite and iron oxide pigments were mined for use as industrial minerals. Atlantic Gold Fields Inc. received a permit to operate a gold mine in southwestern Haralson County approximately 1.5 miles south of Tallapoosa. As of yearend, no attempts to begin mining operations had been made.

Several varieties of metal scrap and metal chemicals were shipped into the State and manufactured into metals or metallic acids. Southwire Corp. of Carrollton, Carroll County, manufactured aluminum and copper cable at its smelter and refinery. Atlantic Steel Co. produced steel from electric arc minimills in Atlanta and Cartersville. The firm was in the midst of a major plant expansion at Cartersville and late in the year announced plans to consolidate all of its operations at Cartersville. Bliss and Laughlin Steel Co. completed construction of a cold-finish carbon steel bar mill in Cartersville. The mill was the company's first major expansion in more than 10 years.

Reynolds Metals Co. announced plans to begin commercial marketing of aluminum composite panels at its Eastman plant in Dodge County. The panel, intended to serve a wide range of architectural applications, combined a solid thermoplastic core with two

sheets of aluminum. Southern Zinc Co., Atlanta, produced zinc dust, zinc oxide, and zinc slabs from its smelter and refining operation.

[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL. He has 32 years of 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] Industrial Minerals (London). Blue Circle Acquires Georgia Marble. No. 265, Oct. 1989, p. 221.

[4] Miningram, Georgia Mining Association (Atlanta). EPA and EPD Discuss Computer Modeling Issue. Feb. 1990, p. 1.

[5] Mining Magazine (London). World's Largest Superconducting Magnetic Separation Plant. V. 161, No. 4, Oct. 1989, p. 327.

[6] Industrial Minerals (London). Annual Review 1989—U.S.A. No. 263, Aug. 1990.

[7] Rock Products. 1989 Aggregate Forecast—Georgia. V. 91, No. 12, Dec. 1988, p. 42.

TABLE 7

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:			
Cherokee Brick & Tile Co.	Box 4567 Macon, GA 31213	Open pit mines and plants	Bibb.
Boral Bricks Inc.	Box 1957 Augusta, GA 30903	Open pit mines	Bibb and Richmond.
Bickerstaff Clay Products Co.	Box 1178 Columbus, GA 31993	Open pit mines and plants	Floyd, Fulton, Muscogee.
Fuller's earth:			
Oil Dri Corp. of America	Box 200A Ochlocknee, GA 31773	do.	Thomas.
Waverly Mineral Products Co.	Box 106 Meigs, GA 31765	do.	Do.
Georgia Tennessee Mining & Chemical Co.	Box 307 Wrens, GA 30833	do.	Jefferson.
Kaolin:			
Engelhard Corp.	Box 37 Gordon, GA 31031	do.	Decatur, Washington, Wilkinson.
Georgia Kaolin Co., a subsidiary of CE Minerals	Box 1504 Milledgeville, GA 31061	do.	Various.
ECC America Inc., a subsidiary of Anglo American Clays	Box 471 Sandersville, GA 31082	do.	Do.
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.

See footnotes at end of table.

TABLE 7—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Gypsum—Continued			
Calcined:			
Georgia-Pacific Corp.	Box 1397 Brunswick, GA 31520	Plant	Glynn.
National Gypsum Co.	4500 Lincoln Plaza Dallas, TX 75201	do.	Chatham.
Domtar Gypsum, Div. of Domtar Inc.	1221 Broadway, Suite 700 Oakland, CA 94612	do.	Do.
Mica:			
Franklin Mineral Products Co. Inc., Div. of The Mearl Corp.	Drawer 390 Hartwell, GA 30643	do.	Hart.
Sand and gravel:			
Construction:			
Howard Sand Co.	Box 118 Butler, GA 31006	Open pit mines	Talbot and Taylor.
Florida Crushed Stone Co.	Box 230 Ochlocknee, GA 31773	do.	Brantley and Thomas.
Butler Sand Co.	Box 1954 Butler, GA 31006	Open pit mine	Taylor.
Industrial:			
Montgomery Sand Co., a subsidiary of Florida Crushed Stone Co.	Box 255 Mount Vernon, GA 39445	Open pit mine and plant	Montgomery.
The Morie Co. Inc., Georgia Silica Div.	1201 North High St. Millville, NJ 08332	do.	Marion.
Atlanta Sand & Supply Co.	Route 1 Roberta, GA 31078	do.	Crawford.
Stone:			
Crushed:			
Vulcan Materials Co.	Box 80730 Atlanta, GA 30366	Quarries and plants	Various.
Davidson Minerals Properties Inc. and The Stoneman Inc., subsidiaries of Beazer USA	Box 486 Lithonia, GA 30058	do.	Do.
Georgia Marble Co., Aggregate Group	Box 409 Lithonia, GA 30058	do.	Do.
Dimension:			
Granite:			
T & C Quarries Inc.	Box 119 Elberton, GA 30635	Quarries and finishing plant	Elbert and Oglethorpe.
Bennie & Harvey Inc.	Box 958 Elberton, GA 30635	do.	Oglethorpe.
Star Granite Co.	Box 159 Elberton, GA 30635	do.	Oglethorpe and Wilkes.
Marble:			
Georgia Marble Co.	1201 Roberts Blvd. Bldg. 100 Kennesaw, GA 30144	do.	Pickens.
Talc:			
Southern Talc Co., a subsidiary of United Catalysts	Drawer F, Holly St. Chatsworth, GA 30705	Underground mine and plant	Murray.

[1] Also produced crude iron oxide pigments.
[2] Also produced common clay and limestone.

THE MINERAL INDUSTRY OF HAWAII

This chapter has been prepared under a Memorandum of Understanding between the 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 1989 was more than $92 million. The 23% increase from 1988's production was attributed to the continuing boom in Hawaii's construction spending and rising prices of the materials used in construction. Hawaii ranked 44th nationally in the value of 1989 nonfuel mineral production.

Industrial minerals accounted for the total mineral value. Portland cement, construction sand and gravel, and crushed stone were the principal commodities produced accounting for approximately 98% of the total value.

TRENDS AND DEVELOPMENTS

Mineral production in Hawaii was used principally for local construction. Since 1985, when the current expansion began, total construction spending has increased at unprecedented rates for 5 consecutive years. According to the Bank of Hawaii, total dollar value of private construction permits in 1989 was $1.9 billion, up 20.1% from 1988, and construction completed was up 26.3% to $3.2 billion.

Mining and processing of the manganese crusts under waters northwest and south of Hawaii at depths of 2,500 to 8,000 feet continued to be evaluated. The U.S. Senate approved $6 million for the University of Hawaii's Center for Pacific Ocean Resource Science and Technology. The Center began the study of the potential for mining strategic minerals on the Pacific Ocean floor. The 547-acre Hawaii Ocean Science and Technology Park at Keahole Point in the Big Island became fully operational in April.

Construction booms on Kauai caused shortages of fine aggregate used in concrete and asphalt, causing slowdowns in various construction projects. Rock was imported from Honolulu to help alleviate the shortage. No lime production was reported in 1989 by former operators.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Hawaiian portland cement production and value increased to 492,844 short tons and $40.5 million during 1989, up 39% and 40% from that of 1988. Masonry cement production decreased slightly, to 9,789 million tons.

The State Department of Transportation conducted sales of coral material stockpiled at Barbers Point Harbor, Oahu. Portland cement was used principally by building material dealers, concrete product manufacturers, ready-mix companies, and highway and building contractors. Raw materials consumed at the State's principal cement plant at Barbers Point, Oahu, included limestone, sand, gypsum, and volcanic ash.

Pumice and Pumicite.—Although pumice production tonnage nearly

TABLE 1

NONFUEL MINERAL PRODUCTION IN HAWAII[1]

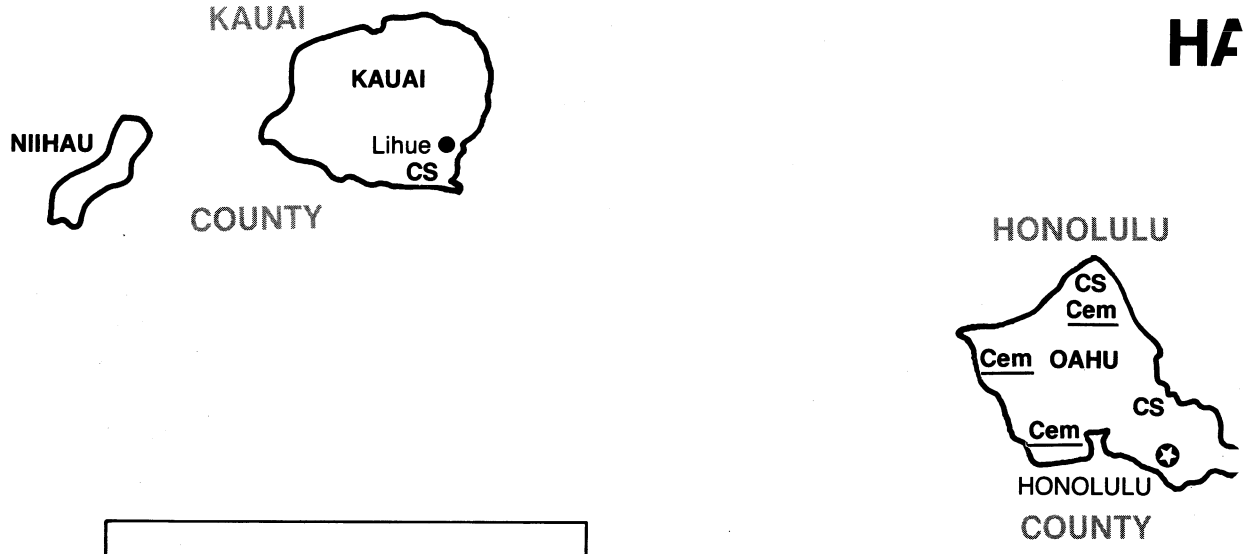
Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	10	$1,559	10	$1,531	10	$1,566
Portland	do.	324	26,550	354	28,880	493	40,495
Gem stones		NA	25	NA	W	NA	44
Lime	thousand short tons	3	W	W	W	—	—
Sand and gravel (construction)	do.	e700	e3,500	652	3,173	e600	e3,200
Stone (crushed)	do.	5,732	41,548	e5,700	e41,000	6,205	46,746
Combined value of other industrial minerals and values indicated by symbol W		XX	297	XX	348	XX	[2]
Total		XX	73,479	XX	74,932	XX	[3]92,051

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.



LEGEND

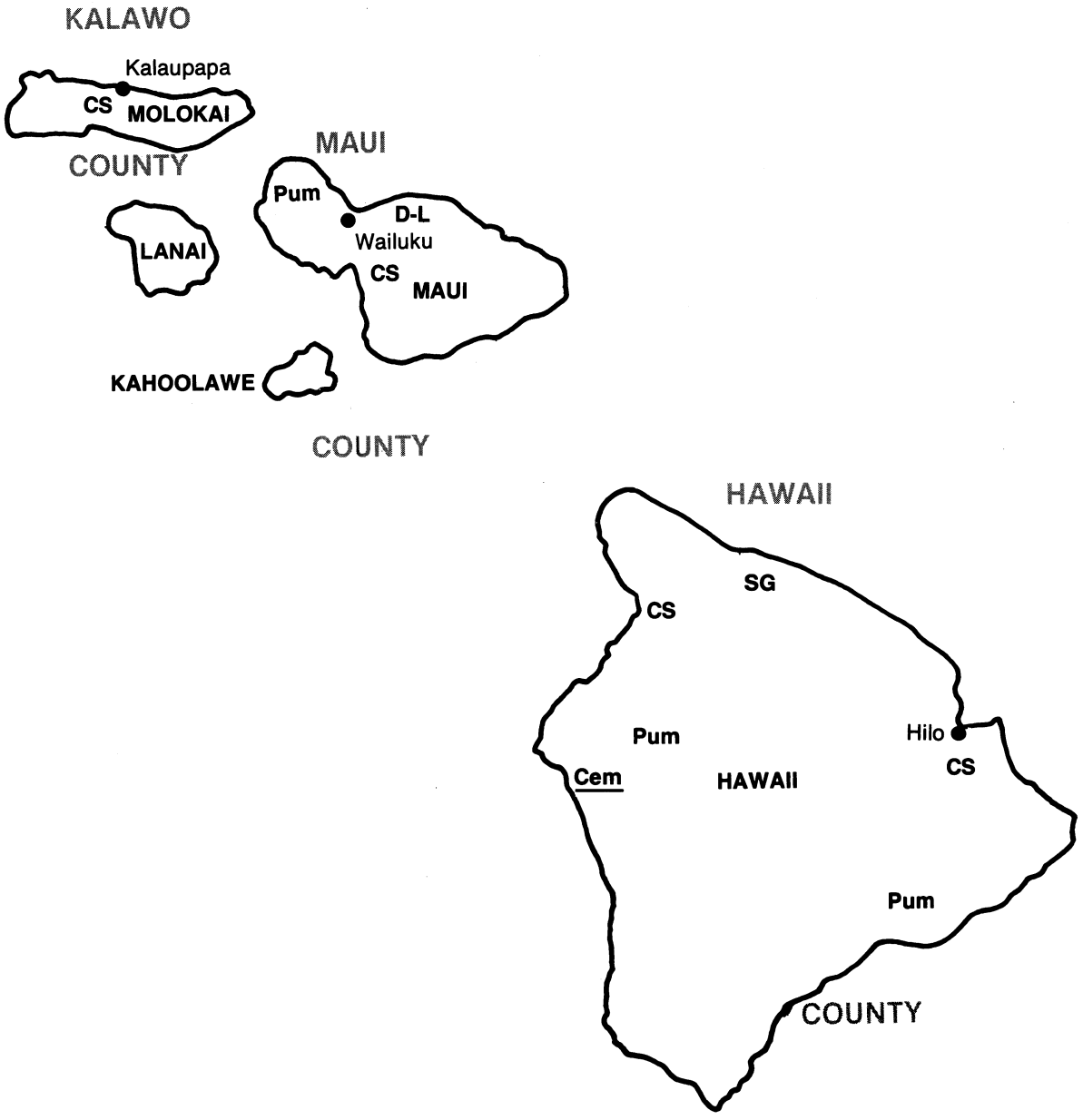
———	State boundary
COUNTY	County
✪	Capital
●	City

MINERAL SYMBOLS

Cem	Cement plant
CS	Crushed Stone
D-L	Dimension Limestone
Pum	Pumice
SG	Sand and Gravel

Principal Mineral-Producing Localities

AII


KALAWO
Kalaupapa
CS
MOLOKAI
COUNTY
MAUI
Pum
D-L
Wailuku
CS
MAUI
LANAI
KAHOOLAWE
COUNTY
HAWAII
SG
CS
Pum
Hilo
CS
Cem
HAWAII
Pum
COUNTY

doubled, the 1989 value of the pumice produced in the State dropped 14% from that of 1988, as nearly all the reported production was used in road construction rather than landscaping.

Crude pumice for road construction was mined in Maui County by Maui Pineapple Co. Ltd. of Lahaina at its Honokohau cinder pit. Puna Sugar Co. used volcanic ash from their Iilewa pit for road construction in Hawaii County. Volcanite Ltd.'s Puuwaawaa pumice plant in Hawaii County remained closed throughout the year, after an April 1988 closure.

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Despite increased construction in Hawaii, preliminary reports indicated sand and gravel production decreased as construction uses were partially supplemented by crushed stone.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—The crushed stone production of 6.2 million short tons in 1989 is nearly 9% higher than the reported 1987 production of 5.7 million short tons.

TABLE 2

HAWAII: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1-1/2 inch):		
Macadam	170	1,556
Riprap and jetty stone	65	688
Filter stone	205	1,618
Coarse aggregate, graded:		
Concrete aggregate, coarse	1,164	10,062
Bituminous aggregate, coarse	508	3,723
Bituminous surface treatment aggregate	95	808
Fine aggregate (-3/8 inch):		
Stone sand, concrete	646	5,553
Stone sand, bituminous mix or seal	317	2,320
Coarse and fine aggregates:		
Graded road base or subbase	1,373	10,651
Unpaved road surfacing	140	761
Crusher run or fill or waste	626	2,917
Other construction materials[2]	69	402
Other miscellaneous uses[3]	383	1,443
Unspecified:[4]		
Actual	15	195
Estimated	428	4,048
Total[5]	6,205	46,746

[1] Includes limestone, traprock, volcanic cinder and scoria, and miscellaneous stone.
[2] Includes stone used in other coarse and fine aggregates.
[3] Includes stone used in agricultural limestone, cement manufacture, asphalt fillers or extenders, and roofing granules.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

[1] State Mineral Officer, Bureau of Mines, Reno, NV. He has covered the mineral activities in Hawaii for 4 years. Assistance in the preparation of the chapter was given by Mary Carico and Pat La Tour, editorial assistants.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Hawaii Cement	Barbers Point Plant 91-055 Kaomi Loop Ewa Beach, HI 96706	Cement plant	Oahu.
Pumice:			
Maui Pineapple Co. Ltd.	Box 445-C Lahaina, HI 96761	Surface mine	Do.
Puna Sugar Co. Ltd.	Box 120 Keaau, HI 96749	do.	Hawaii.
Volcanite Ltd.	Box 3000 Kailua Kona, HI 96740	do.	Do.
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 and 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.

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 in Idaho in 1989 was valued at $366 million, an increase of 26% from that of 1988. A drop in the value of gold production was more than offset by gains in the value of lead, molybdenum, silver, vanadium, and zinc.

Phosphate rock was the leading mineral commodity in terms of value followed by silver, molybdenum, and gold. The metallic minerals—antimony, copper, gold, lead, molybdenum, silver, vanadium, and zinc—accounted for about 62% of the State's nonfuel mineral production value, a slight drop from the 68% in 1988. In 1989, Idaho ranked first in the Nation in antimony and garnet production; second in silver, lead, and vanadium production; and third in marketable phosphate and perlite ore output.

TRENDS AND DEVELOPMENTS

There was a modest increase in the value of silver production in 1989. Idaho ranked second in the Nation, accounting for more than one-fifth of total U.S. production. As it has for more than a century, the bulk of silver and lead produced came from the Coeur d'Alene District. In spite of near record production and rising base metal prices, according to the Sunshine Mining Co. annual report, 1989 was the first time in 40 years that all primary silver mines in the district operated at a loss. Although it decreased in value, gold maintained its position as the fourth highest valued mineral produced in the State and was the focus of a sharply increased number of exploration companies and projects in the State. Idaho's base metal production—copper, lead, and zinc—showed significant increases of more than 85% in quantity and 119% in value from that of 1988. In the industrial minerals sector, phosphate production values dropped slightly, but companies were planning new mines to ensure future supply. Regulatory and environmental concerns were major issues in 1989 and will have a growing effect on future mining activity in Idaho.

EMPLOYMENT

For the second consecutive year, employment in Idaho's mining sector increased. Overall mining employment rose

TABLE 1

NONFUEL MINERAL PRODUCTION IN IDAHO[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	metric tons	8,114	W	8,519	W	W	W
Copper[3]	do.	W	W	2,269	$6,028	2,950	$8,516
Feldspar	short tons	—	—	—	—	12,800	720
Gem stones		NA	$507	NA	500	NA	500
Gold[3]	kilograms	3,041	43,797	3,218	45,349	3,057	37,602
Lime	thousand short tons	97	5,149	W	W	W	W
Phosphate rock	thousand metric tons	3,411	47,072	4,706	81,011	W	W
Sand and gravel:							
Construction	thousand short tons	e7,200	e28,000	6,914	19,897	e5,800	e18,900
Industrial	do.	W	W	483	5,089	459	5,037
Silver[3]	metric tons	W	W	340	71,512	439	77,651
Stone (crushed)	thousand short tons	3,852	15,346	e3,400	e13,100	3,298	12,609
Combined value of antimony (1988-89), cement, clays, (bentonite, common, kaolin), garnet (abrasive), lead, molybdenum (1987, 1989), perlite, pumice, stone (dimension), vanadium, zinc, and values indicated by symbol W		XX	129,502	XX	48,130	XX	204,775
Total		XX	269,373	XX	290,616	XX	366,310

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

to about 3,800 employees, a 15% increase over the 1988 level. The number of metal mining employees grew by 18% to 2,600.

Wages for mineral production workers in Idaho, however, were down slightly from that of 1988. Average weekly earnings were $561 in 1989, a drop of $11 from the previous year; average length of the workweek also declined from 42.3 hours to 41.9 hours. Overall, the average hourly wage earned in Idaho's mineral sector in 1989 was $13.37 per hour, a 1% drop from $13.50 per hour reported in 1988.

REGULATORY ISSUES

The Environmental Protection Agency (EPA) issued a unilateral order for immediate cleanup of hazardous materials at the Bunker Hill smelter complex and tailings site in Shoshone County. The site, closed in 1982, is part of a 21-square-mile area contaminated by toxic metals released from smelter stacks for nearly a century. Parties to the cleanup include Gulf Resources and Chemical Corp. (the former owners) and the current operator, Bunker Ltd. Partnership and its subsidiaries. The order required the companies to immediately stop demolition and salvage efforts and to contain hazardous wastes that include asbestos, arsenic-contaminated dust, sulfuric acid, and mercury sludge.

The EPA implemented tighter Federal standards regulating radioactive releases from elemental phosphorus plants. New standards reduce acceptable releases from 21 curies to 2 curies. After having spent $8 million on new equipment to reduce emissions to 10 curies at its plant west of Pocatello before the change, FMC was fined $12,000 for air pollution violations. FMC was left with the options of designing new technology, petitioning to change the standard, or shutting down the operation. Monsanto Corp. was in compliance (1.4 curies) owing to installation of a new, high-efficiency scrubber at its Soda Springs plant.

J. R. Simplot Co.'s Pocatello phosphate fertilizer plant was cited by the EPA for 30 violations regarding excessive sulfur dioxide emissions and for dust problems from piles of raw phosphate ore. Simplot confirmed that its Conda operations exceeded standards temporarily during a sulfuric acid plant startup, but claimed it was in compliance with State and Federal guidelines. The dust problems should be resolved when a $30 million slurry pipeline is installed between Soda Springs and Pocatello. Simplot was working with the EPA and the Idaho Department of Health and Welfare to resolve the situation.

The Thunder Mountain gold mine, operated by Coeur d'Alene Mines Corp.; Monsanto's phosphate mine east of Henry; the Galena and Coeur Mines operated by Asarco; and two placer mines, A and T Mining's property near Lucille and George Castle's property on Stanley Creek, received awards for sound environmental practices. The awards were presented by the U.S. Forest Service, the U.S. Bureau of Land Management, and several State agencies.

EXPLORATION ACTIVITIES

Exploration was active in 1989 with 82 projects versus 68 in 1988. Precious metals continued to be the dominant target. The discovery of Meridian Gold Co.'s Beartrack deposit at Leesburg, Lemhi County, in 1988 sparked interest in the Salmon and Trans-Challis areas. Excitement generated by discoveries of low-grade disseminated gold deposits in southeastern Oregon spilled over into Idaho. Companies also explored historic gold-producing districts north of Yellow Pine, Valley County; near Elk City, Idaho County; and near Mackay, Custer County.

The joint venture of American Gold Resources Corp. (AGR) and Meridian Gold agreed to further evaluate AGR's Arnett Creek property, Lemhi County. The gold prospect is contiguous to and west of Meridian Gold's Beartrack gold deposit. Corona Gold Inc. and Formation Capitol Corp. drilled at the Bobcat Gulch gold project, a joint venture adjacent to and east of the Beartrack property. Sovereign Exploration Inc., a subsidiary of Total Energold Corp., acquired and staked the Gold Star, Pine Creek, and Phelan Mountain properties also near the Beartrack deposit.

Also in Lemhi County, AMAX Inc. drilled at the Rabbits Foot Mine; Metron Resources drilled its Porphyry Ridge property, where Homestake Mining Co. reportedly outlined a complex vein system in 1988; and FMC Corp. explored the Ditch Creek area near North Fork. U.S. Antimony Corp. (USAC) and Western Gold Exploration & Mining Co. (WestGold) continued drilling and sampling on their Yellow Jacket gold project. WestGold also leased the Estes Mountain property from USAC.

In the Coeur d'Alene District near Murray, Shoshone County, Cimco Mining Corp. joined with the China National Nuclear Industry Corp. to develop a gold placer. Newmont Exploration Ltd. formed a joint venture with Viking Investment Corp. to explore the historic Golden Chest Mine, 1 mile east of Murray. International Basic Resources Inc. announced it had signed an agreement with Newmont for a joint venture on the historic Mother Lode Mines on Ophir Mountain across Prichard Creek from the Golden Chest Mine. Callahan Mining Corp. continued work on the silver-lead mineralization at the Caladay Project near Wallace. Work focused on deep drilling to define the boundary veins on the 4900 level.

Elsewhere in north Idaho, Cominco Ltd. opened four adits and drilled six core holes looking for polymetallic mineralization at the Idaho-Buckhorn Mine near the top of Scout Mountain. In Idaho County, Canyon Resources Corp. drilled on the Comstock property near Dixie. The property is adjacent to the Robinson Dyke Mine where previous drilling outlined a leachable mixed oxide-sulfide shear zone deposit. Newmont conducted geophysical and geochemical studies around the New York Mine near Golden. Idaho Gold Corp. successfully tested an agglomerating process at the Buffalo Gulch heap-leach gold project west of Elk City. Permitting and feasibility studies were underway at both the Buffalo Gulch and Erickson Reef deposits.

In central Idaho, Freeport McMoRan Gold Co. conducted a drilling program at the old Independence Mine in the Logan Creek-Smith Creek area west of Big Creek and Kennecott Exploration Co. did surface geology and exploration work around the old Moscow Mine in the Big Creek area. Also, Placer Dome Ltd. was active on Quartz Creek east of Yellow Pine and FMC conducted surface work in the Warren area.

Atlanta Gold Corp. continued exploration and development of its Atlanta gold and silver prospect northeast of

Boise in Elmore County. After a lengthy court battle with U.S. Gold Corp., Atlanta maintained control of the proposed open pit operation. The ore would be concentrated by flotation and then treated by biooxidation and cyanidation. At year-end, the company was up for sale or joint venture. Also exploring in the Boise area were Newmont, Centennial Resources, and Cactus West Exploration Ltd.

Noranda Inc. drilled and conducted surface mapping and sampling to evaluate the Black Pine heap-leach gold project near the old Tolmin Mine in Cassia County. State and Federal operating permits were applied for. Owyhee and Washington Counties saw an upswing of activity precipitated by discoveries in eastern Oregon. Nerco Minerals Co. also signed an agreement with War Eagle Mining Co. to explore the War Eagle Mountain gold-silver project near Nerco's DeLamar gold-silver mines. Gold Canyon Resources and Bradner Resources had encouraging results at the Blue Dog gold prospect north of Weiser.

LEGISLATION AND GOVERNMENT PROGRAMS

A new Federal law required phosphate manufacturers to produce annual reports on radionuclide releases from ore and slag piles.

A controversial bill, introduced by a U.S. Senator from Idaho and supported by the Governor, proposed setting aside an additional 1.4 million acres as wilderness. The controversy centered around a provision in the bill that would let the Forest Service and the Governor's office "undesignate" wilderness areas. Boundaries would remain subject to change during a 7-year period, primarily based on wilderness road reviews.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Antimony.—Idaho was the only State in the Nation reporting antimony production in 1989. Production increased by more than 33% in quantity and by almost 30% in value from that of 1988. Sunshine Mining Co. recovered antimony as a byproduct from the electrolytic treatment of tetrahedrite, a complex silver-copper-antimony sulfide, the principal ore mined at the Sunshine Mine near Kellogg, Shoshone County.

Cobalt.—Blackbird Metals Co., a New York-based partnership, continued negotiations to buy and reopen the mothballed Blackbird cobalt mine near Salmon, Lemhi County. Reportedly, Noranda and M. A. Hanna Co. agreed to sell the property to Blackbird Metals once several conditions were met and the question of who would be responsible for environmental cleanup of past activity at the site was settled. Noranda owns 85% of the Blackbird Mine and Hanna 15%. Blackbird Metals' plans included reopening the mine and constructing a refinery about 50 miles away near Salmon. Feed for the refinery would include both mine production and scrap.

Copper.—Idaho's copper production increased 30% in quantity and more than 41% in value from that in 1988. Alta Gold Co., formerly Silver King Mines and Pacific Silver Corp., reactivated its copper-silver mine and 600-ton-per-day mill near Hells Canyon Gorge, about 40 miles northwest of Council in Adams County. Thirty workers were employed at the operation. The mine had been closed since 1981 because of low copper prices.

The major copper-producing region in the State continued to be the Coeur d' Alene District where copper was recovered as a byproduct of silver mining at the Galena, Coeur, Sunshine, Lucky Friday, and Bunker Hill Mines.

Gallium.—N. A. Degestrom constructed and permitted a processing plant in Soda Springs, Caribou County, to extract gallium and silver from "treater dust," a waste product at Monsanto's nearby elemental phosphorus plant. The gallium will be sold to the electronics industry where it is used to make gallium arsenide computer chips.

Gold.—Gold production in Idaho decreased by 5% in quantity and 17% in value from that in 1988. The State ranked 10th nationally in gold production in 1989, unchanged from 1988. Production was recorded from 12 lode mines during the year, compared with 11 operations reporting production in 1988.

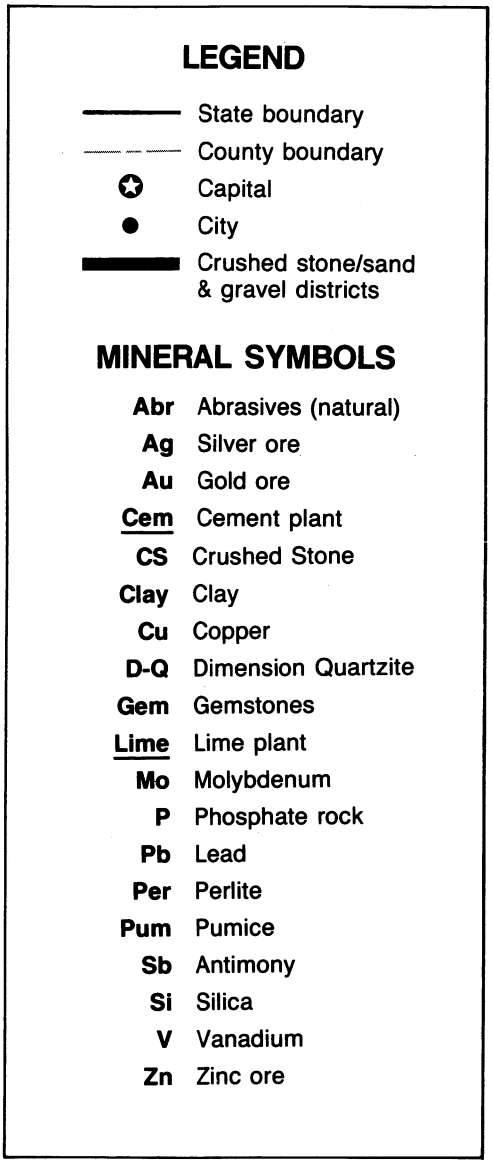
The Stibnite gold mine, owned and operated by a joint venture of Pioneer Metals Corp. and MinVen Gold Corp., was the State's leading gold producer. The seasonal open pit heap-leaching operation is 15 miles southeast of Yellow Pine, Valley County. Hecla Mining Co.'s nearby Yellow Pine Mine, Idaho's third ranked gold producer in 1988, was idled after the ore reserves were increased at the Stibnite Mine. Yellow Pine ore had been toll leached at the Stibnite Mine, but the owners declared they needed all the pads to process their own ore. Hecla received approval to build a leach plant in the Stibnite area for processing Yellow Pine ore; construction began late in the year.

The DeLamar gold-silver mine, 20 miles east of Jorden Valley, OR, in Owyhee County, was the State's second-ranked gold producer. Nerco operated the open pit, vat-leach plant and heap-leach facility at full production. Nerco continued exploration and delineation drilling and permitting at its new Stone Cabin Mine on nearby Florida Mountain. An environmental impact statement on the new gold-silver property was begun, with plans to build a 5-mile road to the company's DeLamar Mine for initial mill processing. The Stone Cabin Mine will use both conventional ore milling and cyanide heap leaching.

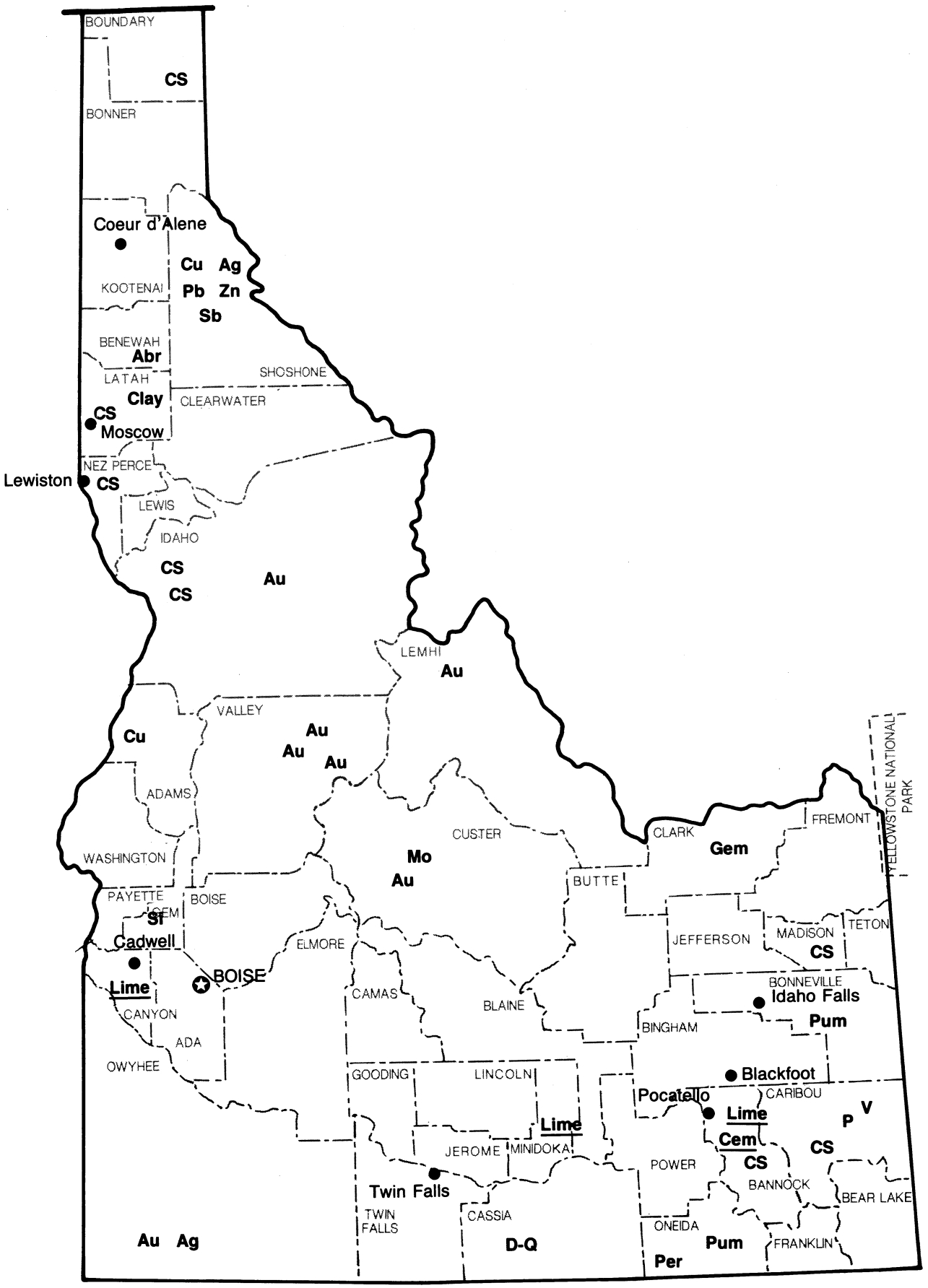
The Coeur-Thunder Mountain Mine, east of McCall in Valley County, was the State's third leading gold producer. The property is leased to and operated by Coeur d'Alene Mines from Thunder Mountain Gold Inc. Coeur d'Alene Mines earns 90% of the net profits until development costs are recovered, then will receive a 70-30 split. The seasonal open pit heap-leach operation produced gold and silver from May through October. The company drilled the Upper Lightning Peak ore body and continued development of its nearby Lightning Peak property. Plans are to process the ore at the existing Sunnyside heap-leach plant operated by the company.

USAC operated the 350-ton-per-day Yankee Fork mill at Preachers Cove, Custer County. Primary mill feed came from USAC's General Custer Mine 12 miles away on the Yankee Fork. Additional mill feed was trucked 110 miles from the company's Yellow Jacket property in Lemhi County. USAC's Speciman Mine, a small 50-ton-per-day mine north of Lowman in Boise County, began production in 1989. Its ore was also trucked to the mill at Preachers Cove, 85 miles away.

IDAHO



Principal Mineral-Producing Localities


BOUNDARY
CS
BONNER
Coeur d'Alene
Cu Ag
Pb Zn
Sb
KOOTENAI
BENEWAH
Abr
LATAH
Clay
CS
Moscow
SHOSHONE
CLEARWATER
NEZ PERCE
Lewiston
CS
LEWIS
IDAHO
CS
CS
Au
LEMHI
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VALLEY
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ADAMS
WASHINGTON
PAYETTE
BOISE
GEM
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Cadwell
Lime
BOISE
ELMORE
CANYON
ADA
OWYHEE
CUSTER
Mo
Au
CAMAS
BLAINE
GOODING
LINCOLN
Lime
JEROME
MINIDOKA
Twin Falls
TWIN FALLS
CASSIA
D-Q
Au Ag
CLARK
Gem
BUTTE
FREMONT
YELLOWSTONE NATIONAL PARK
JEFFERSON
MADISON
CS
TETON
BONNEVILLE
Idaho Falls
Pum
BINGHAM
Blackfoot
Pocatello
CARIBOU
Lime
Cem
CS
P
V
CS
POWER
BANNOCK
BEAR LAKE
ONEIDA
Pum
FRANKLIN
Per

Idaho Gold Corp. began production at its Champagne Mine in June. Idaho Gold is 85% owned by BEMA Gold Inc. and 15% by Glamis Gold Ltd. The open pit heap-leach mine is in the Lava Creek District, 20 miles west of Arco, Butte County. Preproduction costs for the gold and silver producer were about $2 million. The mine will process about 800,000 tons of ore annually with an estimated mine life of 3.5 years. The plant employs 56 and operates year-round using a Merrill-Crowe process, designed with a zero discharge, closed system for environmental considerations.

In Lemhi County, Meridian Gold continued exploration and delineation drilling at the Beartrack property, reportedly the largest single gold discovery ever made in Idaho. About 10,000 feet of core and more than 200 reverse circulation holes were drilled in 1989. The total (sulfide plus oxide) resource was estimated at about 2.6 million troy ounces of gold. Permitting was started for a heap-leach, open pit operation to develop 25 million tons of oxide ore containing 600,000 troy ounces of gold. Plant construction was scheduled for 1991 and production in 1992. Beartrack is owned by Meridan Gold, a subsidiary of Burlington Northern (71%), Canyon Resources (15%), and Minex Partners (14%). In December, Burlington Northern announced plans to sell its gold company. The decision was not expected to delay the Beartrack development.

CoCa Mines Inc. acquired Geodome Resources Ltd., the parent of Sunbeam Mining Corp. The new company, Grouse Creek Mining Co., continued development of the Sunbeam and Grouse Creek deposits near Stanley in the Yankee Fork of the Salmon River. The project has been hampered with environmental concerns involving the Pinyon Basin wetland, which would be used for part of the mining operation. Additional reserves, plus a more conventional milling process that the company hopes is more environmentally acceptable, may give the mine a new lease on life.

Placer gold producers included the A and T Placer near Lucille, Idaho County, the largest gold placer in the State; Old Pan Mine near Pierce, Clearwater County; Blackbear Mining on Independence Creek (Moose Creek area); ABC Mining on Buckskin Creek near Idaho City, Boise County; and George Castle's property on Stanley Creek.

Lead.—Lead production in Idaho in 1989 ranked second nationally. The quantity of lead produced increased 53% over that reported in 1988 and was more than four times the production in 1987. The value of production rose 62% from that of 1988 and almost five times as much as reported in 1987. Lead production was concentrated in the Silver Valley of Shoshone County, with the Lucky Friday Mine being the State's leading producer. Other mines reporting production included Bunker Hill, Coeur, and Sunshine.

Molybdenum.—By yearend, Cyprus Minerals Co. was operating its open pit Thompson Creek molybdenum mine near Challis, Custer County, at nearly 100% capacity. Construction of a new high-purity, lubricant-grade molybdenum disulfide plant was completed at the mine site. The plant will expand the company's ability to produce value added products. Cyprus obtained a new power contract from the Bonneville Power Administration that should reduce costs significantly. Although the operation recovered strongly in 1989, the open pit mine and 30,000-ton-per-day mill closed for 2 weeks late in the year because of a worldwide glut of molybdenum.

Silver.—Silver production in Idaho increased 29% in quantity and almost 9% in value from that of 1988. The State ranked second nationally after Nevada in silver production. Although active mines showed an increase in production, the drop in silver prices kept some developing silver projects on standby status. Except for Nerco's DeLamar Mine in Owyhee County, which was the fifth-ranked producer in the State, all of the top six silver-producing mines were in the Coeur d'Alene mining district of Shoshone County.

The Sunshine Mine returned to full production in 1989 and became the State's leading silver producer. According to Sunshine Mining Co.'s annual 10-K report, the mine produced 4.8 million troy ounces of silver and 1.6 million pounds of copper during the year. The company is a vertically integrated silver producer that operated the mine and silver refinery on Big Creek and a mint in Coeur d'Alene. The mint received a long-term contract with the U.S. Government to produce silver blanks that will be used to make 1-ounce Silver Eagle coins.

ASARCO Incorporated operated the Galena and Coeur Mines. The Galena Mine, the State's second largest silver producer, is owned by Callahan Mining Co. and Hecla Mining Co. Despite lower silver prices and a reported drop in ore grade, the mine operated without interruption, producing 3 million troy ounces of silver, 1,000 tons of copper, and 300 troy ounces of gold, according to the company's 1989 annual report. The Coeur Mine, the State's third-ranked silver producer, is owned by Coeur d' Alene Mines, Callahan, and Hecla. The 3900 level of the mine was opened during the year, and like the Galena Mine, the mine was in production all year. In Asarco's annual report, 1989 output of the Coeur Mine was 2.2 million troy ounces of silver, 1,000 tons of copper, and 400 troy ounces of gold. Asarco continued exploring the American Silver property adjacent to and accessed from the 3400 level of the Coeur Mine.

The Lucky Friday Mine, owned by Hecla, was the State's fourth largest silver producer. The company's annual report showed production of 1.9 million troy ounces of silver, 16,000 tons of lead, 3,300 tons of zinc, 280 tons of copper, and 940 troy ounces of gold recovered at the mine. During the year, Hecla used its new mechanized Lucky Friday Underhand Longwall mining method, which proved effective in decreasing mining costs and controlling rock bursts. Hecla continued drilling from the surface and underground on the Snowstorm and Silver Mountain areas east of Mullen near the Lucky Friday.

Vanadium.—Idaho was second in the Nation in vanadium production. In 1989, output rose by almost 12% in quantity and nearly 54% in value from that of 1988. Kerr-McGee Chemical Corp. operated its vanadium recovery plant at Soda Springs, Caribou County. The operation recovered vanadium from ferrophosphorus slag, a waste product generated by Monsanto's elemental phosphorous plant across the road from Kerr-McGee. In response to a strong demand for vanadium products and increased prices, Kerr-McGee completed a 30% expansion of the plant early in the year. The company produces ammonium metavanadate, potassium vanadate, sodium vanadate, and vanadium pentoxide.

Zinc.—In 1989, the quantity of zinc

production in the State was four times that achieved in 1988, and the value was more than five times greater. The Bunker Hill Mine was reopened by the new Bunker Hill Mining Co. Inc. in 1988, and 1989 was the first full operating year for the Shoshone County zinc-lead-silver producer. According to the company's annual report, the mine produced 19,000 tons of zinc concentrate and 6,000 tons of lead concentrate during the year. Mining was done by a new trackless bulk-mining method. The lead-silver concentrates were sent by rail to Asarco's smelter in East Helena, MT; shipments of zinc concentrates were sent to the Cominco smelter in Trail, British Columbia, Canada, or shipped to smelters in Japan.

Hecla's Lucky Friday Mine produced zinc as a byproduct of silver-lead production. Reopening work was started on the Star-Morning Mine in the Coeur d'Alene mining district, Shoshone County. The zinc-lead-silver mine was being developed by the Star Phoenix Mining Co., a joint venture of a Spokane businessman and the Bunker Hill Ltd. Partnership. The mine is actually two mines: the Star, accessed from a portal on the west side of the ridge, is a zinc mine, and the Morning, a lead-silver mine entered from the east. Both are on the same vein system and are connected underground. The old Hecla Mine is part of the complex, but is on a different vein system. The 1,250-ton-per-day mill at Burke was also being refurbished.

Industrial Minerals

Cement.—Cement production in Idaho decreased by 21% in quantity and 15% in value from that of 1988. The State's only cement producer was Ash Grove Cement West Inc. at Inkom, 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. Finished portland cement was used by the following: ready-mixed concrete companies (62%); highway contractors (19%); other contractors, concrete product manufacturers, and miscellaneous customers (16%); and building material dealers and government agencies (3%). Limestone and quartzite used in the cement production were quarried from near the plant at Inkom.

Clays.—Clay production in Idaho in 1989 decreased less than 1% in quantity but increased more than 6% in value compared with those in 1988. Bentonite, common clay, and kaolinite refractory clays were mined by four companies from pits in Benewah, Clark, and Latah Counties.

Diatomite.—Grefco Inc. continued assessment and drilling programs at two diatomite deposits. At a property near Deep Creek in Owyhee County, the company drilled 30-inch holes up to several hundred feet deep, then lowered geologists into the holes to examine the deposit and geology. Grefco drilled at the American Diatomite deposit north of Bliss in Gooding County.

Garnet.—Idaho ranked first in the nation in garnet production. Reported production dropped nearly 3% in quantity and 9% in value compared with that of 1988. The Emerald Creek Garnet Milling Co. at Fernwood, Benewah County, continued full production as the Nation's largest garnet producer. The company mined garnet from two sites on Carpenter Creek and three locations on Emerald Creek using five washing plants. Two Bureau of Land Management leases totaling 67 acres were added to the company's land holdings. A new shop was built at the plant site, in addition to a new jig plant and modernization of its sizing and bagging plant in 1988. Major uses of garnet were for sandblasting and as a filtration medium

Gem Stones.—The value of 1989 gem stone production in Idaho remained the same as in 1988. Active gem stone deposits were in Benewah, Boise, Clark, Clearwater, and Owyhee Counties. Aquamarine, garnet (including star garnet), gem quartz, jasper, precious opal, topaz, and turquoise were recovered during the year.

Lime.—Idaho lime production increased approximately 4% in quantity and value from that of 1988. Amalgamated Sugar Co. operated three lime plants in Canyon, Minidoka, and Twin Falls Counties that accounted for all of the State's 1989 lime production. The raw material was shipped by rail from Ash Grove Cement's limestone quarry in Durkee, OR. The quicklime production was used by sugar manufacturers.

Perlite.—National Perlite Products, a division of Oglebay Norton Co., mined perlite from the Wrights Creek deposit; the material was processed and expanded at the company's plant at Malad City, Oneida County. During the year, new dust control equipment was installed at the plant, and the office building was modernized. Production increased almost 13% in quantity and more than 23% in value from that of 1988. The expanded product was used for industrial filters, in fireproofing, and as a filter medium.

Phosphate Rock.—The amount of marketable phosphate rock production in Idaho dropped both in quantity and value relative to that of 1988. In spite of the drop, Idaho retained its third ranking nationally in marketable phosphate output.

J. R. Simplot Co. operated the Gay Mine, about 30 miles northeast of Pocatello on the Fort Hall Indian Reservation in Bingham County and the Smokey Canyon Mine near the Wyoming border in Caribou County. Ore production from the Smokey Canyon Mine was slurried, then pumped to a calcining plant at Conda through a 27-mile-long slurry pipeline. The calcined material was shipped by rail to the company's phosphoric acid and fertilizer plant at Pocatello. Simplot received approval to build a 9-inch diameter, 58-mile-long slurry pipeline, estimated to cost about $30 million, between the Conda and Pocatello plants; construction was to begin in 1991.

Ore production from the Gay Mine was processed by Simplot into phosphoric acid and by FMC into elemental phosphorous at its Pocatello plant. Simplot reduced employment at the Gay Mine site and planned to cease production in 1994. FMC started development on a new phosphate mine in Dry Valley near Soda Springs, Carbon County, which will replace the dwindling reserves of high-grade ore from the Gay Mine.

Monsanto Co. operated its Henry Mine and Soda Springs elemental phosphorous plant in 1989. The company plans to cease production at the Henry Mine in 1990 and move to a new site in Enoch Valley, 4 miles east. Stauffer Chemical Co., a subsidiary of Rhone-Poulenc Basic Chemical Co., mined phosphate rock from the Wooley Valley Mine northeast of Soda Springs. The company worked on a new washing plant at the mine site and planned to ship washed ore to its elemental phosphorous plant at Silver Bow, MT, in 1990.

Phosphate rock was mined at the Mountain Fuels Mine in Caribou County by the Conda Partnership, a joint venture

of NuWest Industries Inc. and Western Cooperative Fertilizer Ltd. of Calgary, Alberta, Canada. The ore was beneficiated at the Conda Partnership's calcining plant and the product moved by conveyor to NuWest's nearby fertilizer plant. NuWest alleviated cash-flow problems by obtaining a $31 million loan from General Electric, secured by its Conda Partnership fertilizer operation.

Pumice.—Output of Idaho pumice decreased about 32% in quantity and nearly 19% in value from that of 1988. Two operations, one in Bonneville County and one in Oneida County, accounted for all of the reported production.

Idaho's largest pumice producer was Hess Pumice Products of Oneida County. With about 30 employees, the company operated a mine on Wrights Creek and a processing plant near Malad City. The fine-grained pumice had a wide variety of uses as a polishing medium and abrasive. Producers Products, a subsidiary of Builders Masonry Products, purchased Producers Pumice in 1988. The company had the only other active mine, the Rock Hollow Mine near Ammon, Bonneville County. All of the product was used for lightweight concrete aggregate.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

The estimated 1989 output of construction sand and gravel in Idaho decreased by 16% in quantity and 5% in value from that reported in 1988.

Industrial.—Industrial sand and gravel production dropped 5% in quantity but only 1% in value compared with that of 1988. Output came from three pits in three counties: Monsanto Industrial Chemicals Co. near Soda Springs, Caribou County; Unimin Corp. in Emmett, Gem County; and FMC Corp., Power County. Industrial sand was used in the following applications: glass containers, sandblasting sand, filtration medium sand, fiberglass manufacture, roofing granules, and for other applications. The gravel was used for nonmetallurgical flux.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—The production of crushed stone continued to decline in Idaho. The quantity of crushed stone produced in 1989 dropped almost 3% from that estimated in 1988 and 14% from what was reported in 1987. The value dropped nearly 4% compared with that of 1988 and 18% from the reported 1987 figure.

Crushed stone production was reported by 24 companies and governmental agencies in 15 counties. Bannock, Boundary, Caribou, Idaho, Kootenai, Madison, and Nez Perce Counties accounted for 80% of the State's total production. The counties of Idaho, Kootenai, and Caribou were the leading producers with more than 53% of the total.

Seven companies and government agencies accounted for 79% of the quantity produced and 73% of the value. The bulk of the crushed stone produced was traprock, which accounted for 63% of the total in 1989, followed by limestone, dolomite, granite, and quartzite. The top three uses for crushed stone—graded road base, unpaved road surfacing, and flux stone—accounted for nearly 74% of crushed stone sold or used in the State.

Dimension.—Three companies expanded production of Oakley stone in Cassia County. Idaho Quartzite Corp. shipped facing stone and sawed tiles, Northern Stone Supply Co. operated the Rocky Mountain Quartzite quarry, and Oakley Valley Stone also sold stone in 1989.

Zeolites.—Teague Mineral Products Co. mined zeolite from pits near Sheaville, Owyhee County. The company hauled the zeolites to its processing plant at Adrian, OR. Most of the product was used as a carrier for fungicides, in odor control, and as an animal feed supplement. Teague continued development of a high-grade deposit of zeolites near Oreana, Owyhee County.

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[1]State Mineral Officer, Bureau of Mines, Spokane, WA. He has covered the mineral activities in Idaho for 2 years. Assistance in the preparation of the chapter was given by W. A. Lyons, editorial assistant.

[2]Research geologist, Idaho Geological Survey, Boise, ID.

TABLE 2

IDAHO: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Filter stone	36	99
Coarse aggregate, graded:		
Bituminous aggregate, coarse	89	270
Bituminous surface-treatment aggregate	84	185
Coarse and fine aggregates:		
Graded road base and subbase	1,741	6,165
Unpaved road surfacing	395	1,085
Other construction materials[2]	167	564
Chemical and metallurgical: Flux stone	301	2,334
Other miscellaneous uses[3]	235	702
Unspecified:[4] Actual	249	1,206
Total[5]	3,298	12,609

[1]Includes limestone, granite, quartzite, and traprock.
[2]Includes stone used in concrete aggregate (coarse), railroad ballast, stone sand (concrete and bituminous mix or seal), crusher run or fill, riprap and jetty stone, and screenings (fine).
[3]Includes stone used in agricultural limestone, poultry grit and mineral food, cement manufacture, sulfur oxide removal, mine dusting, and roofing granules.
[4]Data represents production reported without a breakdown by end use.
[5]Data may not add to totals shown because of independent rounding.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Antimony:			
Sunshine Mining Co.	815 Park Blvd. Suite 100 Boise, ID 83702	Mine, mill, plant	Shoshone.
Cement:			
Ash Grove Cement West Inc.	5550 SW. Macadam Ave. Suite 300 Portland, OR 97201	Surface mine and plant	Bannock.
Clays:			
A. P. Green Refractories Co.	Box 158 Troy, ID 83871	Surface mine	Latah.
Interpace Corp.	3502 Breakwater Ct. Hayward, CA 94545	do.	Benewah.
E. J. Wilson & Sons	Dubois, ID 83423	do.	Clark.
Copper:			
Alta Gold Co.	2319 Foothills Dr. Suite 140 Salt Lake City, UT 84109	Mine and mill	Adams.
ASARCO Incorporated	Box 440 Wallace, ID 83873	Mine 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:			
Coeur d'Alene Mines Corp.	505 Front Ave. Box 1 Coeur d'Alene, ID 83814	Surface mine and leach plant	Valley.
NERCO Minerals Co.	111 SW. Columbia Suite 800 Portland, OR 97201	Surface mine, mill, leach plant	Owyhee.
Pioneer Metals Corp.	7275 Franklin Rd. Boise, ID 83709	Surface mine and leach plant	Valley.
United States Antimony Corp.	Box 643 Thompson Falls, MT 59873	Mine and mill	Custer.
Lead:			
Bunker Hill Mining Co. Inc.	Box 29 Kellogg, ID 83837	do.	Shoshone.
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.

TABLE 3—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Phosphate rock:			
Conda Partnership	Box 37 Conda, ID 83230	Surface mine and plant	Caribou.
Monsanto Co.	Box 816 Soda Springs, ID 83276	Surface mine	Do.
J. R. Simplot Co.	Box 912 Pocatello, ID 83201	Surface mine and plant	Bingham and Caribou.
Stauffer Chemical Co., a subsidiary of Rhone-Polenc Co.	Box 160 Montpelier, ID 83254	Surface mine	Caribou.
Pumice:			
Hess Pumice Products	Box 209 Malad City, ID 83252	Quarry and plant	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 83702	Mine, mill, refinery	Shoshone.
Stone:			
Crushed:			
Monsanto Co.	Box 816 Soda Springs, ID 83276	Quarry	Idaho.
Poe Asphalt Paving Inc.	P.O. Box 449 Lewiston, ID 83501	Quarries	Various.
Seubert Excavators Inc.	Box 57 Cottonwood, ID 83522	do.	Idaho.
U.S. Forest Service	324 25th St. Ogden, UT 84401	do.	Various.
Dimension:			
Northern Stone Supply Inc.	Box 249 Oakley, ID 83346	Quarry	Cassia.
Vanadium:			
Kerr-McGee Chemical Corp.	Box 478 Soda Springs, ID 83276	Plant	Caribou.
Zinc:			
Bunker Hill Mining Co. Inc.	Box 29 Kellogg, ID 83837	Mine and mill	Shoshone.
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d' Alene, ID 83814	do.	Do.

THE MINERAL INDUSTRY OF ILLINOIS[1]

This chapter has been prepared under a Memorandum of Understanding between the 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 Doss H. White, Jr.[2]

In 1989, Illinois nonfuel mineral production was valued at $633.4 million, a new State record. This was the first year that mineral value exceeded $600 million. Crushed stone, portland cement, and construction sand and gravel were the three leading commodities, accounting for 76% of the State's nonfuel mineral value. This illustrated the mineral industry's dependency on the health of the construction industry in Illinois and surrounding States. The State continued to rank 17th in total mineral value.

TRENDS AND DEVELOPMENTS

During the past 10 years, Illinois nonfuel mineral production has added $4.8 billion to the State's economy and created thousands of jobs in the mining and mineral processing industries and support industries. Production had an up-and-down pattern during the first half of the decade, but it rose steadily during the last half. In 1980, nonfuel mineral output was valued at $443 million. Value declined in both 1981 and 1982, a result of the nationwide recession. In 1984, the industry recovered, and value climbed to almost $472 million. The following year, a $27 million decline in crushed stone sales drove the State value $12 million below the figure estimated for 1984. Increased sales of other mineral commodities were not sufficient to overcome the significant decrease in stone value. The next four years, 1986–89, saw a steady increase in demand and sales until a record $633 million was achieved in 1989.

An increase in the sales of nonconstruction mineral commodities has been a significant trend during the past 10 years. The value of mineral commodities marketed outside the construction arena has increased 9% during this period. In 1980, the construction mineral commodities, cement, clays, construction sand and gravel, and crushed stone, accounted for 85% of the State's nonfuel mineral value. Five years later, construction mineral commodity sales had declined to 74% of the Illinois total mineral value; in the 1985–89 period, those mineral commodities used in construction averaged 74.8% of the total nonfuel value.

Although output of three of the construction mineral commodities increased in 1989 over the production reported for 1988 (portland cement, 20.3%; construction sand and gravel,

TABLE 1

NONFUEL MINERAL PRODUCTION IN ILLINOIS[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	2,119	$86,210	2,307	$101,760	2,776	$117,224
Clays[2]	metric tons	211,328	977	163,571	704	142,207	641
Gem stones		NA	15	NA	30	NA	W
Sand and gravel:							
Construction	thousand short tons	e28,300	e93,300	30,098	93,504	e33,000	e108,900
Industrial	do.	4,346	45,547	4,328	56,142	4,582	52,935
Stone:							
Crushed	do.	52,102	216,212	e57,900	e251,200	[3]60,829	[3]256,832
Dimension	short tons	W	W	e1,175	e129	W	W
Combined value of barite (1989), cement (masonry), clays (fuller's earth), copper, fluorspar, lead, lime, peat, silver, stone (crushed sandstone, 1989), tripoli, zinc, and values indicated by symbol W		XX	74,945	XX	84,157	XX	96,829
Total		XX	517,206	XX	587,626	XX	633,361

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

9.6%; and crushed stone, 5.2%), the number of private and public residential units permitted fell 13.8%, and the value of nonresidential construction declined almost 1.2%. State road contract value, however, increased 27.6%, which apparently offset the losses in the residential construction sector.

An emerging trend in the State's fuel sector was a shift from surface to underground production. In 1988, 39 million short tons of coal was produced from underground mines and 26 million tons by surface operations. In 1989, 40.5 million tons was mined underground, and 19.6 million tons was recovered at surface mines. The depletion of the thicker, near-surface coal beds was cited as the primary reason for the shift.

Past underground coal mining accounted for one of the environmental problems in Illinois. Homes in the Belleville and Fairview Heights area of St. Clair and Madison Counties have been affected by mine subsidence. The area was mined in the early 1940's, and a 1985 report noted that almost 17% of the two counties was underlain by abandoned coal mines.[3] In May, a Dorris community school was damaged because of subsidence. Temporary repairs allowed the school to remain open.[4]

Coal output was affected by a series of wildcat strikes extending from June 19th to July 17th. The strikes were a show of support for striking miners in Kentucky, Virginia, and West Virginia. At their peak, the strikes idled about 8,600 Illinois miners and closed almost 40 mines.[5]

Several developments, both in the industrial minerals and the metals sector, were in the news. Lonestar Industries announced plans to supplement fuel requirements at its Oglesby cement plant with solvent wastes, and Northwestern University received a $1.75 million grant for an advanced cement-based materials center. Unimin Corp., one of Illinois' two major tripoli producers, acquired the other, Illinois Minerals Co., from Georgia Kaolin Co.

In the metals sector, National Steel Corp. began work in April on a second continuous caster at its Granite City Division. Acme Steel Co., Riverdale, purchased a steel stripping plant in Alabama and a tube manufacturer in Ohio. Laclede Steel Co., Alton, announced a $25-million expansion to its Alton plant. LTV Steel Corp. sold its steel bar division to an employee stock ownership plan (ESOP), and Northwestern Steel and Wire Co. began work on a $25 million expansion at its Sterling mill.

Reynolds Metals Co.'s McCook aluminum sheet and plate plant was scheduled for a $30 million expansion to be completed in 1991.

EMPLOYMENT

Mining and quarrying employment, including coal mining and oil and gas production, totaled 19,500 in 1989. This was a 7.58% decrease from the 21,100 reported in 1988. The average hourly wage was $16.46, up 1% from the $16.34 noted in 1988. Average hours worked per week rose from 39.9 in 1988 to 42.9 in 1989, a 7.52% increase.

Coal employment alone accounted for 11,105 jobs, about 57% of the total mineral sector work force. Surface mines employed 2,376 workers and underground mines employed 8,729.

Steel industry employment rose 4.64% from 23,700 in 1988 to 24,800 in 1989. Wages, however, fell from $14.14 per hour in 1988 to $13.91 per hour in 1989, a decline of 1.63%. This wage decline was slightly offset by a longer average workweek, 44.9 hours a week in 1988 compared to 45.1 hours in 1989.

REGULATORY ISSUES

The closed and abandoned Taracorp lead smelter near Granite City in Madison County was cited as a potential health hazard by both State and Federal environmental agencies. Cleanup costs could reach $50 million. The smelter, which operated from the turn of the century until 1982, generated a 250,000-ton mound of lead-rich slag. Lead levels in the mound were 40 times higher than Federal standards, and earth in a half-mile circle of the smelter contained triple the standard. A State Environmental Protection Agency spokesperson said that the smelter risk was "real, but not immediate." A cleanup plan was to be formulated in 1990.[6]

EXPLORATION ACTIVITIES

Both fuel and nonfuel exploration activity was reported during the year. Coal exploration increased slightly; approximately 189 holes were drilled in the southern Illinois coal field. In east-central Illinois, Consolidated Coal Co. drilled 47 exploration holes to define the low-sulfur Danville coalbed.

Ozark-Mahoning had five diamond core drills active in the Illinois portion of the Illinois-Kentucky fluorspar district. One active and four pending prospecting permits were on file with the U.S. Bureau of Land Management for the Shawnee National Forest. These were for fluorspar and associated minerals. Development or exploration drilling for tripoli was ongoing on private land.[7]

LEGISLATION AND GOVERNMENT PROGRAMS

Several bills affecting the mining industry, directly or indirectly, were enacted into law in 1989. Public Act 86-1057, the Interagency Wetland Act of 1989, established a goal of no overall net loss to the State's existing wetlands or their functional value because of State-supported activities. The act established a State wetland mitigation policy and provided for a wetland committee to coordinate activities and to develop rules and regulations. In certain instances, this law could restrict or deny mining in wetlands and could directly impact peat mining.

Public Act 86-1075 amended the Abandoned Mined Lands and Water Reclamation Act to allow the Abandoned Mined Land Reclamation Council to expend money for reclamation of lands mined for minerals other than coal. Expenditures were limited to 2% of the Council's annual budget, about $1 million over the next 5 years. Under the act, the Council has the authority and funds to reclaim lead-zinc mines in the northwestern part of the State and fluorspar in the southeast.

Public Act 86-0236 required the transferor of real property to disclose information concerning mine subsidence and subsidence insurance to the transferee and lender.

The Illinois State Geological Survey (ISGS) was reorganized into the Mineral Resource, Minerals Engineering, and Environmental Geology and Geochemistry Branches. A pilot study was begun to examine the impacts of geological, political, and legal factors on coal resource availability. Work continued on methods to physically clean coal and recover fine coal particles currently lost during coal cleaning. The U.S. Environmental Protection Agency awarded the State $2.4 million in matching funds for a 4-year program designed to improve recovery of oil from Illinois subsurface petroleum reservoirs. Work was ongoing to prepare maps and cross sections for selected oil-producing regions depicting the depth of ground water containing 10,000 parts per million of total dissolved solids. The information will be used by the Illinois Department of Mines and Minerals to regulate the depth to which oil producers must set surface casing. In cooperation with the Indiana, Kentucky, and Missouri Geological Surveys and the U.S. Geological Survey, work continued on the Paducah CUSMAP project. Detailed cross sections of the Sauk Sequence will be used to evaluate mineral resource potential. Aggregate resource assessments continued from analysis of cores drilled in south Cook County.

The Illinois Department of Mines and Minerals regulates the mining and oil and gas industries. During 1989, the agency rewrote the State Explosives Act and significantly amended the Oil and Gas Act (amendments enacted as Public Act 86-0364). The department continued its training in mine safety, emergency preparedness, explosives handling, and emergency medical training. Work began on developing an oil, gas, and injection well location and ownership data base.

U.S. Bureau of Mines scientists from the Intermountain Field Operations Center in Denver, CO, began to evaluate the mineral potential of the Shawnee National Forest. Bureau of Mines research personnel cooperated with specialists from the Illinois Mine Subsidence Insurance Fund on a long-term program of subsidence data analysis on abandoned underground mining areas. Bureau research personnel published papers on (1) subsidence monitoring, (2) pillar failure in weak-floor underground mines, and (3) foundation response to subsidence (relating to the problem in Illinois).

In 1989, the Bureau of Mines granted the Southern Illinois University Mineral Institute $324,000 to continue various facets of mineral research.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Industrial minerals production and sales accounted for approximately 99% of the Illinois mineral value in 1989. There were 436 industrial mineral mines in operation during 1989, according to the U.S. Mine Safety and Health Administration.

Cement.—The Illinois cement industry produced both portland and masonry cement. Portland cement value ranked second in the State's industrial mineral output and accounted for 19% of the mineral value. The State ranked 8th among the 38 portland cement-producing States and 27th among the 36 States with masonry cement production.

Portland cement production increased 469,000 short tons over that reported in 1988; output has increased every year since 1981. Masonry cement output declined 20%, and value fell almost 28% in 1989, the second consecutive year that tonnage and value fell.

The industry consisted of four companies operating dry-process clinker grinding facilities in the Dixon-La Salle-Oglesby area of northern Illinois and at Joppa on the Ohio River in southern Illinois. The three northern plants produced both portland and masonry cement, while output from the southern facility was limited to portland cement. The State's cement production was marketed in several northern States and throughout the South, including Alabama, Kentucky, Louisiana, Missouri, and Tennessee.[8]

Lone Star Industries Inc. announced that it would implement a supplemental fuel program at its Oglesby cement plant using waste materials to replace a portion of the coal and petroleum coke used for kiln fuel. The firm submitted applications in December for the necessary permits to burn the waste. When the program is implemented, around mid-1990, solvent waste will replace approximately 40% of the solid fuel previously used.

Northwestern University at Evanston received a $1.75 million grant from the National Science Foundation for the development of a center for advanced cement-based materials. The grant was the first in a 5-year program expected to cost approximately $10 million. The goal of the program was to design and create cement-based materials that would be stronger, lighter, more energy efficient, and less costly. The new cement materials were scheduled for use in the construction and restoration of the Nation's infrastructure.[9]

In the spring, Lafarge Coppee anchored a cement silo ship in Chicago's Lake Calumet Harbor and began distributing cement from the vessel.[10]

Clays.—The Illinois clay industry produced both common clay and fuller's earth. Clay value ranked sixth among the 12 industrial minerals mined or manufactured, but accounted for less than 5% of the total value. The industry ranked 32nd in tonnage among the 43 States reporting common clay and shale output and 3rd among the 9 States with fuller's earth production.

Common Clay.—Five companies produced common clay, a substance sufficiently plastic to permit ready molding and with a vitrification level usually below 1,100 degrees Celsius. The clay mining operations were located in the Kankakee, La Salle, and Livingston Counties area in north-central and northeastern Illinois and in Bond County in the southeastern part of the State. The clay was mined by surface methods and trucked to brick plants where it was shredded, extruded, cut into brick-size pieces, fired, and placed on pallets for shipping.

Production, 142,000 tons, was 22,000 short tons below the 1988 level; value declined from $704,000 in 1988 to $641,000 in 1989. This was the third consecutive year that clay production fell. Leading end uses were face brick, cement, and drain tile.

Fuller's Earth.—Two firms, American Colloid Co. and Lowe's Clay Inc., mined and processed fuller's earth, a clay with superior absorbent properties. Both firms used surface mining methods followed by drying, crushing, calcining, and screening to produce a material marketed as an pet waste absorbent and as an agricultural products carrier. Output rose more than 35%, and value increased about 27%.

Fluorspar.—Illinois again was the leading State, and one of two, with fluorspar production. Over 98% of the Nation's fluorspar production was mined in Illinois. Production and value each increased almost 6%. Fluorspar, the commercial name for the mineral fluorite, a calcium fluoride, ranked seventh in value among the State's 12 industrial minerals.

Ozark-Mahoning Co., a subsidiary of Atochem North America Inc., operated three mines and a flotation plant in Pope and Hardin Counties in southeastern Illinois. The company also imported dried fluorspar to supplement production. Seaforth Mineral & Ore Co. Inc. dried imported fluorspar at its facilities at Cave-In-Rock for sale to the ceramic industry.

Ozark-Mahoning reopened the former Inverness Mining Co. Minerva No. 1 mine acquired from Seaforth in December 1988. Ozark completed the mine rehabilitation in December 1989 and planned to initiate production in January 1990.

Lime.—The State maintained its seventh place ranking among the 32 lime-producing States. Marblehead Lime Co. produced quick and hydrated lime at its plant in south Chicago and quicklime at its Thornton plant. Vulcan Materials Co. produced quicklime at its plant in McCook. The steel industry remained the lime producers' principal customer; however, increased sales to powerplants and chemical firms were anticipated. Output increased approximately 4%, while value was up about 5%.

Peat.—Illinois fell from fourth to sixth among the 21 States reporting peat production. Three firms, one less than in 1988, harvested peat in Lake and Whiteside Counties. Reed-sedge was the predominant peat type sold, followed by hypnum and sphagnum. Sales were for general soil improvement. Production plummeted almost 43%, and value dropped about 25%.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Illinois rose one position to eighth among the 50 states with construction sand and gravel production. The estimated construction sand and gravel production, 33 million short tons valued at $109 millon, ranked third in Illinois mineral value. Sand and gravel sales accounted for 17% of the State's nonfuel mineral value.

In 1988, the last year that the industry reported full-year statistics, 107 companies operated 157 mines in 55 counties. Most of the mines (83%) were conventional, dry-land operations, while 17% used dredges in the mining operation. Over 50% of the total tonnage mined came from the Kane, Lake, and McHenry Counties contiguous area in northeastern Illinois.

Industrial.—The State's five industrial sand producers maintained their first-place ranking among the 38 States with industrial sand output. Production, 4.6 million short tons, increased 254,000 tons over the 1988 level. Value, however, fell about $3.2 million because of a unit price decrease that resulted from out-of-State competition.

The five producers operated seven mines, one less than in 1988, in La Salle and Ogle Counties in the north-central part of the State and in Mason County in west-central Illinois. The five leading end uses, accounting for about 83% of the sales, were foundry molds and cores (30%), glass container manufacture (28%), flat glass manufacture (11%), chemical manufacture/processing (7%), and hydraulic fracturing (7%). Unit prices varied from a high of almost $74 for ground fillers to $7.68 for chemical manufacture and processing.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Stone continued to rank as the principal mineral commodity produced in Illinois, both in output and sales. Production and value in 1989, 61 million short tons valued at $257 million, exceeded that reported by industry in 1987 by almost 9 million short tons and $43 million. Crushed stone production was reported from 179 quarries, 20 less than in 1987. Limestone, dolomite, and sandstone were quarried and crushed by 103 companies operating in 54 counties. The five leading counties, Cook, Du Page, Hardin, St. Clair, and Winnebago, accounted for 54% of the output.

Production of limestone and dolomite was reported by 102 companies, dolomite only by 16, and sandstone by 1. The five leading end uses reported were graded road base (12.1 million short tons), concrete aggregate (6.1 million short tons), agricultural limestone (4.1 million short tons), bituminous aggregate (3.6 million short tons), and cement manufacture (3 million short tons).

The Bureau of Mines compiles crushed stone statistics by districts for some States. Table 3 presents end-use data for crushed stone produced in the four Illinois districts depicted in the State map.

Material Service Corp.'s Thornton quarry held its first open house in September. An estimated 15,000 people attended the event. Those attending were introduced to the quarry operations and mining and crushing equipment and observed a production blast.[11] The Thornton quarry and plant were awarded a runner-up prize in the Sentinels of Safety contest during the year for an injury-free record in 1988.

The U.S. Congress granted $419 million to the Chicago Metropolitan Sanitary District for conversion of two quarries into reservoirs for sewage and stormwater runoff. Plans were for part of Vulcan Materials Co.'s quarry in McCook to be turned into a 10-billion-gallon reservoir and part of Vulcan's Thornton quarry to be used as an 8-billion-gallon reservoir.[12]

Two of Illinois' crushed stone quarries ranked in the top 10 nationally. These were the McCook quarry of Vulcan Materials Co. and the Thornton quarry of Material Service Corp.[13]

Dimension.—One firm, Rein Schultz & Dahl Inc. of Illinois, Fox River Stone Co. division, produced dolomite from a quarry in Kane County. The dolomite was marketed as quarry-run material for riprap and finished for veneer and flagging.

Tripoli.—The State maintained its first place ranking among the four

TABLE 2

ILLINOIS: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	865	3,550
Riprap and jetty stone	642	3,416
Filter stone	191	768
Coarse aggregate, graded:		
Concrete aggregate, coarse	6,111	24,851
Bituminous aggregate, coarse	3,627	17,552
Bituminous surface treatment aggregate	1,048	4,525
Railroad ballast	234	1,033
Fine aggregate (−3/8 inch):		
Stone sand, concrete	870	3,175
Stone sand, bituminous mix or seal	327	1,495
Screening, undesignated	997	3,912
Coarse and fine aggregates:		
Graded road base or subbase	12,089	44,002
Unpaved road surfacing	2,229	8,417
Crusher run or fill or waste	426	1,781
Other construction material[2]	1,274	4,550
Agricultural: Agricultural limestone and poultry grit and mineral food	4,146	14,645
Chemical and metallurgical: Cement manufacture	2,979	9,690
Special: Other fillers or extenders	799	25,000
Other miscellaneous uses[3]	1,341	4,449
Unspecified:[4]		
Actual	17,258	66,554
Estimated	3,377	13,466
Total[5]	60,829	256,832

[1] Includes limestone, and dolomite; sandstone withheld to avoid disclosing company proprietary data.
[2] Includes stone used in coarse and fine aggregates, large and graded.
[3] Includes stone used in lime manufacture, flux stone, chemical stone for alkali works, mine dusting or acid water treatment, asphalt and other fillers or extenders, and roofing granules.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

States with tripoli output. Tripoli, a microcrystalline silica, was used as an abrasive and for filler and extender applications. Two firms, Illinois Minerals Co. and Tammsco Inc. in Alexander County in southern Illinois, mined and processed tripoli. Both firms operated surface mines, and Illinois Minerals also operated underground mines. According to company production and value data, tripoli production decreased slightly, but value increased over 250%. The apparent anomaly was caused by a three-fold change: (1) less tripoli was sold to the abrasives industry and more to the filler industry and filler commanded a higher unit price, (2) there was an across-the-board increase in unit value, and (3) a change in reporting procedures.

Other Industrial Minerals.—Barite and slag were recovered as a result of the beneficiation of other minerals and iron and steel production. Barite was recovered by Ozark-Mahoning during the flotation of fluorspar at the plant near Rosiclare in Hardin County. Iron and steel slag, a byproduct of metal making, was marketed for road base material, asphaltic concrete, mineral wool, railroad ballast, and fill. Illinois ranked 8th of 12 States in iron slag output and 10th of 25 States in steel slag production.

A variety of mineral commodities mined in other States or imported from foreign sources were shipped into Illinois for processing into higher value products. Gypsum mined in Michigan was calcined by National Gypsum Co. for wallboard manufacture at a plant in Waukegan, Lake County. Finished iron oxide pigments were manufactured by three companies in Adams and Sangamon Counties in the west-central part of the State and in St. Clair County in southwestern Illinois.

Crude perlite was expanded by three firms, Silbrico Corp., Strong Lite Product Corp., and Manville Products Corp. The crude perlite, a rock of volcanic origin, was obtained from mines in Western States. Leading end uses were for filler, insulation, and acoustical tile. Sulfur was recovered by Marathon Oil Co., Shell Oil Co., the Uno-Ven Co., and Mobil Oil Corp. at refineries in Crawford, Madison, and Will Counties. Production and value, 252,700 metric tons valued at $21.9 million, were slightly lower than the 257,700 metric tons and $22.4 million reported in 1988. Crude vermiculite was exfoliated at plants in Du Page and La Salle Counties. The crude material was mined in South Carolina, Montana, and Virginia. After exfoliation, the vermiculite was sold to the insulation, fireproofing, and concrete aggregate industries.

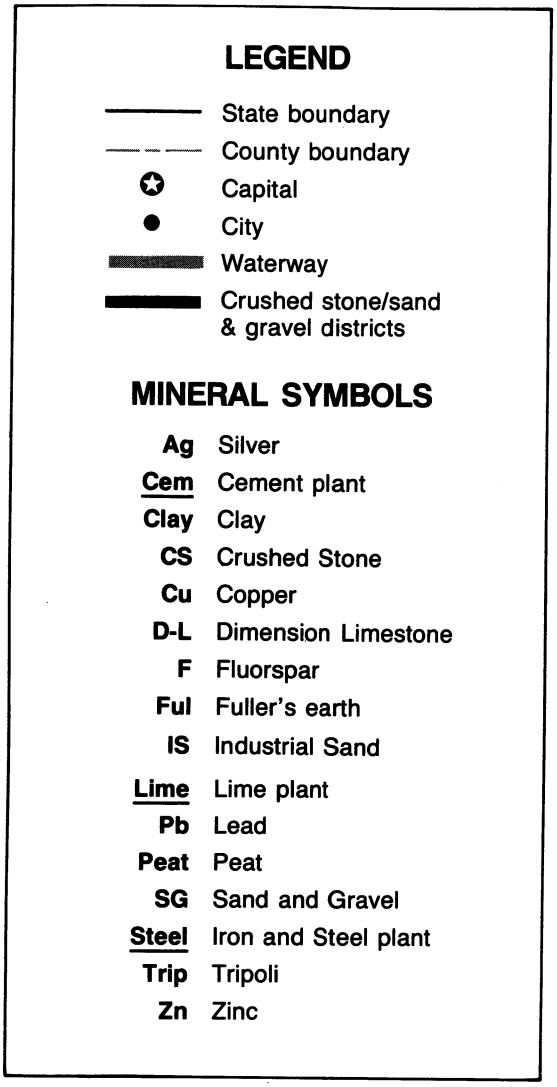
Metals

All metals produced from ores mined in Illinois were recovered as a byproduct of fluorspar beneficiation. The State continued as a major iron and steel producer using ore and scrap obtained from a variety of geographical locations.

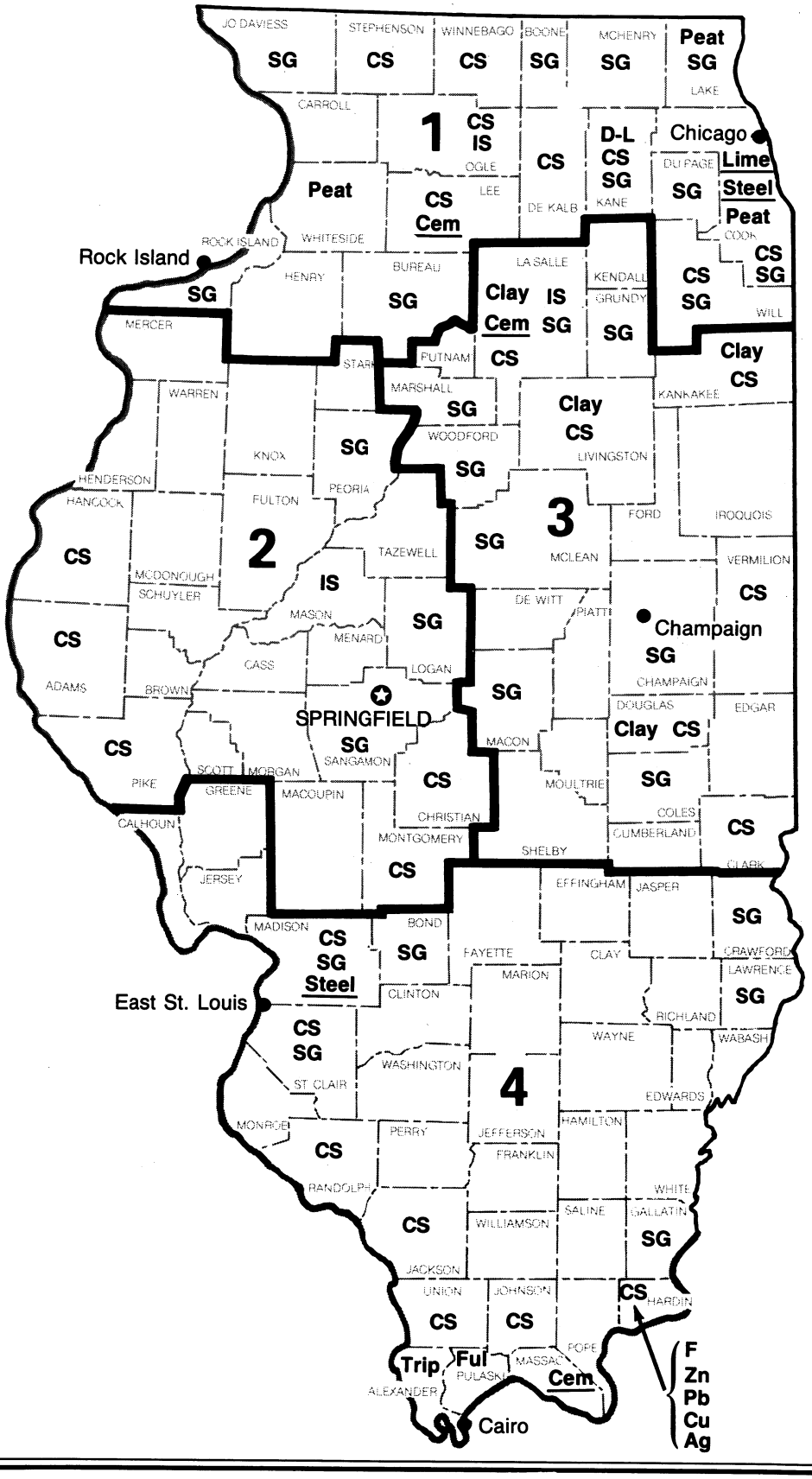
Copper, Lead, Silver, and Zinc.—The four metals were recovered as coproducts of fluorspar beneficiation. Ozark-Mahoning Corp operated two fluorspar mines in Harding and Pope Counties and a flotation plant near Rosiclare. Recovery of copper fell almost 8%, and lead and zinc recovery increased by about 12% and 18%, respectively. Silver output was somewhat higher than that reported in 1989.

The Zinc Corp. of America, formerly the New Jersey Zinc Co., reopened its Depue plant for 2 months to produce a special grade zinc dust. Dust

ILLINOIS



Principal Mineral-Producing Localities


JO DAVIESS
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WHITESIDE
ROCK ISLAND
Rock Island
HENRY
BUREAU
LA SALLE
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MERCER
STARK
PUTNAM
MARSHALL
WARREN
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FORD
IROQUOIS
MCDONOUGH
SCHUYLER
TAZEWELL
MCLEAN
VERMILION
DE WITT
PIATT
MASON
MENARD
Champaign
CASS
LOGAN
CHAMPAIGN
ADAMS
BROWN
SPRINGFIELD
DOUGLAS
EDGAR
SANGAMON
MACON
SCOTT
MORGAN
PIKE
GREENE
MACOUPIN
MOULTRIE
COLES
CALHOUN
CHRISTIAN
CUMBERLAND
MONTGOMERY
SHELBY
CLARK
JERSEY
EFFINGHAM
JASPER
MADISON
BOND
FAYETTE
CLAY
CRAWFORD
MARION
LAWRENCE
East St. Louis
CLINTON
RICHLAND
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MONROE
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SALINE
GALLATIN
WILLIAMSON
JACKSON
UNION
JOHNSON
HARDIN
POPE
MASSAC
Trip
Ful
PULASKI
Cem
ALEXANDER
Cairo
1
2
3
4
SG
CS
IS
Peat
Clay
Cem
D-L
Lime
Steel
F
Zn
Pb
Cu
Ag

TABLE 3

ILLINOIS: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Constructions aggregates:								
Coarse aggregate (+1 1/2 inch)[1]	840	4,069	287	1,040	182	1,012	406	1,648
Coarse aggregate, graded[2]	6,951	30,640	508	2,214	2,108	9,801	1,756	6,446
Fine aggregate (−3/8 inch)[3]	1,360	5,456	187	730	301	1,273	805	2,750
Coarse and fine aggregates[4]	9,625	35,515	941	3,020	1,926	7,207	2,387	8,992
Other construction aggregates	26	100	13	36	84	225	235	857
Agricultural[5]	532	1,623	592	2,739	1,144	5,090	1,878	5,194
Chemical and metallurgical[6]	W	W	—	—	W	W	1,574	5,760
Special[7]	—	—	W	W	W	W	199	714
Other miscellaneous	1,193	3,547	672	24,392	1,481	4,726	—	—
Unspecified:								
Actual[8]	12,762	47,386	1,250	4,990	1,361	5,894	1,885	8,284
Estimated[9]	1,662	6,316	506	2,199	381	1,744	827	3,207
Total[10]	34,950	134,651	4,958	41,359	8,967	36,970	11,953	43,851

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[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 graded coarse aggregates.
[3] Includes stone sand (concrete), stone sand (bituminous mix or seal), and fine aggregate (screening-undesignated).
[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run or fill or waste.
[5] Includes agricultural limestone and poultry grit and mineral food.
[6] Includes crushed stone for cement manufacture, lime manufacture, flux stone, chemical stone for alkali works, and sulfur oxide removal.
[7] Includes crushed stone for mine dusting or acid water treatment, asphalt fillers or extenders, other fillers or extenders, and roofing granules.
[8] Includes production reported without a breakdown by end use.
[9] Includes estimates for nonrespondents.
[10] Data may not add to totals shown because of independent rounding.

demand could not be met at the company's plant in Pennsylvania. The Depue plant closed in January 1988.[14]

Iron and Steel.—Illinois retained its fifth-place ranking in United States steel production, according to the American Iron and Steel Institute. The State's steel companies produced 7.5 million short tons of steel in 1989.[15]

Steel workers at Laclede Steel Co., Alton, and National Steel Corp.'s Granite City Division, Granite City, ratified a 4-year contract in September. Hourly and incentive wage rates were increased, and pension benefits and cost-of-living adjustment improvements were included in the new contract.[16]

National Steel Corp. began installation of a second continuous caster at its Granite City Division. The $140 million project, which began in April, was scheduled for completion in late 1990. When completed, National Steel will be the first U.S. company to cast 100% of its steel products.[17]

Acme Steel Co. of Riverdale completed acquisition of two companies during 1989 to further its strategy of focusing on downstream integration to provide markets for its flat-rolled steel. In March, the company completed purchase of a steel strapping facility in Leeds, AL, previously owned by A.J. Gerrard & Co. of Des Plaines. The acquisition will allow the company to better serve its customers in the South. In May, Acme completed acquisition of Alpha Tube, a subsidiary of Sudbury Inc. based near Toledo, OH. Alpha Tube is a manufacturer of welded carbon steel tubing for mechanical and structural applications in household and patio furniture, automotive parts, construction, agriculture, and other durable goods.

Laclede Steel Co. announced plans in May to increase steelmaking capacity and to install an electric furnace to treat dust at its Alton plant. The $25 million expansion includes a ladle crane to improve steel handling in the electric-melt shop and equipment to boost capacity to produce skelp, flat pieces of steel used to make pipe. The expansion will increase capacity by 65,000 short tons per year from the current 860,000 tons. The dust treatment furnace will remove zinc, which is considered hazardous, and recover it for reuse in galvanized steel.

The LTV Steel Corp. sold its steel bar division for almost $22 million in the last quarter of 1989. The division had been for sale for over a year. An ESOP made up of the division's 3,900 members of the United Steel Workers of America union and 1,050 management employees purchased the division. No wage concessions were included in the buyout. According to the ESOP, union members will hold 76% of the stock in the new company and management personnel 24%. The new company is called Republic Engineered Steels Inc. and has major plants in Canton and Massillon, OH, and smaller plants in Chicago, IL, Gary, IN, Beaver Falls, PA, and Willimantic, CT.

Construction began on a $25 million three-strand jumbo-beam blank continuous caster in the last quarter of 1989 at Northwestern Steel & Wire Co.'s Sterling, IL, mill. The new casting machine, scheduled for December 1990 completion, will provide semifinished beam blanks for Northwestern's wide-flange mill in Houston. Northwestern Steel acquired the Houston facility from Armco Inc. in June 1989 for $150 million. The new casting facility will allow the company to take full advantage of its electric furnaces, raising steelmaking capacity from 1.5 million short tons to about 2.4 million short tons annually.

Other Metals.—Reynolds Metals Co. announced in mid-December that it would expand and update its McCook, IL, plant at a cost of about $30 million to meet increased domestic demand and to allow the company to expand abroad. The McCook plant produces aluminum sheet and plate for the aircraft and aerospace industries. The expansion, scheduled for 1991 completion, will increase Reynolds plate production capacity by 16% to 80 million pounds annually. The project also will increase the plant's machining capacity for aircraft wingskins by 50%. Reynolds, based in Richmond, VA, is the second-largest aluminum producer in the United States.

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[1] A portion of the information in this chapter was developed by the late James J. Hill. Mr. Hill was the State Mineral Officer from 1979 until his death in 1990.

[2] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL. He has 29 years of industry and government experience and has covered the mineral activities in Illinois for 1989. Assistance in the preparation of the chapter was given by Wanda West and Maylene Hubbard, editorial assistants.

[3] Belleville Journal. Task Force Chairman Warns of Mine Subisdence (sic) Hazard. Mar. 27, 1989.

[4] Jerseyville News Journal. Mine Subsidence Hits Dorris School. May 3, 1989.

[5] St. Louis Post-Dispatch. Coal Mining Nearing Normal. July 30, 1989.

[6] St. Louis Post-Dispatch. Granite City Smelter Cleanup Estimated Up to $50 Million. Oct. 6, 1989.

[7] Mining Engineering. State Activities, 1989. May 1990, V. 42, No. 5, p. 443.

[8] Metropolis Planet. Building on a 26-year Heritage. Aug. 18, 1989.

[9] Rock Products. $1.75 Million Awarded for Cement Center. Mar. 1989, V. 92, No. 3, pp. 21, 23.

[10] ———. Another Floating Silo for Chicago. Mar. 1989, V. 92, No. 3, p. 7.

[11] Chicago Daily Calumet. Quarry Day a Real Blast. Sept. 11, 1989.

[12] Rock Products. Chicago to Convert Quarries to Reservoirs. Jan. 1989, V. 92, No. 1, p. 24.

[13] ———. 1989's Top Crushed Stone Plants. May 1990, V. 93, No. 5, p. 49.

[14] La Salle Daily News-Tribune. Depue Zinc Plant to Reopen for Two Months "One Shot Deal". Apr. 8, 1989.

[15] Indianapolis Star. Indiana Still Top Steel State. Feb. 1, 1990.

[16] St. Louis Post-Dispatch. Steel Contract approved at Alton, Granite City. Oct. 3, 1989.

[17] ———. Continuous Caster to Cut Costs. Jan. 11, 1989.

TABLE 4

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.	Box 120 Anna, IL 62906	Pit and plant	Pulaski.
Lowe's Southern Clay Inc.	348 South Columbia South Bend, IN 46624	do.	Do.
Richards Brick Co.	234 Springer Ave. 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):			
Pfizer 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	do.	Cook.
Granite City Div. of National Steel Corp.	Box 365 Granite City, IL 62041	Iron and steel furnaces	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	Cook.
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 footnote at end of table.

TABLE 4—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 (1988):			
Feltes Sand & Gravel Co. Inc.	RR 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.	258 Elm St. New Canaan, CT 06840	Pits and plants	La Salle and Ogle.
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	Pit and plant	La Salle.
Wedron Silica Co.	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, Pulaski, St. Clair, Union.
Material Srvice 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 footnote at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sulfur (recovered):			
Marathon Oil Co.	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:			
Illinois Minerals Co., a subsidiary of Georgia Kaolin Co.	2035 Washington Ave. Cairo, IL 62914	Underground and open pit mines and plant	Alexander.
Tammsco Inc.	Box J Tamms, IL 62988	Underground mine and plant	Do.
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 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 Wanda J. West [1]

Buoyed by record production and/or prices for several commodities, the value of nonfuel mineral production in Indiana increased for the seventh consecutive year to a record $434.1 million in 1989. Record-high total values were set for portland cement, gypsum, construction sand and gravel, crushed stone, and dimension stone. Ranking 24th nationally in the value of nonfuel mineral production, the State was the leading supplier of dimension stone and ranked second and third, respectively, in sales of masonry cement and peat. Although no metallic ores were produced within its boundaries, Indiana was a major processor of metals, ranking first in pig iron and raw steel production and fourth in aluminum output.

Portland cement, construction sand and gravel, and crushed stone, the leading industrial minerals produced, each registered gains over 1988 production levels. Together they accounted for 79% of the State's nonfuel mineral value. Increased output of these materials reflected a strong demand by the construction industry in 1989. The value of State road contract awards totaled $794 million, an increase of nearly 73% over that of 1988.[2] According to the Indiana Mineral Aggregates Association, extensive rehabilitation of interchanges and pavement along the Indiana Tollway and resurfacing of State highways were underway during the year. Housing construction also increased in 1989 with 26,473 private and public residential units authorized, about 5% more than in the previous year. Value of nonresidential construction declined 3%, however, from $1,537 million in 1988 to $1,498 million.

EMPLOYMENT

The Employment Security Division, Indiana Department of Employment and Training Services, reported that Indiana's civilian labor force totaled 2.88

TABLE 1

NONFUEL MINERAL PRODUCTION IN INDIANA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	422	$32,299	405	$27,442	357	$24,054
Portland	do.	2,320	103,177	2,315	107,179	2,364	108,297
Clays	metric tons	[2]940,451	[2]4,056	1,035,837	4,630	871,179	3,836
Gem stones		NA	10	NA	10	NA	W
Peat	thousand short tons	44	W	54	W	34	607
Sand and gravel:							
Construction	do.	e18,900	e65,200	25,923	79,985	e29,600	e99,200
Industrial	do.	230	1,357	362	1,829	W	W
Stone:							
Crushed	do.	31,067	106,770	e36,600	e130,000	[3]36,188	[3]136,252
Dimension	short tons	183,609	23,115	e195,444	e24,956	[3]198,531	[3]27,212
Combined value of abrasives, clays (fire clay, 1987), gypsum, lime, stone (crushed marl and miscellaneous, 1989; dimension sandstone, 1989), and values indicated by symbol W		XX	27,881	XX	30,358	XX	34,657
Total		XX	363,865	XX	406,389	XX	434,115

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

million, 64,000 persons more than in 1988. The State's unemployment rate dropped from 5.3% to 4.7%, the lowest since 1973 when the rate was 4.3%. In the mining and quarrying industry, however, employment dropped from 8,200 to 7,800. Average weekly earnings increased from $619.52 in 1988 to $666.31 in 1989. Average hours worked each week increased from 44 to 45.7, the highest average weekly hours among the Indiana goods- and service-producing industries.

Steel mill employment totaled 37,900 workers, a slight improvement over the 37,800 employed in 1988, but only about one-half of the peak 72,000 steel mill work force of 1973 and 1974. Average weekly earnings increased from $667.23 in 1988 to $703.08 in 1989, and average hours worked each week decreased from 44.1 to 43.4.

United Steelworkers of America union members approved new labor contracts with Bethlehem Steel Corp., Inland Steel Co., and National Steel Corp., replacing pacts due to expire on July 31, 1989. The 4-year contracts, each negotiated without a work stoppage, provided for wage increases and improvements in pensions and other benefits. Bethlehem and National Steel contracts also restored wage or benefit cuts taken by employees in the 1986 contracts, a concession not made by Inland workers in 1986.

EXPLORATION ACTIVITIES

According to the Indiana Geological Survey (IGS), exploration for industrial limestone deposits was carried out during 1989 while companies looked to growing markets. A significant part of the exploration was for high-calcium limestone suitable for sulfur dioxide emission control and for fillers. It was anticipated that Federal legislation regulating the burning of Midwestern coal with a high-sulfur content could expand the market for scrubber stone.

The Department of Natural Resources' (DNR) Division of Reclamation, which handles permits for coal exploration and mining, approved one permit application for exploration activities that proposed to remove less than 250 short tons of material. The division also received 36 notifications of intent to conduct exploration core drilling operations.

LEGISLATION AND GOVERNMENT PROGRAMS

The Indiana General Assembly passed several laws during 1989 that may impact the State's mineral industry. Public Law 75 of 1989 established the DNR as the permitting authority for actions involving filling, erecting permanent structures in, or removing material from, a navigable waterway. It also required the DNR to cooperate with the Department of Environmental Management in matters concerning water and land pollution.

Public Law 105 amended the Indiana Code concerning clean coal technology. While promoting the use of Indiana coal, the Act provided property tax deductions for clean coal systems and recovery of preconstruction costs of clean coal technology used at new or existing generating facilities.

Public Law 152 required that permits be obtained from the DNR for large quantity water withdrawals (100,000 gallons or more per day) from ground and surface water resources.

Public Law 169 required yearly permits for geophysical surveys for oil and gas and established bonding requirements to protect public interests. Drill holes for geophysical surveys were required to be plugged and abandoned in accordance with Natural Resources Commission rules.

The IGS staff continued research on Indiana's geology and mineral resources and disseminated information through a variety of technical papers, reports, maps, and oral presentations. A study on the effect of jointing on roof conditions in underground limestone mines was completed, and a map showing directions of bedrock jointing was issued. During a drilling project of Silurian rocks in northern Indiana, a 213-foot-thick limestone reef was discovered. Samples from the Howard County reef, which reportedly had potential for widespread use as crushed stone aggregate and as a possible source of high-calcium limestone, were submitted for chemical analyses. An updated map showing thickness of Silurian rocks and locations of reefs was in progress.

IGS personnel completed a field study of all active and abandoned underground limestone and dolomite mines in Indiana and the geologic factors affecting mine conditions. Since 1832, a total of 29 underground limestone mines have operated in the State with 6 currently active. Although the old mines generally were less than 200 feet below the surface, the study found that most have stable roofs and have produced very little surface subsidence.

IGS programs regarding the Salem Limestone of the southern Indiana building stone district sought to determine the cause of alkali staining on the stone and ways to prevent its occurrence. Another effort promoted the development and utilization of Salem Limestone. A directory of dimension stone quarry operations in Indiana was published.

Cooperative basin-wide studies with geological surveys of adjacent States continued. The Illinois, Indiana, and Kentucky Surveys formed the Illinois Basin Consortium to develop detailed geologic cross-section studies of the basin and a specific basin-wide study of the Springfield Coal Member of the Petersburg Formation. Mapping of the west-central Indiana part of the Illinois Basin, funded by the U.S. Geological Survey as part of its Cooperative Geologic Mapping Program, continued. A consortium was formed with the Ohio and Kentucky Surveys to study and assess the hydrocarbon potential of a Proterozoic sedimentary basin in parts of all three States.

During the fiscal year that ended June 30, 1989, the IGS issued 11 reports and 3 new and 70 revised maps. A current catalog of material published by the IGS, entitled "Geologic Publications of Indiana," is available from its Bloomington office.

The DNR's Division of Reclamation conducted a variety of programs to achieve its primary function of administration and enforcement of State and Federal laws regarding reclamation of lands disturbed by clay, coal, oil shale, and shale mining. Responsibilities included issuing permits to coal companies for exploration, mining, and processing activities; monthly inspections of nearly 400 sites, including active mines, mines under reclamation, and tipples or processing facilities; and enforcing permit requirements and assessing penalties where necessary. Other responsibilities included administering the mine subsidence insurance and

small operators' assistance programs; conducting a blaster training and certification program; and providing public information on mining and reclamation. The Division of Reclamation's revenue for fiscal year 1988-89 (ending July 30, 1989) included Federal funds totaling $2.2 million.

In fiscal year 1989, Purdue University at West Lafayette received research and allotment grants totaling $204,998 from the Bureau of Mines under provisions of Public Laws 98-409 and 100-483, the State Mining and Mineral Resources Research Institute Program. Funds provided under the act support basic research in the mineral sciences and engineering, and they are matched by State funds on a 2:1 basis. Since designated a participant in the Mineral Institute Program in 1980, Purdue has received more than $3 million in Federal funds through provisions of the program.

The Bureau of Mines published results of blasting research conducted at eight surface coal mines in western and southwestern Indiana.[3] Blast vibration characteristics resulting from near-surface abandoned underground workings underlying the mines were described in the report. The report is the latest of several published in recent years on blasting studies conducted by the Bureau's Twin Cities (MN) Research Center personnel at Indiana coal mines. Research under way late in 1989 included an interagency agreement with the Office of Surface Mining Reclamation and Enforcement, in cooperation with the Indiana DNR, to study the effect of blast vibrations on structures in two communities near a Warrick County surface coal mine.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Abrasives.—A unique chapter in Indiana's mining history ended in July when Hindostan Whetstone Co. closed its sandstone quarry near Orleans, Orange County, and began using crushed Arkansas novaculite and a bonding agent in its manufacturing process. Hindostan, established in 1821, was one of the oldest mineral producers in the State and the only remaining producer of natural abrasives. Historically, sharpening stones were the company's principal product. In recent years, however, cuticle stones and coasters from the natural whetstone dominated production at its plant in Bedford, Lawrence County. In responding to an increased demand for its coaster products, Hindostan found the use of crushed novaculite as a raw material to be more practical than using natural stone, resulting in the decision to close the quarry.

Cement.—Nationally, Indiana ranked 2d and 10th in shipments of masonry and portland cement, respectively. Cement sales contributed about 30% of Indiana's nonfuel mineral production value in 1989. Three companies manufactured both portland and masonry cement at four plants in Cass, Clark, Lawrence, and Putnam Counties. One company, Lehigh Portland Cement Co., also produced a calcium aluminate cement—for use in lining blast furnaces at steel mills—at its Buffington Station plant in Gary, Lake County.

Masonry cement shipments decreased 12% in both tonnage and value compared with 1988 figures. Portland cement sales, however, increased 2% over those of 1988 and were the highest since 1979. Although the unit value per ton dropped from $46.30 to $45.81, total sales value increased 1% over that of 1988 to an alltime high. The plants operated at nearly 84% of their combined 3.1-million-short-ton finish grinding capacity, compared with a national average of 74% utilization. Each of the companies produced Types I and II, general-use and moderate-heat (91% of total portland cement sales), and Type III, high-early strength. Two companies also sold small amounts of white portland cement. About 75% of the portland cement sales were to ready-mixed concrete companies; other customers included concrete product manufacturers (13%), highway contractors (7%), building material dealers (5%), and other miscellaneous customers. More than 94% was shipped to consumers by truck in bulk form. Cement shipments to and within Indiana from all domestic sources included 1.9 million short tons of portland cement and 98,000 short tons of masonry cement. Compared with 1988 data, this was an increase of 92,000 short tons of portland cement and a decrease of 10,000 short tons of masonry cement.

Raw materials consumed in the manufacturing process included 3.4 million short tons of limestone, 308,000 short tons of clay and shale, 157,000 short tons of gypsum, and smaller amounts of fly ash, pyrite, sand, and slag.

Lone Star Industries Inc. began production of Pyrament[4] cement in a new facility at its Greencastle plant. This new cement, whose development was announced by Lone Star late in 1988 following 10 years of research, hardened in 4 hours instead of the 7 to 14 days required for other cements. Lone Star claimed that in addition to its early hardening properties, Pyrament cement was stronger and more durable than ordinary cement, and that it could be used in temperatures below 28° F.[5] Although Pyrament cost nearly twice as much as other cement, the investment resulted in long-term savings in time and expenses, according to the company.

Clays.—Indiana ranked 12th of 30 States in common clay and shale production. Sales declined 16% in quantity and 17% in value during 1989, reversing a 6-year trend of increases. Ten companies reported production from 13 pits. Cement manufacturing consumed about 68% of the clay produced, and 12% was used for brick manufacture. It was also used in the manufacture of tile and concrete block and as a filler or extender for a variety of products.

In May, KPT Inc. completed a $3 million expansion of its ceramic tile manufacturing plant near Bloomfield, Greene County. Addition of a new kiln doubled the capacity of its plant, which was opened in 1986. The company purchased part of its clay from local producers.

Gypsum.—In 1989, record highs were established in the State's 35-year history of gypsum mining when quantity and value increased 1% and 22%, respectively, over those of 1988. Indiana ranked seventh among 21 producing States. National Gypsum Co. and USG Corp. each operated underground mines near Shoals, in south-central Indiana, and calcined gypsum at plants adjacent to the mines. USG's Shoals Mine ranked fourth among the 65 U.S. mines active in 1989. USG also manu-

factured wallboard at East Chicago using crude gypsum transported by lake carrier from Michigan. Calcined gypsum production from the three Indiana plants decreased 3% in quantity but increased 9% in value.

During 1989, National Gypsum began work on a new $8 million wallboard drying kiln at its Shoals plant. The project was scheduled for completion in 1991.[6]

Lime.—Quicklime, mostly for use at local steel plants, was produced by Inland Steel Co. and Marblehead Lime Co. at Indiana Harbor and Gary (Buffington Station), respectively. Total production from these Lake County plants dropped 3% from the 1988 level, paralleling a slight decline in steel production. Nationally, Indiana ranked 10th of the 32 States producing lime. Limestone used in the manufacturing process was shipped in by lake freighter from Michigan quarries.

Indiana ranked second, behind Pennsylvania, in lime consumption. Lime shipments to and within Indiana, from all domestic sources, totaled 1.5 million short tons of quicklime and 30,000 short tons of hydrated lime, compared with 1.6 million short tons of quicklime and 26,000 short tons of hydrated lime in 1988.

Peat.—In spite of a 37% decline in its peat sales, Indiana again ranked third among the producing States. Only Michigan and Florida reported greater sales during the year. Five companies harvested peat from bogs in Allen, Hamilton, La Porte, and Madison Counties. Reed sedge was the predominant type produced, with smaller quantities of humus and hypnum also reported. About two-thirds of the sales was for general soil improvement. The remainder was for use on golf courses, as an ingredient for potting soils, as an earthworm culture, for use by nurseries, and for packing flowers, plants, shrubs, etc. Most sales were in packaged form.

Perlite (Expanded).—Four Indiana plants expanded perlite mined in Western States. Sales of 22,000 short tons, valued at $5.8 million, were for use in concrete, horticultural, and plaster aggregates, fillers, filter aids, and insulation.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Nationally, Indiana ranked 10th in the production of sand and gravel, the State's third leading commodity in terms of value in 1989. Sales were estimated at 29.6 million short tons, valued at $99.2 million. These record highs represented increases of 14% and 24%, respectively, over the 1988 totals. An accelerated highway construction program, spurred by the receipts of a 1988 1-cent-per-gallon increase in the fuel tax, contributed to the rise.

Near yearend, CSR Ltd., an Australian sugar company with an interest in building and construction materials, was in the process of acquiring ARC America Corp. from Hanson Plc, an English company that had recently acquired Consolidated Gold Fields Plc of the United Kingdom. ARC America and its parent, ARC, were owned by Consolidated Gold Fields.

Industrial.—After 3 consecutive years of growth, industrial sand production fell sharply in 1989. Closure of major operations resulted in the State's lowest production level since 1983. Manley Brothers of Indiana Inc. closed its operation at Michigan City, La Porte County, because it was unable to obtain additional adjacent reserves as a result of high property costs in the area. Harrison Steel Castings Co. closed its Fountain City sand pit, Fountain County, and began purchasing sand required for its foundry operation. Card Industrial Sand Co. at Elizabeth, Harrison County, also closed. U.S. Silica Co. acquired the Card property in April and in September began core drilling to analyze the deposit. The company expected to begin commercial production at the operation in 1990.

Most of the sand produced in 1989 was for refractory use.

Slag, Iron and Steel.—Two companies processed slag from Lake and Porter County steel mills. Sales totaled 4.5 million short tons, valued at nearly $15 million, a slight increase over 1988 figures. Road base construction represented the largest use of the material, with lesser amounts for fill, concrete aggregate, mineral wool, glass manufacture, asphaltic concrete, soil conditioning, railroad ballast, and other miscellaneous uses.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Crushed stone production increased to a record high in 1989, reflecting a sharp increase in highway construction and repair. Thirty-eight companies reported production of crushed limestone/dolomite from 81 operations (including six underground mines) in 40 of the State's 92 counties. Crawford County led in production, followed by Allen, Putnam, and Clark. Agricultural marl was produced by one company in Lagrange County.

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

Ownership changes occurred at several Indiana quarry operations during 1989. American Aggregates Co. (ARC America Corp.) exchanged its quarries in Owensburg, Greene County, and Spencer, Owen County, for a Rogers Group Inc. quarry at Cloverdale, Putnam County. Cowan Stone Co. of Nashville, TN, sold its Indiana Cal Pro Div. to a group headed by I. C. King of Converse. Indiana Cal Pro operated an underground mine near Stinesville, Monroe County, that produced sand-sized limestone for the glass industry. Liter's Quarry of Indiana Inc. acquired the operations of T. J. Atkins Quarry of Jeffersonville. Mill Creek Stone & Gravel Corp. terminated production at its Bunker Hill Quarry in Miami County when a major investor withdrew from the company. All equipment and stockpiles were sold.

Near yearend, CSR Ltd. was in the process of acquiring ARC America Corp. from Hanson Plc.

Dimension.—Indiana led the Nation in dimension stone output for the third consecutive year. Production increased slightly over that estimated for 1988 as a resurgence of the dimension limestone industry, particularly the demand

TABLE 2

INDIANA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	1,173	4,951
Riprap and jetty stone	751	2,672
Filter stone	159	668
Coarse aggregate, graded:		
Concrete aggregate, coarse	4,309	13,545
Bituminous aggregate, coarse	2,641	8,924
Bituminous surface-treatment aggregate	1,514	4,950
Railroad ballast	322	1,210
Fine aggregate (−3/8 inch):		
Stone sand, bituminous mix or seal	121	437
Screening, undesignated	158	512
Coarse and fine aggregates:		
Graded road base or subbase	3,235	12,105
Unpaved road surfacing	989	3,850
Crusher run or fill or waste	373	1,439
Other construction material[2]	3,241	16,301
Agricultural: Agricultural limestone and poultry grit and mineral food	1,903	9,159
Chemical and metallurgical: Cement manufacture	3,738	10,411
Other miscellaneous uses[3]	496	2,579
Unspecified:[4]		
Actual	10,724	41,286
Estimated	341	1,253
Total	36,188	136,252

[1] Includes limestone, dolomite, and marl; miscellaneous stone and value for marl withheld to avoid disclosing proprietary data.
[2] Includes stone used in coarse aggregates (large and graded), fine aggregates, and stone sand (concrete).
[3] Includes stone used in terrazzo and exposed aggregate, flux stone, sulfur oxide removal, mine dusting or acid water treatment, asphalt and other fillers or extenders, and whiting or whiting substitute.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.

for building stone, continued. Quantity sold was the highest since 1978, and its attendant value set a record high for the State. The industry employed about 800 persons during 1989, perhaps twice as many as 10 years earlier.[7] Twelve companies reported dimension limestone production from 18 quarries and 1 underground mine. Lawrence and Monroe Counties in south-central Indiana's limestone belt accounted for the bulk of the production. One company reported production of dimension sandstone from quarries in Martin County.

Sulfur (Recovered).—Amoco Oil Co. recovered byproduct sulfur at its Whiting petroleum refinery in Lake County. Sales increased slightly compared with those of 1988.

Metals

Aluminum.—Indiana ranked fourth of 14 aluminum-producing States in 1989. Production approximated that of 1988 as a slowdown of the industry late in 1989 did not override the strong demand that existed during much of the year.[8] resulting in a sharp decline in total sales value. Aluminum Company of America (Alcoa) was Indiana's only producer of primary aluminum. The company's Warrick County smelter at Newburgh, one of the largest in the Nation, has an annual rated capacity of about 331,000 short tons.

Early in the year, Kaiser Aluminum & Chemical Corp. sold its Bedford plant, Lawrence County, to Ravenswood Aluminum Corp. The 25-year-old plant recycled aluminum cans in a meltdown furnace that yielded about 25,000 pounds of aluminum per hour. Forms poured at the plant were shipped to the company's Ravenswood, WV, plant for further recycling. The product was then sold to other companies that cast the aluminum back into aluminum cans. The Bedford plant poured its 500 millionth pound of aluminum in July 1988. Fifteen billion cans over a period of 7 years were recycled to attain the mark.[9]

Iron and Steel.—Indiana led the Nation in raw steel production for the eighth consecutive year. According to the American Iron and Steel Institute, Indiana's production of 20.8 million short tons accounted for 21% of the raw steel produced nationwide. The State's output exceeded that of second place Ohio by 4.4 million short tons. Pennsylvania, which had been the top steel-producing State until Indiana assumed the lead position in 1982, ranked third. A softening of steel markets in the second half of the year, particularly in the automotive sector, resulted in a nearly 2% decrease from Indiana's 1988 production of 21.2 million short tons. The decline paralleled a drop in U.S. production of slightly more than 2%.

Modernization of Indiana steel mills during the 1980's made them among the most efficient in the Nation. According to the Indiana Department of Employment & Training Services, employment in Indiana's basic steel industry in 1979, when 22.9 million short tons of steel was produced, totaled 66,600 persons. In 1989, only 37,900 persons were employed in the production of the 20.8 million short tons. Since 1982, companies had spent nearly $3 billion in plant modernizations that have included the installation of continuous casters, vacuum degassers, and other equipment to make them more efficient.

Streamlining and restructuring of the industry continued in 1989 with several developments occurring. Bethlehem Steel Corp., the Nation's second largest steel producer, completed a $14 million

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

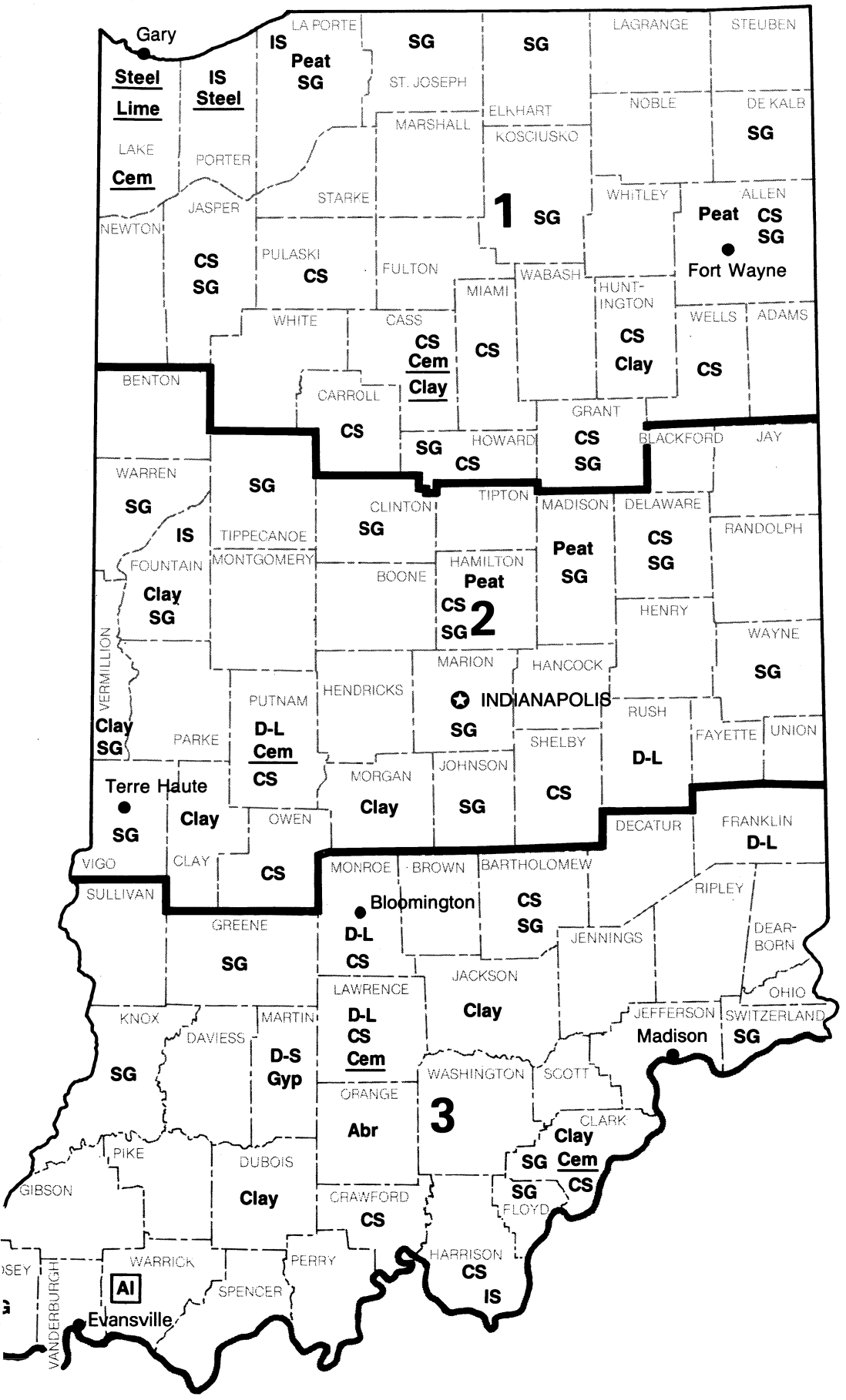
Gary
LA PORTE
IS
Peat
SG
SG
LAGRANGE
STEUBEN
Steel
Lime
IS
Steel
ST. JOSEPH
ELKHART
NOBLE
DE KALB
SG
MARSHALL
KOSCIUSKO
LAKE
Cem
PORTER
STARKE
1
SG
WHITLEY
ALLEN
Peat
CS
SG
JASPER
NEWTON
CS
SG
PULASKI
CS
FULTON
WABASH
Fort Wayne
MIAMI
HUNT-
INGTON
WELLS
ADAMS
WHITE
CASS
CS
Cem
Clay
CS
CS
Clay
CS
BENTON
CARROLL
CS
GRANT
SG
HOWARD
CS
CS
SG
BLACKFORD
JAY
WARREN
SG
SG
IS
TIPPECANOE
CLINTON
SG
TIPTON
MADISON
Peat
SG
DELAWARE
CS
SG
RANDOLPH
FOUNTAIN
Clay
SG
MONTGOMERY
BOONE
HAMILTON
Peat
CS
SG
2
HENRY
WAYNE
SG
VERMILLION
MARION
HANCOCK
INDIANAPOLIS
SG
PUTNAM
D-L
Cem
CS
HENDRICKS
RUSH
D-L
FAYETTE
UNION
Clay
SG
PARKE
SHELBY
CS
JOHNSON
SG
MORGAN
Clay
Terre Haute
SG
Clay
OWEN
DECATUR
FRANKLIN
D-L
VIGO
CLAY
CS
MONROE
BROWN
BARTHOLOMEW
CS
SG
RIPLEY
SULLIVAN
Bloomington
D-L
CS
GREENE
SG
JENNINGS
DEAR-
BORN
JACKSON
Clay
LAWRENCE
D-L
CS
Cem
OHIO
KNOX
SG
DAVIESS
MARTIN
D-S
Gyp
WASHINGTON
SCOTT
JEFFERSON
Madison
SWITZERLAND
SG
ORANGE
Abr
3
CLARK
Clay
SG
Cem
CS
PIKE
DUBOIS
Clay
GIBSON
CRAWFORD
CS
SG
FLOYD
HARRISON
CS
IS
WARRICK
PERRY
SPENCER
AI
Evansville
VANDERBURGH

TABLE 3

INDIANA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	1,260	5,406	182	819	671	2,195
Coarse aggregate, graded[2]	2,226	8,793	1,318	5,568	5,440	15,157
Fine aggregate (−3/8 inch)[3]	210	752	116	529	50	145
Coarse and fine aggregates[4]	2,056	7,183	3,563	17,326	1,342	5,027
Other construction aggregates	87	289	452	2,323	13	52
Agricultural[5]	857	5,406	233	1,467	813	2,286
Chemical and metallurgical[6]	W	W	W	W	2,416	8,302
Special[7]	—	—	W	W	W	W
Other miscellaneous	684	1,255	1,112	3,348	22	86
Unspecified:						
Actual[8]	4,177	16,156	2,892	10,913	3,655	14,217
Estimated[9]	246	904	—	—	95	349
Total[10]	11,804	46,144	9,869	42,292	14,516	47,816

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[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 graded coarse aggregates.
[3] Includes stone sand (concrete), stone sand (bituminous mix or seal), fine aggregate (screening-undesignated), and other fine aggregates.
[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run or fill or waste.
[5] Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[6] Includes crushed stone for cement manufacture, flux stone, and sulfur oxide removal.
[7] Includes crushed stone for mine dusting or acid water treatment, asphalt fillers or extenders, whiting or whiting substitues, and other fillers or extenders.
[8] Includes production reported without a breakdown by end use.
[9] Includes estimates for nonrespondents.
[10] Data may not add to totals shown because of independent rounding.

upgrade of the No. 1 caster at its Burns Harbor plant in May. When combined with the No. 2 caster, the upgrade gives the plant potential to produce 4.1 million short tons of cast slab annually.[10] In July, Bethlehem announced plans to install a 72-inch hot-dip galvanizing line capable of producing 450,000 short tons of hot-dip galvanized and galvannealed products, primarily for the automotive market. Completion of the state-of-the art project was scheduled for 1992. Construction of a $50 million vacuum degassing facility at the Burns Harbor plant was nearing completion at yearend. The facility, expected to begin operating in early 1990, would remove microscopic impurities from molten steel. Since 1980, the company had invested more than $750 million at the 25-year-old Burns Harbor plant, the Nation's youngest and reportedly most modern integrated steel mill.[11]

Bethlehem applied to the U.S. Department of Energy for partial funding of a "clean coal technology" project at the Burns Harbor plant. The project would test the use of granulated coal injected into a blast furnace instead of using oil or natural gas, thereby reducing energy costs. The project also would reduce the need for coke, thus improving air quality. Part of the experiment would develop methods to convert a blast furnace to coal injection without shutting it down.

Inland Steel Co. was engaged in a $100 million capital improvement program at the East Chicago mill of its wholly owned subsidiary, Inland Bar & Structural Co. In addition to installing a new ladle metallurgy station, the program also provided for upgrading two electric furnaces, a billet caster, and two bar mills. Some of the upgraded equipment was expected to become operational in 1990, with the remainder of the modifications to be completed in 1991. During 1989, Inland's No. 1 continuous slab caster underwent a $50 million modernization to improve quality and increase its capacity by 35%. The No. 3 combination caster and equipment in other areas of the mill also were upgraded. The facilities were all part of Inland's Indiana Harbor Works, one of the Nation's largest steelmaking plants. According to the company's annual report, the plant had an annual rated capacity of 6.5 million short tons of raw steel. Construction of the I/N Tek plant at New Carlisle, a joint venture between Inland (60%) and Nippon Steel Corp. (40%), was nearing completion at yearend. Initial shipments from the 1-million-short-ton capacity cold-rolling mill were scheduled for the second quarter of 1990. A new continuous process at the I/N Tek plant was expected to dramatically reduce the traditional production time for sheet steel from 12 days to less than 1 hour. In September, Inland and Nippon Steel formed a second (equally owned) partnership, I/N Kote, to construct and operate two galvanized steel coating lines adjacent to the I/N Tek facility. The $450 million I/N Kote plant would be capable of producing 900,000 short tons of electrogalvanized and continuous hot-dip galvanized sheet steel annually for the automotive, appliance, and other industries. Production was expected to begin at the end of 1991. Inland's Indiana Harbor Works would

supply steel to both plants.

After being on the sales block for more than 1 year, LTV Steel Corp. sold its steel bar division in the last quarter of 1989 to an employee stock ownership plan (ESOP) made up of the division's 3,900 members of the United Steelworkers of America union and 1,050 management employees for about $185 million. No wage concessions were included in the buyout. According to the ESOP, union members would hold about 75% of the stock in the new company and management personnel, the remainder. The new company, Republic Engineered Steels Inc., had major plants in Canton and Massillon, OH, and smaller plants in Chicago, IL, Gary, IN, Beaver Falls, PA, and Willimantic, CT.

Nucor Corp.'s new steel minimill near Crawfordsville came on-stream in September. Most of the fourth quarter was spent fine tuning the newly developed equipment that would continuously cast 2-inch slabs of steel. The $270 million plant was unique because it would be the first minimill to produce sheet steel, traditionally the role of the large integrated mills. Full production of 800,000 short tons was expected to be reached in 1990. Employment was projected to reach 500 persons at capacity operation.

Several projects were underway at USX Corp.'s Gary Works, the Nation's largest steel mill. In May, the company announced plans to spend $240 million to install a third continuous caster that would make the mill a 100% continuous casting operation. According to the company's annual report, the Gary Works' casting capability would be about 7 million short tons when the new 1.6-million-short-ton capacity caster begins operating. A major upgrading of the 160-inch plate mill, also announced during 1989, featured installation of hydraulic automatic gauge control equipment that will allow the company to meet the ever closer tolerances required by major plate users and manufacturers. Both projects were scheduled for completion in 1991. A $34 million vacuum degassing unit that will enable the company to produce ultralow and very low carbon sheet and tinplate for the automotive and appliance industries began operating in November.

In May, Consolidated Rail Corp. inaugurated an overnight, 5-days-per-week rail service dedicated to carrying coiled steel from Chicago area (including northern Indiana) steelmakers to Detroit automakers at prices competitive with trucking alternatives. "SteelTrain's" schedule enables steel shipments released from Chicago area mills to be at customers' unloading docks in Detroit within 36 hours. Previous railroad transit time was 3 to 4 days.

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[1] Editorial assistant, Bureau of Mines, Minneapolis, MN.

[2] Highway and Heavy Construction Magazine. Market Update: Battle Lines Form Over Gridlock, Gas Tax. V. 132, No. 3, Mar. 1989, p. 34.

[3] Siskind, D. E., S. V. Crum, R. E. Otterness, and J. W. Kopp. Comparative Study of Blasting Vibrations From Indiana Surface Coal Mines. BuMines RI 9226, 1989, 41 pp.

[4] Reference to specific products does not imply endorsement by the Bureau of Mines.

[5] Chicago Tribune. Cement Maker Breaks Some Hard, Fast Rules. Nov. 15, 1988.

[6] National Gypsum Co. (Dallas, TX). 1989 Annual Report to Stockholders, p. VI.

[7] Sunday, The Chicago Tribune Magazine. Cutting Edge. Sept. 24, 1989, p. 15.

[8] Alcoa, (Pittsburgh, PA). 1989 Annual Report to Stockholders, p. 23.

[9] Bedford Times-Mail (Bedford, IN). Kaiser Aluminum Sold, Changes Name. Feb. 9, 1989.

[10] American Metal Market. Caster Modernized at Bethlehem Plant. V. 97, No. 100, May 23, 1989, p. 4.

[11] Portage Press (Portage, IN). Steelmaker's 25th Year is Best. Mar. 8, 1990.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Abrasives (natural):			
Hindostan Whetstone Co.	Box 862 Bedford, IN 47421	Quarry Plant	Orange. Lawrence.
Aluminum:			
Aluminum Co. of America	Warrick Operations Box 10 Newburgh, IN 47630	Smelter and fabricating plant	Warrick.
Cement:			
Coplay Cement Co., a subsidiary of Societe des Ciments Francais:	Box 35750 Louisville, KY 40232		
Logansport plant [1 2]	do.	Plant, quarry, clay pit	Cass.
Speed plant [1 2]	do.	do.	Clark.
Lehigh Portland Cement Co., a subsidiary of Heidelberger Zement AG:	Box 1882 Allentown, PA 18105		
Buffington Station plant	do.	Plant	Lake.
Mitchell plant	do.	Plant and quarry	Lawrence.
Lone Star Industries Inc.: Greencastle plant [1 2]	Box 5050 Greenwich, CT 06836	Plant, quarry, clay pit	Putnam.
Clays:			
General Shale Products Corp.	Box 96 Mooresville, IN 46158	Pits and plant	Morgan.
Hydraulic-Press Brick Co., Haydite Div.	Brooklyn, IN 46111	Pit and plant	Morgan.
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.	Do.
Do.	do.	Plant	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.
LTV Steel Co.	3001 Dickey Rd. East Chicago, IN 46312	do.	Do.
National Steel Corp., Midwest Steel Div.	U.S. 12 Portage, IN 46368	Mill (rolling)	Porter.
Nucor Corp.	4425 Randolph Rd. Charlotte, NC 28211	do.	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 4—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 (1988):			
American Aggregates Corp., a division of ARC America Corp.	Drawer 160 Greenville, OH 45331	Pits and plants	Hamilton, Marion, Wayne.
Evansville Materials Inc.	Box 3596 Evansville, IN 47734	do.	Posey, Spencer, Vanderburgh.
Fairfield Builders Supply Corp.	Box 4427 Lafayette, IN 47905	do.	Boone, DeKalb, Tippecanoe.
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	Clark, DeKalb, Delaware, Fayette, Grant, Hamilton, Henry, Madison, Wayne.
Martin Marietta Aggregates	Box 30013 Raleigh, NC 27622	do.	Clark, 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.	Parke, St. Joseph, Tippecanoe.
Industrial:			
Crisman Sand Co. Inc.	6480 Melton Rd. Portage, IN 46368	do.	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	Plants	Lake and Porter.
Steel:			
Heckett Co.	Box 1071 Butler, PA 16001	Plant	Lake.
Stone:			
Crushed:			
Limestone:			
American Aggregates Corp., a division of ARC America Corp.	Drawer 160 Greenville, OH 45331-0160	Quarries and plants	Hamilton and Marion.
Beazer USA	1850 Koppers Bldg. Pittsburgh, PA 15219	do.	Allen, Jennings, Putnam, Riley, Scott, Washington.

See footnote at end of table.

TABLE 4—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 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 Donald K. Harrison[1] and Robert M. McKay[2]

The value of nonfuel mineral production in 1989 was $282.7 million, a $7.6 million decrease compared with the 1988 value. Crushed stone, portland cement, sand and gravel, and gypsum were the leading mineral commodities produced and accounted for nearly 95% of the State's mineral production value. Nearly all of the output of these mineral commodities was used by the construction industry. Other commodities produced included masonry cement, clays, lime, peat, and dimension stone. Nationally, Iowa ranked 33d in the value of nonfuel mineral production. The State ranked second, after Oklahoma, in crude gypsum output and third among 28 States that produced calcined gypsum.

Because demand for mineral aggregates is usually dependent on construction activity, there is usually a correlation between aggregate output and construction contract awards. In 1989, the number of private and public residential units authorized in Iowa rose nearly 9%, from 6,785 units in 1988 to 7,392 units in 1989. The value of State road contract awards, which rely heavily on mineral aggregates, rose by 6.7% in 1989. In 1989, production of construction sand and gravel rose almost 8%. Increases in output were also reported for portland cement, clays, lime, and dimension stone. Crushed stone, the State's leading commodity in terms of value, declined slightly—down 4%.

EMPLOYMENT

Although there were only about 2,000 workers engaged in mining in the State in 1989, nearly 40,500 persons worked in the mineral-dependent construction industry. Stone, clay, and glass product employees totaled 5,800; primary and fabricated metal product employees numbered nearly 25,900 workers.

LEGISLATION AND GOVERNMENT PROGRAMS

Under the State Mining and Mineral Resources Institute Program Act, the Bureau of Mines awarded an allotment grant of $138,000 to Iowa State University to support basic research in the mineral sciences. Iowa State was 1 of 34 universities nationally that received a grant under the program. Since the program was started in 1978, Iowa State has received more than $1.8 million from the Bureau of Mines. Under stipulations of the act, the State of Iowa was required to match this grant on a 2:1 basis.

The Iowa Department of Natural Resources Geological Survey Bureau (GSB) neared completion of a publication on abandoned coal mines and the geology of the Des Moines area. The publication will be useful for planning commercial or residential development, for mitigating land-subsidence problems

TABLE 1

NONFUEL MINERAL PRODUCTION IN IOWA[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Cement:							
Masonry	thousand short tons	W	W	W	W	47	$4,450
Portland	do.	2,139	$104,457	2,029	$98,930	2,072	102,387
Clays	metric tons	428,907	1,495	403,923	1,588	439,323	1,773
Gem stones		NA	W	NA	W	NA	10
Gypsum	thousand short tons	1,874	12,887	2,047	13,710	2,273	16,884
Peat	do.	24	W	r15	433	W	W
Sand and gravel (construction)	do.	e19,000	e63,800	11,880	36,087	e12,800	e37,800
Stone:							
Crushed	do.	25,991	110,106	e29,200	e128,500	28,049	111,182
Dimension	short tons	W	W	W	e588	15,151	613
Combined value of other industrial minerals and values indicated by symbol W		XX	12,332	XX	10,420	XX	7,603
Total		XX	305,077	XX	290,256	XX	282,702

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

caused by underground mine collapse in the Des Moines area, and for estimating remaining coal reserves. At yearend, the GSB was completing work on a special report on results of geologic research on the AMOCO Production Co.'s deep-oil test site in Carroll County. Information obtained in the 1987 drilling was held in confidence by the GSB until late October 1989. Rocks penetrated in the 15,850-foot-deep hole held trace amounts of hydrocarbons.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Four companies produced both portland and masonry cements in 1989. Lehigh Portland Cement Co. and Northwestern States Portland Cement Co. operated dry-process plants near Mason City in Cerro Gordo County. Davenport Cement Co. operated a dry-process plant near Buffalo, Scott County, and Monarch Cement Co. ground clinker from its Humboldt, KS, facility at a plant in Des Moines, Polk County. Two of the cement plants (Lehigh and Davenport) were owned by Western European firms. This was not unusual, however, since nearly 65% of the U.S. cement capacity has been acquired by foreign owners during the past decade.

Principal markets for the cement products were ready-mix concrete companies (66%), concrete product manufacturers (19%), highway contractors (11%), and building material dealers and other users (4%).

In late December, Northwestern States Portland Cement Co. of Mason City was expected to be sold for $44 million to Dundee Cement Co. of Michigan. Dundee is a subsidiary of Holderbank Financiere Glaris Ltd., a Swiss holding company. At yearend, the acquisition of the 950,000-short-ton-per-year plant had been approved by Northwestern shareholders, but the sale was still awaiting Federal Government approval. In recent years, Northwestern had undergone layoffs, losses, and loan defaults. Dundee has indicated intentions to spend several million dollars over the next 2 or 3 years to upgrade production equipment at the Mason City plant.

Gypsum.—Crude gypsum was mined by five companies and processed at six plants in Iowa. Both underground and open pit mining methods were used. In 1989, both production and value of crude gypsum rose by 11% and 23%, respectively, over 1988 levels. Most of the gypsum produced was used in wallboard manufacturing with lesser amounts in cement manufacturing.

In early 1989, USG Corp. opened a second gypsum wallboard line at its Sperry plant. Within 3 weeks of startup, the plant was operating at 100% capacity.[3]

Lime.—Linwood Mining & Minerals Corp., the State's only producer, produced lime at a plant in Scott County. Most of the production was quicklime; a small amount of hydrated lime also was produced.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; this chapter contains estimates for 1987 and 1989 and actual data for 1988. Data for odd-numbered years are based on annual company estimates.

Iowa's estimated 1989 construction sand and gravel production was 12.8 million short tons valued at $37.8 million. Estimated production and value increased 8% and 5%, respectively, compared with 1988 figures. Major uses are for concrete aggregate, asphaltic concrete, road base, and coverings and fill.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

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

Crushed.—Crushed stone, the leading mineral commodity produced in the State, accounted for nearly 40% of the State's nonfuel mineral value. Limestone-dolomite was the only type of stone produced in the State. Major uses of the crushed stone production were for road base, cement manufacturing, and agricultural limestone.

Dimension.—Dimension limestone was produced by one company in Jones County. In 1989, dimension stone production and value increased compared with 1988 figures. Most of the stone was used for building front veneers, flagging, and curbing.

Other Industrial Minerals.—Two companies mined clay in 1989. Production and value rose 9% and 12%, respectively, over 1988 levels. The clay was used primarily to manufacture brick and ceramic tile products. Estimated value of gem stones, collected by amateur collectors and rockhounds, was $10,000 in 1989. Two companies produced peat from bogs in Worth and Muscatine Counties. Nearly two-thirds of the peat was sold in packaged form; the remainder was sold in bulk form. The peat was used primarily for general soil improvement and as a seed inoculant. National Gypsum Co. expanded crude perlite, received from out-of-State, at two plants in Webster County.

Metals

There were no metallic ores mined in Iowa; however, processing facilities for aluminum, ferroalloys, iron and steel, molybdenum, and nickel mined in other States operated in the State.

In September, Aluminum Co. of America (Alcoa) announced that it would boost capacity at its Davenport rolling complex by adding three preheat furnaces and expanding heat-treating capacity at the plant. The aerospace industry was the major market for the Davenport sheet-and-plate division. The expansion announcement was the result of a continuing exceptionally strong demand for aluminum aerospace products. Also, in August, a new 100-inch continuous hot mill came on-stream at the plant, and a new cold mill was scheduled to begin operation in 1990.

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 is used to manufacture specialty steel alloys.

In November, PMX Industries, a subsidiary of Poongsan Corp. of Seoul, South Korea, received a $1 million forgivable loan from the Iowa Department of Economic Development Board to open a new copper and brass mill. PMX planned to spend $127 million to equip an existing building in Cedar Rapids, which, when operational, would employ about 700 people. This would be Poongsan's first North American copper and brass mill. The State financial assistance was derived from lottery fund proceeds.

[1]State Mineral Officer, Bureau of Mines, Pittsburgh, PA. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assisrtant.

[2]Geologist, Iowa Department of Natural Resources, Geological Survey Bureau, Iowa City, IA.

[3]USG Corporation, 1989 Annual Report, p. 10.

TABLE 2

IOWA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	129	486
Riprap and jetty stone	109	600
Filter stone	130	530
Coarse aggregate, graded:		
Concrete aggregate, coarse	1,243	6,393
Bituminous aggregate, coarse	868	4,439
Bituminous surface-treatment aggregate	1,453	7,125
Railroad ballast	16	71
Fine aggregate (-3/8 inch): Screening, undesignated	292	1,000
Coarse and fine aggregates:		
Graded road base or subbase	4,403	15,741
Unpaved road surfacing	2,617	10,718
Crusher run or fill or waste	90	275
Other construction materials[2]	61	225
Agricultural:		
Agricultural limestone	2,016	8,245
Poultry grit and mineral food	310	5,250
Chemical and metallurgical: Cement manufacture	2,930	5,857
Other miscellaneous uses[3]	684	3,619
Unspecified:		
Actual	9,890	37,715
Estimated	807	2,893
Total	[4]28,049	111,182

[1]Includes limestone, dolomite, and sandstone.
[2]Includes stone used in stone sand (concrete and bituminous mix or seal), terrazzo and exposed aggregate, and other coarse and fine aggregates.
[3]Includes stone used in other agricultural uses, lime manufacture, flux stone, sulfur oxide removal, asphalt fillers or extenders, and glass manufacture.
[4]Data do not add to total shown because of independent rounding.

IC

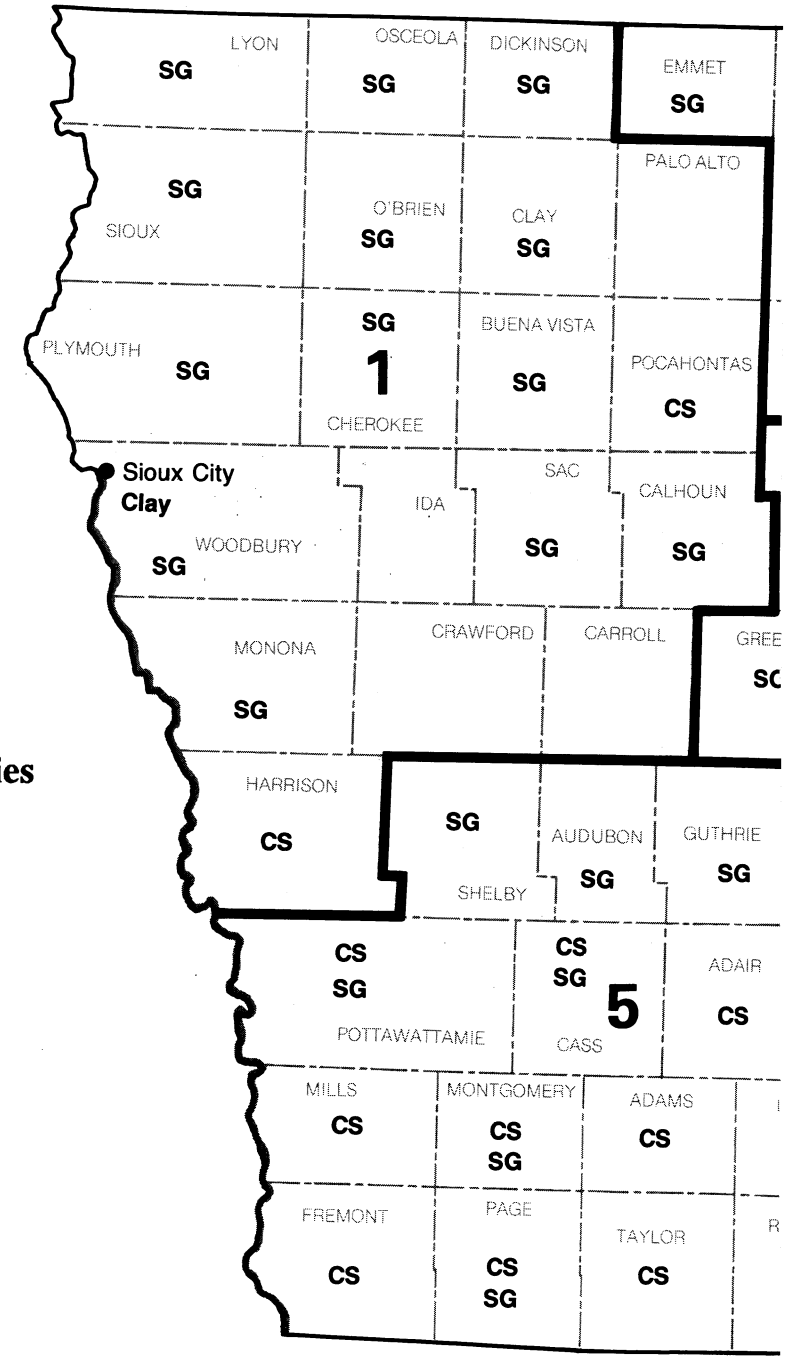
LEGEND

- 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



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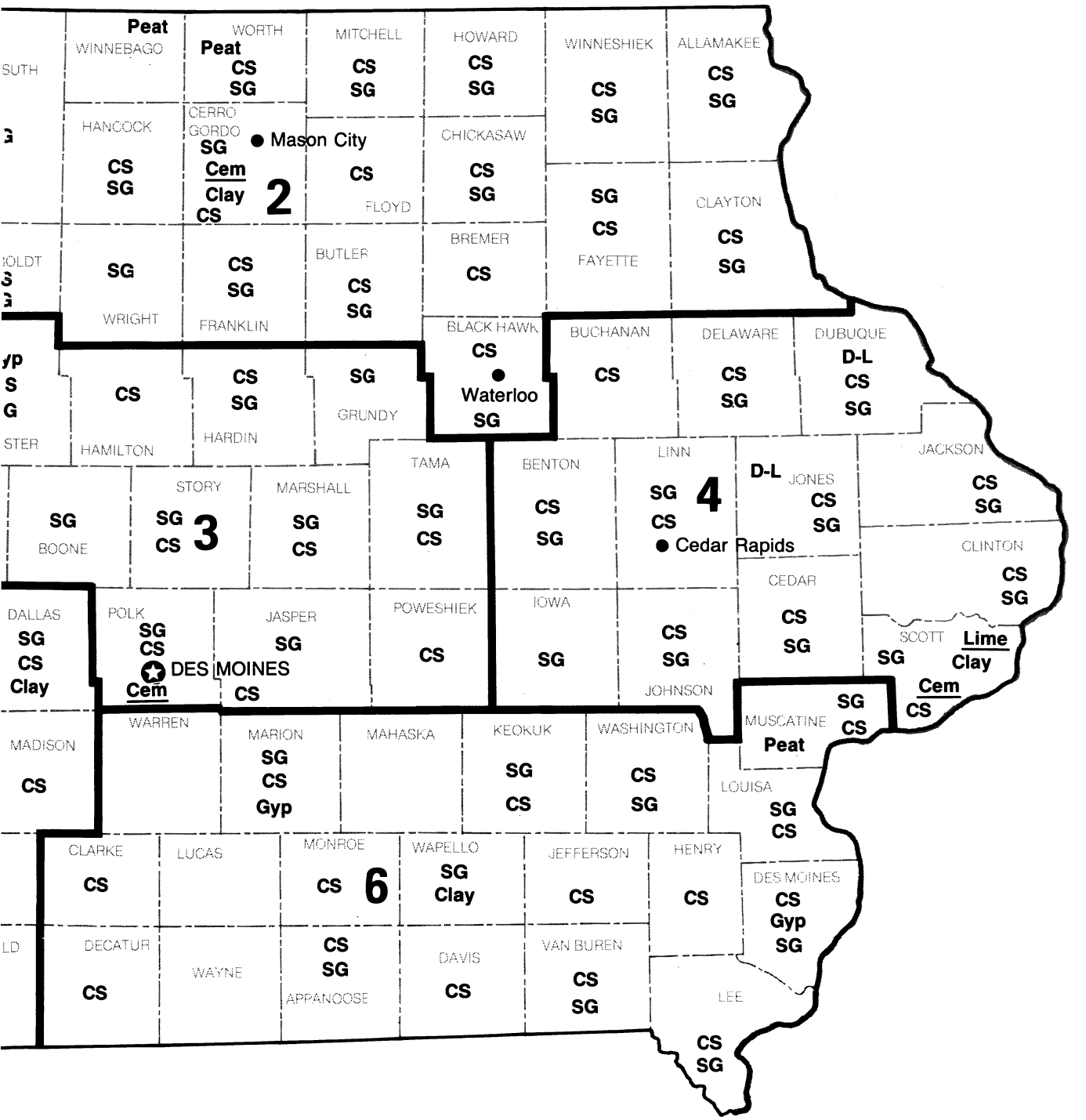
Peat
WINNEBAGO
WORTH
Peat
CS
SG
MITCHELL
CS
SG
HOWARD
CS
SG
WINNESHIEK
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ALLAMAKEE
CS
SG
HANCOCK
CS
SG
CERRO GORDO
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Cem
Clay
CS
2
● Mason City
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FLOYD
CHICKASAW
CS
SG
SG
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FAYETTE
CLAYTON
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WRIGHT
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FRANKLIN
BUTLER
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BREMER
CS
BLACK HAWK
CS
● Waterloo
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GRUNDY
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HARDIN
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BENTON
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LINN
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CS
4
● Cedar Rapids
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JONES
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SG
JACKSON
CS
SG
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BOONE
STORY
SG
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3
MARSHALL
SG
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CLINTON
CS
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CEDAR
CS
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DALLAS
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CS
Clay
POLK
SG
CS
DES MOINES
Cem
CS
JASPER
SG
POWESHIEK
CS
IOWA
SG
CS
SG
JOHNSON
SCOTT
SG
Lime
Clay
Cem
CS
SG
MUSCATINE
Peat
CS
MADISON
CS
WARREN
MARION
SG
CS
Gyp
MAHASKA
KEOKUK
SG
CS
WASHINGTON
CS
SG
LOUISA
SG
CS
CLARKE
CS
LUCAS
MONROE
CS
6
WAPELLO
SG
Clay
JEFFERSON
CS
HENRY
CS
DES MOINES
CS
Gyp
SG
DECATUR
CS
WAYNE
CS
SG
APPANOOSE
DAVIS
CS
VAN BUREN
CS
SG
LEE
CS
SG

TABLE 3

IOWA:[1] CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[2]	W	W	71	303	W	W
Coarse aggregate, graded[3]	W	W	473	1,904	106	554
Fine aggregate (-3/8 inch)[4]	—	—	31	100	W	W
Coarse and fine aggregates[5]	W	W	1,581	5,144	454	2,248
Other construction aggregates	576	2,567	—	—	45	210
Agricultural[6]	(7)	(7)	404	1,434	440	5,612
Chemical and metallurgical[8]	—	—	(7)	(7)	—	—
Special[9]	—	—	—	—	—	—
Other miscellaneous	189	1,025	1,635	4,570	—	—
Unspecified:						
Actual[10]	144	1,228	3,150	9,251	3,560	16,205
Estimated[11]	224	1,173	—	—	—	—
Total[12]	1,133	5,993	7,345	22,706	4,604	24,829

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[2]	192	700	56	350	25	142
Coarse aggregate, graded[3]	765	3,816	W	W	297	1,456
Fine aggregate (-3/8 inch)[4]	183	596	W	W	1	2
Coarse and fine aggregates[5]	2,755	8,390	W	W	1,430	6,804
Other construction aggregates	—	—	2,149	11,589	—	—
Agricultural[6]	738	2,736	(7)	(7)	239	1,018
Chemical and metallurgical[8]	1,919	4,339	—	—	—	—
Special[9]	(7)	(7)	—	—	—	—
Other miscellaneous	9	99	355	2,108	—	—
Unspecified:						
Actual[10]	1,245	3,616	485	2,153	1,306	5,262
Estimated[11]	408	1,419	—	—	175	300
Total[12]	8,213	25,711	3,044	16,200	3,473	14,984

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[1]Excludes 236,469 short tons valued at $757,818 not reported by county.
[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 crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run or fill or waste, and other coarse and fine aggregates.
[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."
[8]Includes crushed stone for cement manufacture, lime manufacture, flux stone, glass manufacture, and sulfur oxide removal.
[9]Includes crushed stone for asphalt fillers or extenders.
[10]Includes production reported without a breakdown by end use.
[11]Includes estimates for nonrespondents.
[12]Data may not add to totals shown because of independent rounding.

TABLE 4

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	Quarry, clay pit, plant	Scott.
Lehigh Portland Cement Co., a subsidiary of Heidelberger Zement AG.	Box 1882 Allentown, PA 18105	do.	Cerro Gordo.
Monarch Cement Co.	Humboldt, KS 66748	Plant	Polk.
Northwestern States Portland Cement Co.	Box 1008 Mason City, IA 50401	Quarry and plant	Cerro Gordo.
Clays:			
Midland Brick Co.	Box A Redfield, IA 50233	Pits and plants	Dallas and Wapello.
Sioux City Brick & Tile Co.	Box 807 Sioux City, IA 51102	do.	Dallas and Woodbury.
Gypsum:			
Celotex Div., a subsidiary of Jim Walter Corp.	4010 Boy Scout Blvd. Tampa, FL 33607	Open pit mine and plant	Webster.
Georgia-Pacific Corp.	133 Peachtree St., NE. Atlanta, GA 30303	do.	Do.
Kaser Corp.	Box 3569 Des Moines, IA 50322	Underground mine and plant	Marion.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	Open pit mine and plant	Webster.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	Underground mine and plant Open pit mine and plant	Des Moines. Webster.
Lime:			
Linwood Mining & Minerals Corp.	Route 2 Davenport, IA 52804	Plant	Scott.
Peat:			
Colby Pioneer Peat Co.	Box 8 Hanlontown, IA 50444	do.	Worth.
Pikes Peat Co.	Route 6, Box 21 Muscatine, IA 52761	do.	Muscatine.
Perlite (expanded):			
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	do.	Webster.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Do.
Sand and gravel (construction, 1988):			
Acme Fuel & Material Co.	Route 5, Box 34 Muscatine, IA 52761	Pit and plant	Muscatine.
Basic Materials Corp.	Box 2277 Waterloo, IA 50704	Pits 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 13 Boone, IA 50036	do.	Audubon, Boone, Buena Vista, Cherokee, Dallas, Greene, Marshall, Osceola, Polk, Sac, Story.
Martin Marietta Aggregates, Central Div.	Box 30013 Raleigh, NC 27622	do.	Various (20 counties).
Stevens Sand & Gravel Co. Inc.	Route 4, Box 35 Iowa City, IA 52240	do.	Johnson and Washington.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone (limestone):			
Crushed:			
Kaser Corp.	7200 Hickman Rd. Des Moines, IA 50322	Underground mines, quarries, plants	Des Moines, Jasper, Keokuk, Mahaska, Marion, Monroe, Washington.
Martin Marietta Aggregates, Central Div.	Box 30013 Raleigh, NC 27622	do.	Clarke, Decatur, Linn, Madison, Marshall, Polk, Story.
P. Niemann Construction Co.	106 North Maple St. Sumner, IA 50674	Quarries and plants	Black Hawk, Bremer, Buchanan, Butler, Chickasaw, Fayette, Winneshiek.
River Products Co.	220 Savings and Loan Bldg. 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, Madison, Pottawattamie, Union.
Vulcan Materials Co.	5300 North Park Place, NE. Box 1428 Cedar Rapids, IA 52406	do.	Benton, Buchanan, Clinton, Jackson, Johnson, Jones, Linn, Tama.
Dimension:			
Wm. Becker & Sons Stone Co.	1735 Kaufmann Ave. Dubuque, IA 52001	Quarry and plant	Dubuque.
Weber Stone Co.[1]	Route 1 Anamosa, IA 52205	Quarries and plant	Appanoose and Jones.

[1]Also crushed limestone.

THE MINERAL INDUSTRY OF KANSAS

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

By Jane P. Ohl[1] and David A. Grisafe[2]

The value of nonfuel minerals produced in Kansas in 1989 was $318 million, compared with $292 million in 1988, a 9% increase. The State ranked 31st in the Nation and accounted for less than 1% of the national value. Salt, valued at $82 million, was the leading nonfuel mineral commodity produced in the State in 1989. Portland cement was second, valued at $69 million, followed by crushed stone at more than $57 million, Grade-A helium, and nine other industrial minerals.

During the year, the U.S. Army Corps of Engineers proposed changes to regulations on sand and gravel dredging in the Kansas River. The new regulations would be more restrictive of the amount of sand and gravel that could be dredged from the river. Such restrictions are becoming part of a national trend. By yearend, no decision had been made on the total production of dredged sand to be allowed from Kansas rivers. Whatever the decision, it will have a pronounced effect on area sand and gravel producers, many of whom operate at relatively low costs.

EMPLOYMENT

Mining employment in Kansas, exclusive of workers in the oil and gas sector, fell from 1,300 in December 1988 to 1,200 in December 1989. The overall unemployment rate in Kansas, however, decreased from 4.8% in January 1989 to 4.4% one year later.

REGULATORY ISSUES

During the year, the Governor and officials of the State Department of Health and Environment visited mine sites proposed for cleanup in central Kansas. Of concern was a brine plume emanating from an aquifer at the site of an old salt mine. It is believed that salt had leached into the freshwater

TABLE 1

NONFUEL MINERAL PRODUCTION IN KANSAS[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Cement:							
Masonry	thousand short tons	52	$3,150	50	$2,988	42	$2,514
Portland	do.	1,697	81,045	1,569	72,805	1,505	69,390
Clays[2]	metric tons	547,650	2,576	555,739	2,632	533,099	2,700
Gem stones		NA	3	NA	3	NA	W
Salt[3]	thousand short tons	1,689	70,148	1,284	55,753	1,948	82,212
Sand and gravel:							
Construction	do.	e15,600	e37,800	10,760	25,329	e13,000	e33,200
Industrial	do.	127	1,400	W	W	230	2,690
Stone:							
Crushed	do.	19,319	69,628	e17,300	e72,700	4 15,850	4 56,976
Dimension	short tons	11,423	445	e6,889	e219	W	W
Combined value of clay (bentonite), gypsum, helium (crude and Grade-A), pumice, salt (brine), stone (crushed sandstone and quartzite, 1989), and values indicated by symbol W		XX	53,409	XX	59,284	XX	68,449
Total		XX	319,604	XX	291,713	XX	318,131

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

aquifer from one of two old mine shafts or from unprotected and abandoned piles of unsold salt at the mine that remain from production in the 1940's or 1950's.

American Salt Co., which was ordered to pay farmers in Rice County for the loss in productivity from their fields caused by salt contamination, lost its bid to have an appeal heard by the U.S. Supreme Court. The Court listed several reasons, one being the unbroken continuity of the pollution, which allowed for no clear-cut determination of a starting point for statute of limitations.

Farther southeast, in Cherokee County, the U.S. Environmental Protection Agency (EPA) offered a new proposal for cleaning up lead and zinc mine waste in the Tri-State mining district. EPA proposed to bury contaminated rock in the area without moving it, at an estimated cost of $8.3 million. An earlier plan to remove the waste to another site was calculated to be too expensive at $21 million.

To maintain jobs and shore up the State's economy, two bills were proposed in the Kansas legislature: Senate bill 201 and House bill 2232. These bills would have required all Kansas electric utilities to burn a coal mixture containing at least 10% Kansas coal. The State's coal-fired electric utilities have been purchasing about 88% of their coal from Wyoming and a combined total of about 10% to 12% from coal fields in southeastern Kansas, Missouri, and Oklahoma. To burn larger amounts of high-sulfur Kansas coal, electric utility companies would have to install additional pollution-control equipment to maintain compliance with EPA pollution standards in the 15 plants that would be affected. The cost to do this was estimated to be about $150 million per plant. Neither bill came out of committee.

According to the Utility Data Institute, the State's single nuclear plant, the Wolf Creek nuclear plant (in Osage County), led the Nation in electrical output from a nuclear reactor. In 1989, Wolf Creek was the Nation's lowest cost producer of nuclear energy at $0.00933 per kilowatt hour.

EXPLORATION ACTIVITIES

The Kansas Geological Survey, among other investigators, continued to study the structure and geology of the Central North American Rift System (CNARS) to determine its potential for major metallic mineral deposits. CNARS trends southwest through Kansas from Marshall and Washington Counties along the Nebraska border to the Oklahoma border. Concentrations of cobalt, copper, gold, nickel, silver, titanium, and platinum-group minerals are known to occur in some rock types associated with the CNARS.[3]

The Kansas Geological Survey cored a 417-foot-deep hole at Microlite Inc.'s lamproite deposit at the Silver City dome, in Woodson County. Lamproite group rocks are rich in potassium and magnesium, and the area may have potential as a mineral resource. The Kansas Geological Survey also completed an evaluation of the mineral resource potential in the Joplin quadrangle in cooperation with the Missouri Department of Natural Resources and the U.S. Geological Survey. Among industrial minerals that the quadrangle contains were abundant amounts of limestone suitable for dimension stone and cement production as well as for general construction purposes. Also present were clays usable for brick, tile, sewer pipe, and pottery, and lesser amounts of sand and gravel and dimension sandstone. In 16 midcontinent States, including Kansas, subsurface geochemical studies indicated consistent, broad regional patterns of distribution and abundance for the metals arsenic, cobalt, copper, lead, molybdenum, nickel, silver, and zinc.

LEGISLATION AND GOVERNMENT PROGRAMS

Kansas H.S. 2014, as amended in the 1989 session, provided $2.6 billion for an enhanced 8-year highway program. Expenditures in each of the State's 105 counties during the period July 1, 1988, through June 30, 1997, were to be at least $2 million annually. Sand and gravel, crushed stone, and cement producers will supply the necessary raw materials for this highway work.

The State had not collected mineral taxes on nonfuel minerals since the elimination in July 1987 of a $0.04 per ton tax on salt. The gross severance tax collected in 1989 on oil and gas and a very small amount of coal amounted to $80.4 million. About 92%, or $74.3 million of the tax, was deposited to the State's general fund and about 7% went to the counties.

The Bureau of Mines and EPA completed, in September 1989, a cooperative study and drafted a report on the Tri-State mining district in Cherokee County.

Total royalties derived from Federal mineral leases in Kansas amounted to $2.7 million, up from $2.6 million in 1988. Operators paid royalties on oil and gas. The Federal Government (the Minerals Management Service and the Bureau of Land Management) distributed $830,000 to the State as its share of revenues collected.

In accordance with the Payments in Lieu of Taxes (PILT) Act of 1976, Kansas received $338,195 from the Bureau of Land Management. Annual PILT payments are distributed to help offset the loss of revenues caused by the presence of certain tax-exempt land within local government boundaries.

The Kansas Geological Survey celebrated its 100th year in 1989.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Only industrial minerals were extracted in Kansas. Salt was the State's most valuable nonfuel mineral product, followed in value by portland cement, crushed stone, and 12 other commodities. This value ranking was a marked change from that of 1988, when portland cement was the leading commodity.

Cement.—Reduced highway repairs and construction, before legislation in 1989 boosted highway funding, contributed to the continuing fall in demand for portland cement. Portland cement sales fell 5% in 1989, 10% in 1988, and 11% in 1987. Masonry cement decreased 16% in output and total value in 1989.

The average price of portland cement declined 28 cents to $46.12 per short ton, and that of masonry cement declined 30 cents to $59.44.

Five firms in Kansas operated 15 kilns, 8 of which were wet process and 7 dry

process. Raw materials consumed included principally cement rock or limestone, plus anhydrite, clay, iron ore, gypsum, sand, sandstone, or shale. In addition, the cement plants used a variety of resins and other chemicals.

Clays.—Clay production in Kansas included bentonite and common clay and shale, the latter used mostly for brick and sewer pipe manufacture. Bentonite output rose 5% and its value 10% over figures for 1988.

Gypsum.—Output of crude gypsum rose 11% and a significant price increase of $1.81 to $7.28 per short ton raised the total value about 50%. Output of calcined gypsum increased slightly from figures for 1988, and value decreased slightly. National Gypsum Co. at Medicine Lodge and Georgia Pacific Corp. at Blue Rapids produced calcined gypsum from crude ore mined near their respective plants.

Helium.—Output of crude helium recovered from natural gas peaked for the decade in 1987, declined sharply in 1988, and continued downward in 1989. Price per thousand cubic feet remained at $22. Crude helium extraction plants were located in southwestern Kansas at Bushton (Enron Helium Co.), at Ulysses (OXY Cities Services Helex Inc.), and at Scott City (Kansas Nebraska Energy). The Otis (Kansas Refined Helium Co.) plant no longer produces crude helium.

Grade-A helium production plants are located at Otis (Kansas Refined Helium Co.), Bushton (Union Carbide), and Ulysses (Union Carbide). The Elkhart (Union Carbide) plant has been mothballed since 1988. The quantity and value of Grade-A helium rose more than 12% above figures for 1988, reaching their highest level since 1977. In contrast with the generally upward trend in production of Grade-A helium over the past decade, the quantity of crude helium extracted was irregular.

Crude helium was obtained as a byproduct of natural gas production for fuel and chemical markets. Private industry's excess crude helium production was stored under contract in the Government's Cliffside Storage Reservoir. This privately owned crude helium is returned to the owners for purification when current production is not sufficient to provide for the private demand.

Perlite (Expanded).—Only one operator, in Wyandotte County, was reported to be a producer of expanded perlite in 1989. The expanded perlite was used as cavity fill and horticultural aggregate. Average price per short ton rose to $365.40 from $354.46 in 1988.

Pumice (Pumicite, Volcanic Ash).—Output and total value of volcanic ash increased at the only reporting mine in Kansas, the Calvert Mine in Norton County. Calvert Corp. processed volcanic ash for use in specialty products and abrasives.

According to the Jewell County Record,[4] Kansas Minerals Inc. officials worked with several State universities on developing a nonpoisonous insecticide from volcanic ash. The operation's products have more traditionally been used for a variety of filteraid and filler applications.

Salt.—Kansas ranked fifth of 13 salt-producing States, accounting for 5% of output. Output and total value of salt increased 52% and 47%, respectively, above 1988 figures.

In the summer of 1989, a long-standing lawsuit was settled with distribution of $3 million in actual damages and $10 million in punitive damages to landowners in Rice County whose farmland had been polluted by salt. This distribution was the culmination of a lawsuit, filed in 1977, claiming pollution of the aquifer near Lyons. Payment of the judgment in the original lawsuit by General Host Corp., the parent company of the old American Salt Co., resolved this litigation. Several subsequently filed lawsuits that were pending were also settled by General Host at that time. On February 23, 1988, a group of new investors purchased the assets of the old American Salt.

Bonds issued by the Citizens State Bank and Trust Co. in Ellsworth provided money for employees to purchase the Independent Salt Co. and its salt mine under an employee stock ownership plan. The purchase saved 50 jobs in Kanopolis, Ellsworth County.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Construction sand and gravel production in 1989 was estimated to have increased about 21%, and total value 31%, above figures for 1988. The increases were due mostly to the State legislative action (H.S. 2014), previously discussed. Fewer than two-thirds of the State's counties—64 of 105—were sources of sand and gravel in 1988, the latest year for which specific data are available. Kansas' total output and sales of construction sand and gravel declined between 1986 and 1988, but an improved economic scene in 1989 found more than 100 firms or highway departments extracting construction sand and gravel from more than 250 pits. The seven largest producers provided about 40% of the quantity and value of this important mineral commodity.

Sand and gravel was used principally in concrete aggregates, followed by road base and cover, road stabilization cement and lime, asphaltic concrete, and several other uses. The average price for all uses of sand and gravel was $2.55 per ton, compared with $2.35 in 1988. Roofing granules were the highest valued product, averaging $10.78 per ton.

Industrial.—Three firms produced industrial sand in Republic and Wyandotte Counties. Production and total value increased significantly over figures for 1988. Average price per short ton sold, however, was $11.70, down 9 cents from that of 1988. Industrial sand from Kansas was used as a raw material for fiberglass production, molding and cores, blasting, ground fillers, and as traction sand. The greatest share of output was transported by truck; about 8% was moved by rail.

Stone.—Stone production is surveyed by the Bureau of Mines in odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains actual data for 1987 and 1989 and estimates for 1988.

Kansas stone statistics are compiled by geographical districts as depicted on the State map. Tables 2 and 3 present end-use statistics for Kansas' six districts.

Crushed.—Crushed stone output fell nearly 18% from that of 1987, and

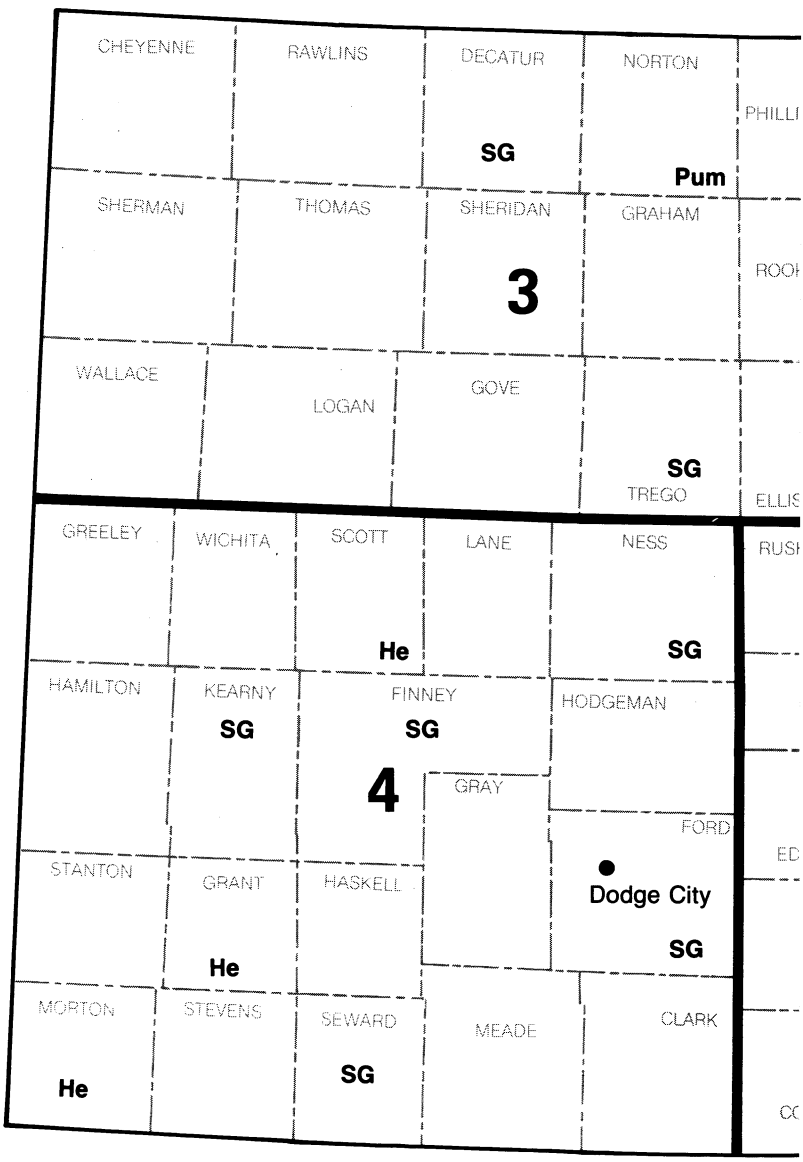
KAN

LEGEND

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

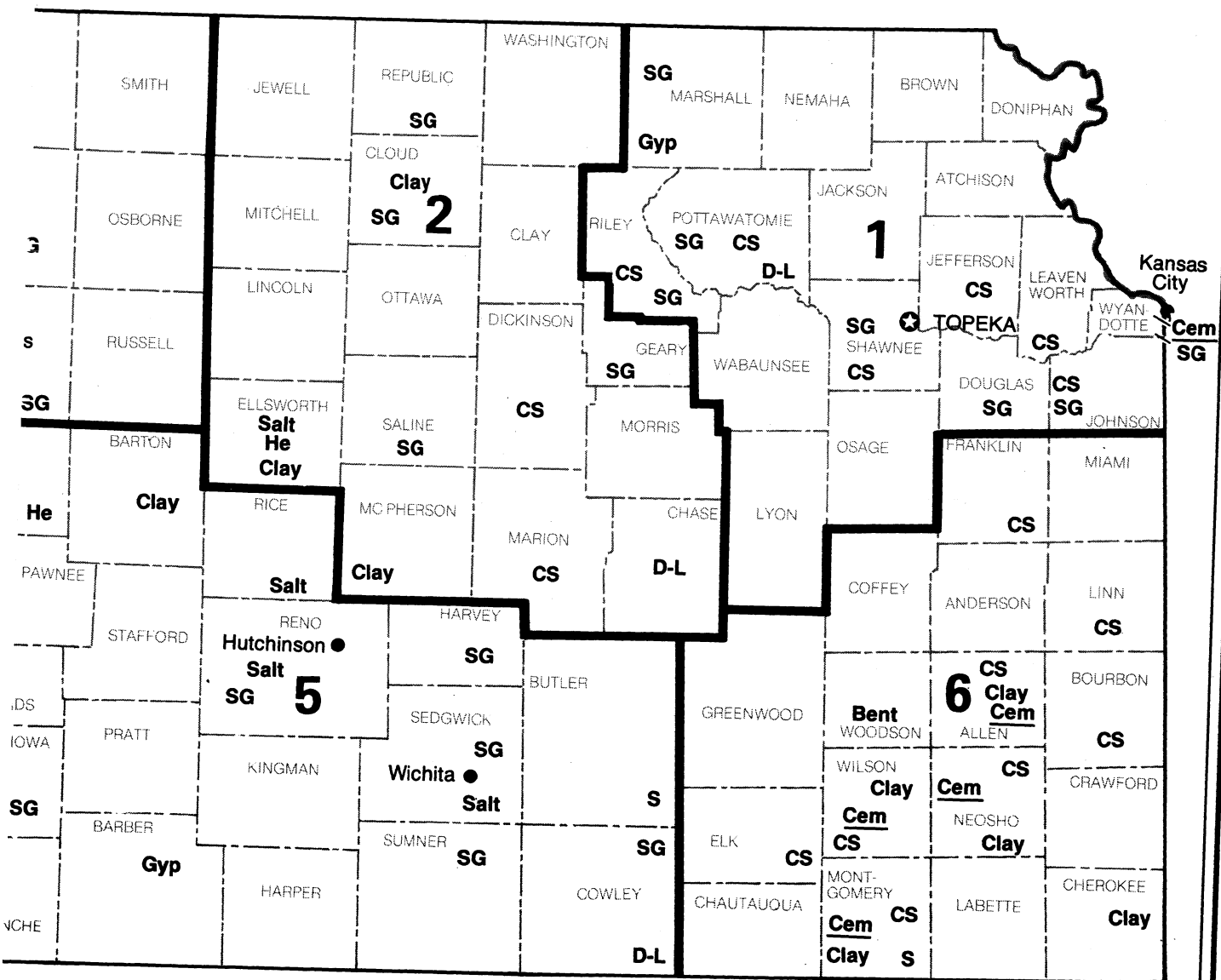
MINERAL SYMBOLS

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

AS


SMITH
JEWELL
REPUBLIC
SG
WASHINGTON
SG
MARSHALL
NEMAHA
BROWN
DONIPHAN
Gyp
CLOUD
Clay
SG
2
OSBORNE
MITCHELL
CLAY
RILEY
POTTAWATOMIE
SG
CS
D-L
JACKSON
1
ATCHISON
JEFFERSON
CS
LEAVEN
WORTH
Kansas
City
WYAN
DOTTE
Cem
SG
CS
LINCOLN
OTTAWA
CS
SG
DICKINSON
SG
TOPEKA
SHAWNEE
CS
CS
RUSSELL
GEARY
SG
WABAUNSEE
SG
CS
DOUGLAS
SG
CS
SG
JOHNSON
ELLSWORTH
Salt
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Clay
SALINE
SG
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MORRIS
OSAGE
FRANKLIN
MIAMI
BARTON
Clay
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RICE
MC PHERSON
MARION
CS
CHASE
D-L
LYON
CS
PAWNEE
Salt
Clay
COFFEY
ANDERSON
LINN
CS
STAFFORD
RENO
Hutchinson
Salt
SG
5
HARVEY
SG
BUTLER
GREENWOOD
Bent
WOODSON
6
CS
Clay
Cem
ALLEN
BOURBON
CS
PRATT
SEDGWICK
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HARPER
COWLEY
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CHAUTAUQUA
LABETTE

total value was down $12.6 million or 18% to $57 million.

Crushed limestone was extracted from 132 quarries in 42 of the State's 105 counties. In addition, sandstone was quarried in Lincoln and Neosho Counties, and quartzite was quarried in Smith County.

The top ten limestone-producing firms accounted for 53% of Kansas' tonnage and 60% of its value. These firms operated the top 54 of 132 limestone quarries in Kansas. Crushed limestone was used principally for cement manufacture, followed by graded road base, concrete aggregate, bituminous aggregate, and 17 other uses. The highest f.o.b. price received was $16.13 per short ton for asphalt fillers. All other uses were priced between $1 and $5.96 per short ton. More than 47% of crushed limestone was transported by truck, and nearly 32% was used at the site.

On November 9, a majority of Shawnee County commissioners voted to permit Martin Marietta Aggregates to expand its limestone quarry operation southeast of Topeka. Area residents denounced the decision as "a deathblow to their quiet home lives." The 6-year permit realistically allowed 4 years of mining and 2 years for reclamation.

In December, Martin Marietta announced the purchase of seven limestone quarries in central Kansas from Hallett Materials Corp. of Des Moines, IA. The purchase included inventories, property, plants, and equipment. Martin Marietta officials hoped that the properties would help meet the increasing demand for limestone that is expected to result from a $2.6 billion highway construction program recently enacted by the State.

TABLE 2

KANSAS: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	322	1,416
Riprap and jetty stone	76	268
Filter stone	241	932
Coarse aggregate, graded:		
Concrete aggregate, coarse	1,423	6,074
Bituminous aggregate, coarse	1,054	5,041
Bituminous surface-treatment aggregate	285	1,054
Fine aggregate (−3/8 inch):		
Stone sand, concrete	4	21
Stone sand, bituminous mix or seal	79	289
Screening, undesignated	403	1,366
Coarse and fine aggregates:		
Graded road base or subbase	1,881	5,263
Unpaved road surfacing	562	1,632
Crusher run or fill or waste	392	1,459
Other construction materials[2]	36	164
Agricultural: Agricultural limestone	327	759
Chemical and metallurgical: Cement manufacture	2,424	5,793
Other miscellaneous[3]	16	214
Unspecified:[4]		
Actual	6,176	24,933
Estimated	149	297
Total	15,850	[5]56,976

[1] Includes limestone; sandstone and quartzite withheld to avoid disclosing company proprietary data.
[2] Includes stone used in railroad ballast, terrazzo and exposed aggregate, and other coarse and fine aggregates.
[3] Includes stone used in lime manufacture, asphalt fillers and extenders, and roofing granules.
[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.

Dimension.—Dimension stone quarries in Kansas more than doubled output and total value over figures estimated for 1988, a year of apparent decline. Bandera Stone Co. reopened a sandstone quarry in Bourbon County. This was the first dimension sandstone company to operate in Kansas for nearly 20 years. The firm also produced some dimension limestone. Average price per short ton of all dimension stone increased by about one-third.

Sulfur (Recovered).—Sulfur is a nondiscretionary byproduct of petroleum refining. In 1989, sulfur was recovered by Texaco Refining Marketing Inc., at El Dorado, Butler County, and by Farmland Industries Inc., at Coffeyville, Montgomery County. Production and value of recovered sulfur sold or used dropped from those of 1988 but were at or near the averages for the 1980's.

[1] State Mineral Officer, Bureau of Mines, Denver, CO. She has covered the mineral activities in Kansas for 7 years. Assistance in the preparation of the chapter was given by Pat La Tour, editorial assistant.

[2] Associate scientist, Mineral Information, Kansas Geological Survey, Lawrence, KS.

[3] Berendsen, P. Mineralization Potential Along the Trend of the Keweenawan-Age Central North American Rift System, in Iowa, Nebraska, and Kansas. Min. Eng., v. 41, No. 8, Aug. 1989, pp. 845-848.

[4] Mankato, K. S. Kansas Minerals Ships Large Order. Jewell County Record, v. 99, No. 29, p. 1, Dec. 14, 1989.

TABLE 3

KANSAS: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	W	W	W	W	—	—
Coarse aggregate, graded[2]	W	W	W	W	—	—
Fine aggregate (−3/8 inch)[3]	W	W	W	W	—	—
Coarse and fine aggregates[4]	796	2,990	270	543	—	—
Other construction aggregates	2,496	11,586	177	1,113	—	—
Agricultural[5]	(6)	(6)	(6)	(6)	—	—
Chemical and metallurgical[7]	(6)	(6)	—	—	—	—
Special[8]	—	—	—	—	—	—
Other miscellaneous	570	1,400	17	30	—	—
Unspecified:						
Actual[9]	2,972	13,923	1,246	4,099	—	—
Estimated[10]	—	—	—	—	—	—
Total[11]	6,833	29,900	1,709	5,784	—	—

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	—	—	—	—	137	507
Coarse aggregate, graded[2]	—	—	—	—	899	2,878
Fine aggregate (−3/8 inch)[3]	—	—	—	—	198	477
Coarse and fine aggregates[4]	—	—	309	606	1,471	4,257
Other construction aggregates	—	—	—	—	5	22
Agricultural[5]	—	—	41	61	205	531
Chemical and metallurgical[7]	—	—	(6)	(6)	1,919	4,530
Special[8]	—	—	—	—	13	(6)
Other miscellaneous	—	—	1	1	1	213
Unspecified:						
Actual[9]	373	559	382	1,588	1,204	4,764
Estimated[10]	—	—	—	—	149	297
Total[11]	373	559	733	2,256	6,202	18,477

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."

[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 crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run or fill or waste, and other coarse and fine aggregates.

[5] Includes agricultural limestone.

[6] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."

[7] Includes crushed stone for cement manufacture and lime manufacture.

[8] Includes crushed stone for asphalt fillers or extenders and roofing granules.

[9] Includes production reported without a breakdown by end use.

[10] Includes estimates for nonrespondents.

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

TABLE 4

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]	7701 East Kellogg St. Suite 240 Wichita, KS 67207	do.	Wilson.
Heartland Cement Co.[4]	Box 428 Independence, KS 67301	do.	Montgomery.
Lone Star Industries Inc.[5]	Box 12449 Dallas, TX 75225	do.	Wyandotte.
The Monarch Cement Co.[6]	Box 187 Humboldt, KS 77648	do.	Allen.
Clays:			
Acme Brick Co., Justin Industries Inc.	Box 98 Kanopolis, KS 67454	Pits and plants	Cherokee and Ellsworth.
Buildex Inc., a division of Clemens Coal Co.	Box 15 Ottawa, KS 66067	Pit and plant	McPherson.
Cloud Ceramics, a division of General Finance Inc.	Box 369 Concordia, KS 66901	Pits and plant	Cloud.
Kansas Brick & Tile Co. Inc.	Box 450 Hoisington, KS 67544	Pit and plant	Barton.
Gypsum:			
Georgia-Pacific Corp.	133 Peachtree St., NE. Atlanta, GA 30303	Underground mine and plant	Marshall.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	Open pit, underground mine, plant	Barber.
Helium:			
Kansas Refined Helium Co.	Otis, KS 67565	Plant	Rush.
Union Carbide Corp., Linde Div.	Box 444 Somerset, NJ 08873	Plants	Ellsworth, Grant, Morton, Rush.
Perlite (expanded):			
Lite-Weight Products Inc.	1706 Kansas Ave. Kansas City, KS 66105	Plant	Wyandotte.
Pumice and pumicite:			
Calvert Corp.	Box 97 Norton, KS 67654	Pit and plant	Norton.
Salt:			
American Salt Co.	6950 West 56th Mission, KS 66202	Wells and underground mine	Rice.
Carey Salt Inc.	do.	do.	Reno.
Cargill Inc., Salt Div.	Box 1403 Hutchinson, KS 67501	Wells	Do.
Independent Salt Co.	Box 36 Kanopolis, KS 67454	Underground mine	Ellsworth.
Morton Salt Co., a division of Morton Thiokol Inc.	110 North Wacker Dr. Chicago, IL 60606	Wells	Reno.
Vulcan Materials Co., Chemical Div.	Box 7689 Birmingham, AL 35223	do.	Sedgwick.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel (construction):			
Associated Material & Supply Co. Inc.	Box 4064 Wichita, KS 67204	Pit and plant	Sedgwick and Sumner.
Builders Sand Co.	4150 Kansas Ave. Kansas City, KS 66106	Dredges and plants	Johnson, Shawnee, Wyandotte.
Holliday Sand & Gravel Co., a division of List & Clark Construction Co.[7]	6811 West 63d St. Overland Park, KS 66202	Pits and plants	Johnson and Wyandotte.
Ritchie Sand Co., a division of Ritchie Corp.	6500 West 21st St. Wichita, KS 67204	Dredge and plant	Sedgwick.
Stone:			
Crushed:			
N. R. Hamm Quarry Inc.	Box 17 Perry, KS 66073	Quarries and plants	Various (9 counties).
Inland Quarries, a subsidiary of Americold Inc.	Box 2249 Kansas City, KS 66110	Underground mine and plant	Wyandotte.
McAdam Construction Co. Inc.	Main Street Moran, KS 66755	Quarries and plants	Allen, Anderson, Bourbon, Linn.
Martin Marietta Aggregates, Central Div.	Box 30013 Raleigh, NC 27622	do.	Various (7 counties).
Midwest Minerals Inc.	Box 412 Pittsburg, KS 66762	do.	Cherokee, Crawford, Labette, Montgomery, Neosho, Wilson.
Dimension:			
Bayer Stone Inc.	6th and Mission St. Marys, KS 66536	Quarries	Pottawatomie and Riley.
H. J. Born Stone Co. Inc.	Route 3, Box 312 Silverdale, KS 67005	do.	Chase and Cowley.
Sulfur (recovered):			
Farmland Industries Inc.	North Linden St. Coffeyville, KS 67337	Secondary recovery plant	Montgomery.
Texaco Refining & Marketing Co.	Box 1650 Tulsa, OK 74102	do.	Butler.

[1] Also clays in Neosho County.
[2] Also crushed stone in Johnson, Linn, and Neosho Counties.
[3] Also clays and crushed stone in Wilson County.
[4] Also clays and crushed stone in Montgomery County.
[5] Also crushed stone in Wyandotte County.
[6] Also clays and crushed stone in Allen County.
[7] Also industrial sand in Wyandotte County.

THE MINERAL INDUSTRY OF KENTUCKY

This chapter has been prepared under a Memorandum of Understanding between the 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 in 1989 declined slightly, but remained above the $300 million level for the second year in a row.

Despite the decline in value in 1989, the State's industrial minerals sector reported production only slightly below the record-setting levels of 1988. The coal mining industry remained a significant part of Kentucky's economy. The State was the Nation's second leading producer of coal accounting for approximately one-fifth of U.S. output. The State's metals manufacturing sector expanded during the year because a number of aluminum and steel companies opened new operations or added capacity. Overall, Kentucky's mineral industries appeared to be in a stable-to-improving position as the year ended.

REGULATORY ISSUES

By the late 1980's, crushed limestone production in Kentucky had increased by about 50%, compared with the 1980–82 period. This significant increase in output generated additional public awareness of mining and its effect on the environment. Subsequently, both State and local government officials decided to review the stone industry's regulatory statutes, particularly for underground mines. Mining regulations monitored and enforced by State government included those affecting the use of explosives as well as air and water quality. Local government primarily dealt with mining by adopting and revising zoning ordinances.

In Fayette County, the Urban County Government Council appointed a committee to draft an ordinance to regulate limestone mining. The 10-member committee was expected to recommend stipulations concerning land use, reclamation, mapping of mines and quarries, and truck traffic. In 1989, two underground limestone mines and one quarry were operating in the county. The committee expected to complete its work in 1990.

EXPLORATION ACTIVITIES

Limited exploration activity occurred in the western Kentucky fluorspar district for the first time since 1985. High zinc prices generated renewed interest in ore bodies discovered during the 1970's in the south-central part of the State. Industrial-grade limestone and dolomite deposits were investigated on a small scale in western Kentucky.

LEGISLATION AND GOVERNMENT PROGRAMS

After years of court challenges, owners of unmined coal reserves in Kentucky were required to pay property taxes at the rate of about $0.21 per $100 in assessed value retroactive to 1986. The Kentucky Revenue Cabinet was authorized to make the assessments and began developing criteria and geologic data for a comprehensive

TABLE 1
NONFUEL MINERAL PRODUCTION IN KENTUCKY[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Clays[2]	metric tons	801,287	$3,393	762,324	$3,217	716,990	$3,357
Gem stones		NA	3	NA	3	NA	W
Sand and gravel (construction)	thousand short tons	e7,100	e15,200	6,325	15,243	e5,500	e15,100
Stone (crushed)	do.	43,330	173,222	e50,700	e207,900	3 48,178	3 187,849
Zinc[4]	metric tons	10	9	W	W	—	—
Combined value of cement, clays (ball clay, fire clay), lime, sand and gravel (industrial, 1987, 1989), stone (crushed dolomite, 1989), and values indicated by symbol W		XX	98,508	XX	118,616	XX	124,353
Total		XX	290,335	XX	344,979	XX	330,659

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.
[4] Recoverable content of ores, etc.

evaluation of the State's coal resources.

Although the issue was settled for coal, a decision on whether unmined nonfuel minerals must also be taxed at the $0.21-per-$100-assessed-value rate remained in court at yearend. For limestone, the major nonfuel mineral mined in Kentucky, property taxes were based on assessments by local government officials.

The Kentucky Geological Survey (KGS) conducted geologic and mineral-related research. The State's leading nonfuel mineral, limestone, was the subject of a KGS study because of anticipated demand for limestone products used in lowering air pollution. A report outlining location and availability of limestone suitable for use in controlling sulfur dioxide emissions at coal burning electric utility plants was scheduled for publication in 1990. Compilation of a new map by the KGS showing the industrial and metallic mineral resources of the State began during the year. Active mines, quarries, and pits, as well as mineral industry plants, were to be included on the map.

KGS also continued work on coal resources with the U.S. Geological Survey. The objective of this project was to update and improve the estimates of coal resources available for mining and to determine the effects of environmental and technological restrictions upon those resources. In 1989, work was conducted in the Middlesboro North and Millard Quadrangles in eastern Kentucky. Further work on coal recoverability in these quadrangles has been started by the Bureau of Mines.

The Governor's Office for Coal and Energy Policy, in cooperation with the Kentucky Coal Association, published a booklet that provided historical data and facts about the State's coal industry. The Kentucky coal industry employed 31,500 workers and paid about $1 billion in wages in 1988, according to the booklet.[3]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—In 1989, production of portland cement remained about the same as that of 1988. Kosmos Cement Co., Jefferson County, began a $25 million to $30 million expansion project designed to boost capacity by 42%, to about 1 million tons per year.[4] Kosmos Cement is the State's only cement producer and is jointly owned by Southdown Inc. (75%) and Lone Star Industries Inc. (25%).

Late in the year, Kosmos Cement began burning liquid wastes as an alternative fuel for coal. The firm received approval to burn the wastes from the Jefferson County Air Pollution Control District on a trial basis.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Output of sand and gravel declined again in 1989, for the fifth consecutive year. The drop in output reflected only a small portion of the market for aggregate used in construction. Sand and gravel accounted for only about 10% of the mineral aggregate produced in Kentucky and was mined in only 15 of the State's 120 counties.

Stone.—Stone production is surveyed by the Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual

TABLE 2

KENTUCKY: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	418	1,826
Riprap and jetty stone	2,033	7,537
Filter stone	283	979
Coarse aggregate, graded:		
Concrete aggregate, coarse	3,883	15,054
Bituminous aggregate, coarse	3,281	13,100
Bituminous surface-treatment aggregate	1,476	5,301
Railroad ballast	120	304
Fine aggregate (−3/8 inch):		
Stone sand, concrete	325	1,019
Stone sand, bituminous mix or seal	1,264	4,644
Screening, undesignated	767	2,380
Coarse and fine aggregates:		
Graded road base or subbase	8,832	32,996
Unpaved road surfacing	1,146	4,047
Crusher-run or fill or waste	1,115	4,065
Other construction materials[2]	208	548
Agricultural: Agricultural limestone	1,433	5,361
Chemical and metallurgical[3]	4,899	22,666
Special: Mine dusting or acid water treatment	204	3,018
Other miscellaneous uses[4]	95	253
Unspecified:[5]		
Actual	4,430	16,170
Estimated	11,965	46,581
Total	[6]48,178	187,849

[1] Includes limestone; dolomite withheld to avoid disclosing company proprietary data.
[2] Includes stone used in other coarse and fine aggregates.
[3] Incudes stone used in cement and lime manufacture, flux stone, and sulfur oxide removal.
[4] Includes stone used in poultry grit and mineral food, asphalt fillers or extenders, waste material, and pipe bedding.
[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.

company estimates. This chapter contains actual data for 1987 and 1989 and estimates for 1988.

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

In the 1980's, crushed stone was the leading nonfuel mineral produced in Kentucky, accounting for $1.4 billion or about 55% of the State's total nonfuel value. The highest output of crushed stone ever reported in Kentucky was 50.7 million short tons in 1988; the lowest production during the decade was 29.5 million tons in 1982. Output in 1989 of 48.2 million tons was the second highest total reported in State history.

A trend of stone company acquisitions that began in the mid-1980's continued in 1989. Vulcan Materials Co., one of the Nation's top crushed stone producers, reached an agreement to purchase Reed Crushed Stone Co. Inc, Livingston County. The Reed Crushed Stone quarry was the Nation's top producer in 1988 and 1989 with output of between 10 and 11 million tons.[5] The agreement also included Reed Terminal Co. Inc. and BRT Transfer Terminal Inc. near Paducah. These terminals were used in the transport of coal and stone to markets in western Kentucky and along the Mississippi River and the Tennessee-Tombigbee Waterway. Vulcan also purchased Central Rock Minerals Inc.'s underground limestone mine in Lexington, which has a capacity of about 800,000 tons per year. Prior to the acquisitions, Vulcan operated five quarries and one mine in the State—three in Hardin County, two in Fayette County, and one in Meade County. Lafarge Corp. purchased a limestone quarry in Carter County as part of a sale by the Standard Slag Co. of 32 operations nationwide.

Other Industrial Minerals.—The State's leading ball clay producer, Kentucky-Tennessee Clay Co., Mayfield, purchased kaolin mines and plants in Georgia and South Carolina from Cyprus Minerals Co. Kentucky-Tennessee Clay is a subsidiary of Heckla Mining Co. of Idaho. Kentucky ranked second nationally in production of ball clay.

Dravo Lime Co., with two plants in Kentucky, was the Nation's leading lime producer in 1989. That position appeared secure based on a report by an investment firm on the impact of Federal clean air legislation that was proposed in 1989. The report estimated that shipments of lime by Dravo could increase by 50% to 100% by 1995.[6]

Production of industrial sand in Kentucky was reported by one company in Hart County. The pit operated by Green River Silica Co. has also mined construction sand and gravel.

Metals

Small quantities of fluorspar and zinc were recovered from surface ore at the Lafayette Mine in Chittenden County. Production of byproduct zinc recovered at a limestone operation in 1988 and previous years was not reported in 1989.

TABLE 3

KENTUCKY: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(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 aggregate (+1 1/2 inch)[1]	W	W	W	W	935	4,160	348	1,206
Coarse aggregate, graded[2]	974	3,086	2,094	8,314	3,915	16,214	1,777	6,145
Fine aggregate (−3/8 inch)[3]	W	W	W	W	913	3,060	878	2,983
Coarse and fine aggregates[4]	1,603	5,450	1,726	6,945	5,580	21,260	2,343	7,823
Other construction aggregates	1,188	3,738	828	3,239	43	159	11	30
Agricultural[5]	449	1,445	571	2,319	302	1,241	113	364
Chemical and metallurgical[6]	—	—	(7)	(7)	(7)	(7)	—	—
Special[8]	89	(7)	—	—	204	1,658	—	—
Other miscellaneous	—	1,593	996	996	3,902	21,669	—	—
Unspecified:								
Actual[9]	12,001	45,972	1,032	4,181	839	2,672	1,558	5,695
Estimated[10]			105	448	560	2,644	300	1,138
Total[11]	16,304	61,284	7,354	26,443	17,192	74,738	7,328	25,384

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."

[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 crushed stone for graded road base or subbase, unpaved road surfacing, crusher run or fill or waste, pipe bedding, and other coarse and fine aggregates.

[5] Includes agricultural limestone and poultry grit and mineral food.

[6] Includes crushed stone for cement manufacture, lime manufacture, flux stone, and sulfur oxide removal.

[7] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."

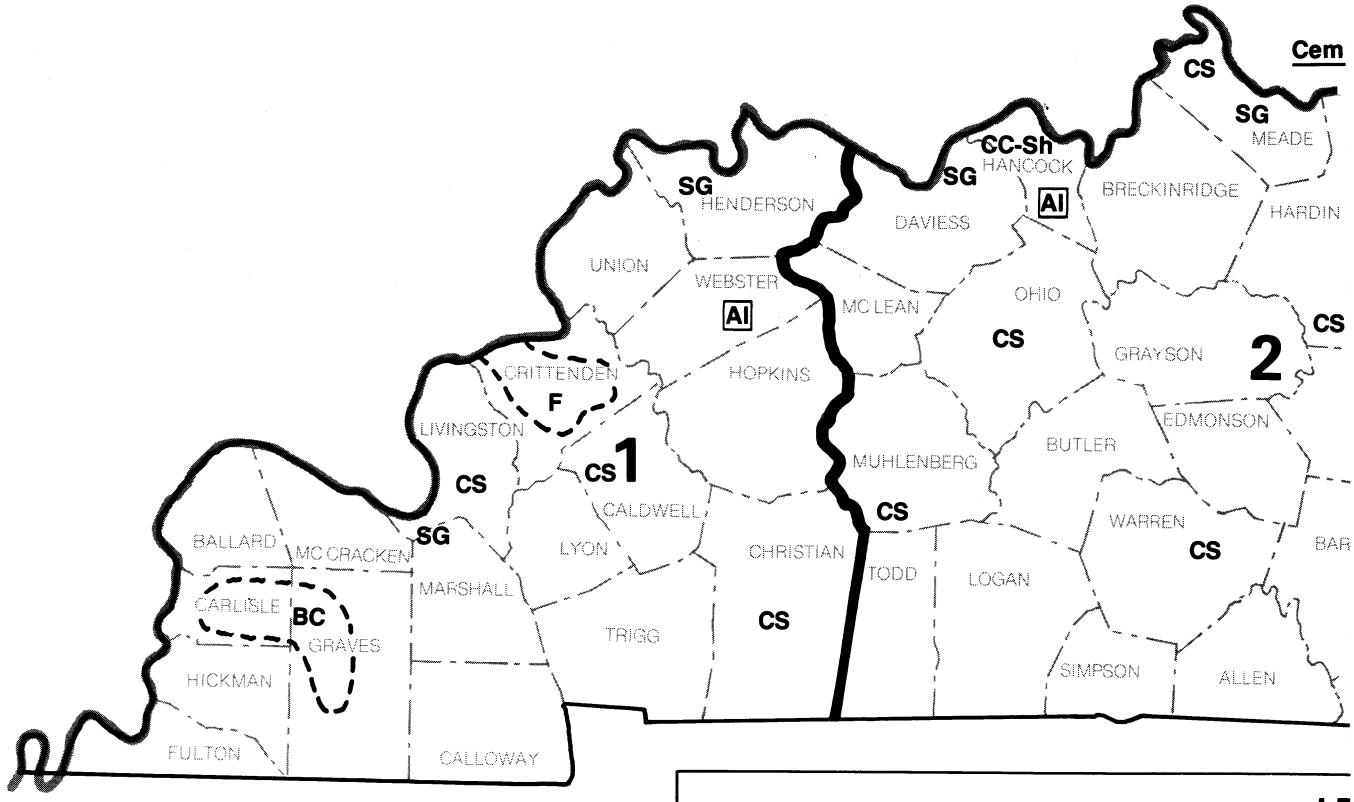
[8] Includes crushed stone for mine dusting or acid water treatment, asphalt fillers or extenders, and waste material.

[9] Includes production reported without a breakdown by end use.

[10] Includes estimates for nonrespondents.

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

KEN



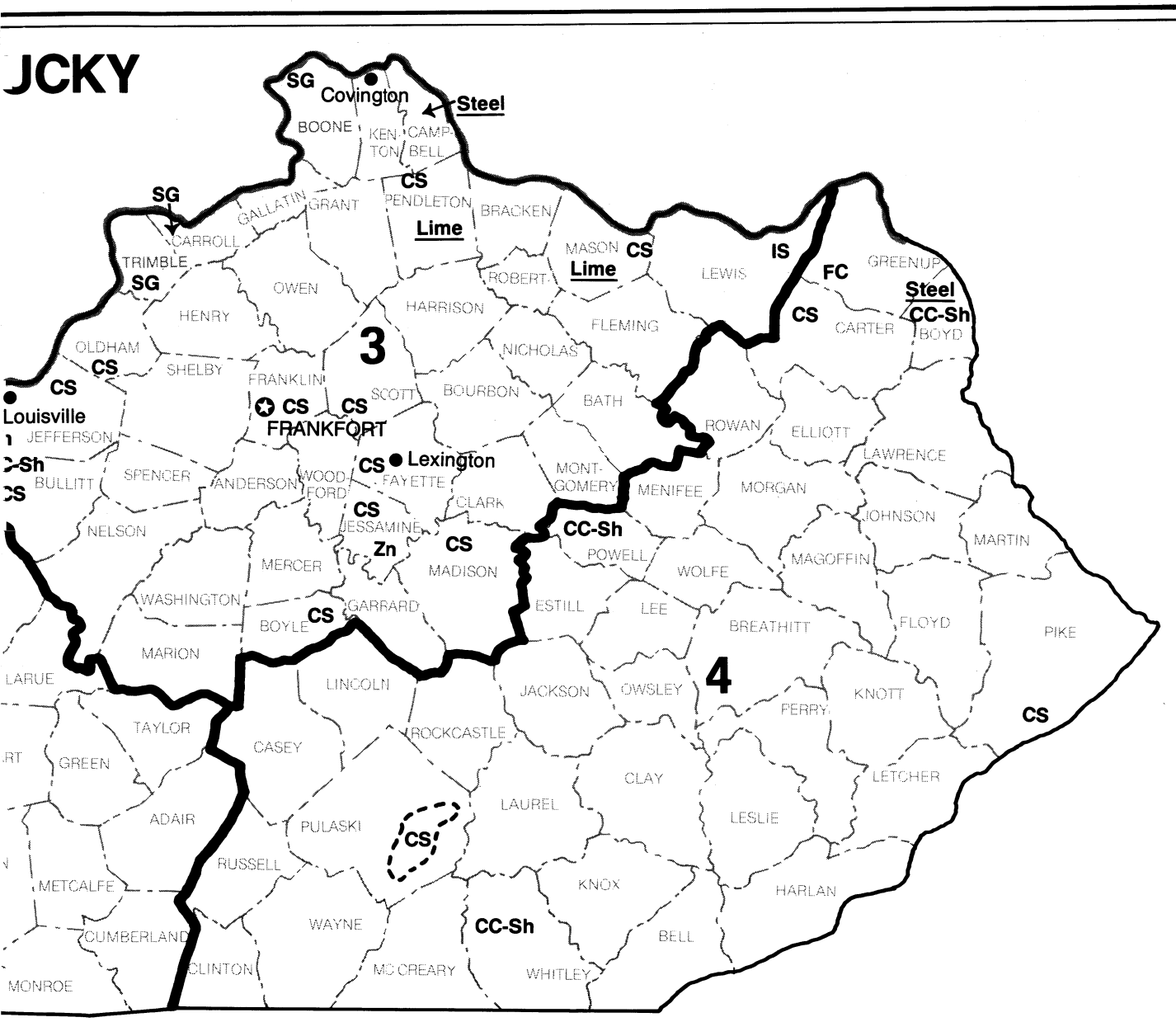
LE

MINERA

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

AI Alun
BC Ball
CC-Sh Con
Cem Cem
CS Crus
F Fluo
FC Fire

Principal Mineral-Producing Localities



END

SYMBOLS

	um plant
	ay
	ɔn Clay & Shale
	ıt plant
	ed Stone
	ɔar
	ay
IS	Industrial Sand
Lime	Lime plant
SG	Sand and Gravel
Steel	Iron and Steel plant
Zn	Zinc
	Concentration of mineral operations

Metals manufacturing, however, was significant to Kentucky's economy as indicated by employment and wage data. Unlike industrial minerals, this sector remained highly dependent on national and international developments that affected metal prices. In 1989, steel and aluminum manufacturers announced and initiated several projects.

Aluminum.—Developments in Kentucky's aluminum industry were considerable during the year. Alcan Ingot & Recycling, a subsidiary of Alcan Aluminum Ltd. of Montreal, opened a recycling plant with the capacity to process 6 billion used beverage containers per year. The plant in Berea opened in October and cost about $50 million, of which about 20% was spent on pollution control equipment. A smaller recycling plant was opened in Morgantown by Imco Recycling Inc. Imco invested $8 million in the operation, which has the capacity to recycle about 5.5 million used beverage containers.

Aluminum processing companies were also expanding in the State. In October, Logan Aluminum Inc. announced a 5-year, $280 million program to upgrade its Russellville sheet rolling operations. Reynolds Aluminum Supply Co. began construction of a $9 million plant at Shelbyville for processing aluminum, stainless steel, and nickel coil into sheets and plates.

Iron and Steel.—Kentucky's leading steel producer, Armco Inc., finalized an agreement with Kawasaki Steel Corp. of Japan. Through the agreement, Kawasaki paid $350 million for 40% ownership of Armco's steel mills in Ashland and in Middletown, OH. Kawasaki also has an option to purchase an additional 10% of the company by 1992 for $175 million. The new joint venture was called Armco Steel Co., L.P.

Newport Steel Corp. continued installation of a continuous caster at its Wilder plant and invested $45 million for a 170-ton-per-hour furnace and slab handling equipment to be used in conjunction with the caster.

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[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in Kentucky for 5 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] Kentucky Coal Facts, 1989-90 Pocket Guide. Governor's Office for Coal and Energy Policy and Kentucky Coal Association. Nov. 15, 1989, 44 pp.

[4] The Courier Journal (Louisville, KY). Kosmos Cement Plans Expansion To Meet Demand, May 27, 1989, p. B1.

[5] Rock Products. Top Crushed Stone Plants. V. 93, No. 5, May 1990, p. 44.

[6] Rock Products. Dravo Expected To Benefit From Acid Rain Legislation. V. 93, No. 1, Jan. 1990, p. 27.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum (primary):			
Alcan Aluminum Corp.	Sebree, KY 42555	Smelter	Webster.
National-Southwire Aluminum 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.
U.S. Brick Inc., Sipple Div.	Box 567 Stanton, KY 40380	do.	Powell.
Fire clay:			
Ford Burchett Clay Co.	Route 1, Box 850 Olive Hill, KY 41164	Mine	Carter.
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	Mines and plants	Mason and Pendleton.
Sand and gravel (construction):			
Evansville Materials Inc.	Box 249 Tell City, IN 47586	Dredges	Daviess.
Northern Kentucky Aggregates	11641 Mosteller Rd. Cincinnati, OH 45241	do.	Boone.
Nugent Sand Co. Inc.	Box 6072 1833 River Rd. Louisville, KY 40206	do.	Trimble.
Stone (crushed):			
Beazer Materials & Service Inc.	436 7th Ave. Pittsburgh, PA 15219	Underground mines, quarries, plants	Various.
Medusa Aggregates Co.	880 Corporate Dr., Suite 101 Lexington, KY 40503	Quarries and plants	Nelson, Ohio, Pendleton, Warren.
Reed Crushed Stone Co. Inc.	Box 35 Gilbertsville, KY 42044	Quarry and plant	Livingston.
Rogers Group Inc.	Box 310 Shepherdsville, KY 40165	Quarries and plants	Bullitt, Christian, Oldham.
Vulcan Materials	3001 Alcoa Highway, Box 7 Knoxville, TN 37901	Underground mines, quarries, plants	Hardin, Fayette, Meade.

[1] Also clays.
[2] Also stone.

THE MINERAL INDUSTRY OF LOUISIANA

This chapter has been prepared under a Memorandum of Understanding between the 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, Jr.,[1] and John Johnston[2]

In 1989, the nonfuel mineral industry in Louisiana produced mineral commodities valued at $379.7 million. This was a decrease of $54.8 million from that produced in 1988. The decline was due primarily to a drop in clay (-35.9%), Frasch sulfur (-21.9%), and stone (-16.4%) production.

The State ranked 8th in mineral value among the 10 Southeastern States. It ranked 27th nationally in total mineral value and led the Nation in shell and salt output and ranked second in total (Frasch and recovered) sulfur production.

TRENDS AND DEVELOPMENTS

The 1980's were a tumultuous period for Louisiana's mineral producers. Mineral value exceeded $500 million for the first time in 1980 when $584 million worth of mineral commodities was produced. Following this record, output and value declined in 1981-1982 as a result of the nationwide recession. Beginning in 1983, the State experienced a 3-year period of increased mineral demand; value rose from $447 million in 1983 to $521 million in 1985.

The worldwide decline in oil prices that heralded the second half of the decade had a devastating effect on most sectors of the State's economy, including the mineral industry. Value fell in 1986-87, recovered slightly in 1988, but dropped below the $400 million plateau in 1989 for the first time in the 1980's.

Despite the malaise affecting the mineral industry, several companies reopened plants or announced expansions or plans for new facilities.

The Lake Charles carbon anode plant of Reynolds Metals Co. was scheduled for a $47 million expansion. Ormet Corp., one of the Nation's four alumina producers, reopened a closed plant at Burnside and reached full capacity early in 1989. Louisiana Energy Services, a consortium of three utility companies, an engineering and construction firm, and an English uranium enrichment group, announced plans for a new uranium enrichment plant to be built in northern Louisiana in 1992.

REGULATORY ISSUES

The principal environmental controversy during the year concerned the dredging of shell, used as an aggregate material, from Lake Pontchartrain. The dredging met with increased citizen, fishing industry, and environmental group opposition. Opponents charged that dredging kills marine life and degrades

TABLE 1

NONFUEL MINERAL PRODUCTION IN LOUISIANA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	323,778	$9,192	340,900	$9,535	233,992	$6,115
Gem stones		NA	1	NA	3	NA	14
Salt	thousand short tons	12,498	108,999	14,274	108,982	13,218	115,203
Sand and gravel:							
Construction	do.	e12,200	e43,600	14,233	52,820	e13,600	e54,400
Industrial	do.	289	3,997	318	4,786	572	9,664
Stone (crushed)	do.	2 4,390	2 36,514	e 2 3,700	e 2 29,200	3,206	24,414
Sulfur (Frasch)	thousand metric tons	1,458	W	1,719	W	1,334	W
Combined value of cement (masonry (1987-88), portland, (1987-88)), gypsum, lime, stone (crushed miscellaneous, (1987-88), and values indicated by symbol W		XX	221,918	XX	229,210	XX	169,912
Total		XX	424,221	XX	434,536	XX	379,722

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

the water quality of the lake. Dredging was banned within 3 miles of the shore. At yearend, a newly formed environmental group announced plans to sue the State's Department of Environmental Quality and three dredging firms if the dredging was not terminated.

Texas Brine Corp.'s request for permits to drill multiple-solution and brine-disposal wells into the Starks Salt Dome met with opposition from local citizens and environmental groups. The wells would dissolve three caverns in the dome for the storage of approximately 1.5 million barrels of petroleum-derived feedstock.

LEGISLATION AND GOVERNMENT PROGRAMS

The Louisiana Geological Survey began a project to define and map the location of the State's significant industrial minerals. The project will determine the geographic distribution and history of mineral products and define the geological factors associated with resource trends. Environmental considerations and potential hazards associated with mineral production will also be identified.

Work was also underway to develop a Resource Series folio on past mineral production using Louisiana severance tax statistics.

Several parishes filed suit against the State and the three active shell dredging companies for 10% royalties on the sale of shells. A 1974 amendment to the State constitution allows parishes to receive 10% royalties when minerals are extracted.[3]

U.S. Geological Survey personnel testified at a public hearing that discussed plans for a Texas company to develop cavities within a salt dome for storage of petroleum products.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Eight mineral commodities were extracted or manufactured in Louisiana during 1989. Several different mineral raw materials were imported or shipped into Louisiana from other States for the manufacture of higher value products.

Clays.—The State continued to rank 27th nationally among the 44 clay producing States. The value of clay production accounted for approximately 2% of Louisiana's total mineral value in 1989. Five companies operated five mines in five parishes to produce 234,000 metric tons of common clay valued at $6.1 million. Production fell 107,000 metric tons, and value declined almost $3.4 million, reflecting the slowdown of construction activity from the 1988 level. Caddo and Coupee Parishes accounted for over 50% of the clay mined. The clay firms reported sales for concrete block manufacture, common brick production, highway surfacing, and face brick manufacture.

Gypsum.—Winn Rock Inc. mined anhydrite, a variety of gypsum, from a quarry near Winnfield. The material was crushed and used for surfacing oil and gas drilling site access roads.

Approximately one million tons of gypsum have accumulated in Louisiana from the processing of phosphate rock into gypsum. The phosphate rock was shipped in from Florida. In January, a $3 million test refinery in St. James Parish began extracting sulfur from the phosphogypsum.[4]

Lime.—Orleans Parish was the site of a USG Corp. facility that produced both quick and hydrated lime. Production decreased slightly from the tonnage reported in 1988; however, value rose slightly. Sales were to the chemical and industrial sectors.

Salt.—Louisiana produced 34% of the Nation's salt. It was the second leading commodity produced in the State, accounting for 31% of the State's mineral value in 1989.

Production was in three forms: (1) rock salt from underground mines, (2) vacuum pan salt obtained from the mechanical evaporation of brine, and (3) salt brines. Output decreased 1 million short tons; however, value was up about $6 million over that reported in 1988.

The Avery Island salt mine is believed to be the oldest continuously operating salt facility in the U.S. During the year a team employed by the Historic American Engineering Record, a program of the National Park Service, documented mine facilities. Of particular interest was the mine's 90-year-old reciprocating steam engine, the only one of its kind in the U.S.[5]

Texas Brine Corp. sought to have 75 acres of land overlying the Starks Salt Dome rezoned. The Texas company planned to solution mine the dome to create three cavities for storage of ethylene and ethane.[6]

Sand and Gravel.—The value derived from sand and gravel sales ranked third among the extractive minerals produced in Louisiana. The estimated 1989 production was 633,000 short tons less, but $1.6 million more, than reported in 1988.

Construction.—Construction sand and gravel production is surveyed by the 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 estimates for 1987 and 1989.

In 1988, the last year that the industry was canvassed, 64 companies operated 101 mines in 24 parishes. Washington, St. Helena, and Rapides Parishes accounted for 36% of the total output. The 1988 industry reports noted that the main end uses were for concrete aggregate, fill, and asphaltic concrete. Standard Gravel Co., Franklinton, developed a method to mine sand and gravel from beneath the State's swamps. Overburden, consisting of mud, root mat, and decayed trees, was stripped, moved by floating conveyor to a mined-out area and returned to the pit floor. An 84-inch-diameter double-wheel cutter, submersible jet pump, and 14-inch suction pipe were used to mine the deposits.[7]

Industrial.—The State ranked 12th among the 38 States with industrial sand and gravel production. Output, 572,000 short tons valued at $9.6 million, exceeded the 1988 production and value by 254,000 tons and $4.9 million, respectively. The industry, four companies, operated four mines in four parishes. The leading parishes were Red River and Webster. Principal sales were to the (1) sand blasting, (2) container manufacturing, (3) roofing, (4) chemical, and (5) foundry industries.

Stone **(Crushed).**—Stone production is surveyed by the 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 1987 and 1989 and company estimates for 1988.

Louisiana's stone industry, including oyster shell producers (shell was used in roadbed construction), consisted of four companies operating seven dredges or mines in four parishes. More than 90% of the tonnage reported was shell. Approximately 60% of the shell was dredged from Orleans Parish (Lake Pontchartrain). The remainder was dredged from waters of St. Marys and St. Tammany Parishes.

The dredging industry remained under stiff attack from environmental, fishing, and citizens groups who charged that shell dredging was degrading the waters of Lake Pontchartrain.

One company mined and crushed a salt dome cap-rock. The crushed material was used to surface access roads to oil/natural gas drilling/production sites. A second firm mined sandstone in Sabine Parish.

Much of the stone used in Louisiana is barged into the State on the Mississippi River from quarries in Arkansas, Kentucky, Missouri, and Illinois. Vulcan Materials Inc. began stone shipments to the New Orleans area from a new quarry in the Yucatán Peninsula, Mexico.

The Red River Waterway Project, supervised by the U.S. Corps of Engineers, involved the construction of five locks and dams and the dredging of a 9-foot deep, 200-foot wide channel to open the river to navigation. This project was a major user of stone during 1989.

Three companies supplemented stone shipped into Louisiana by manufacturing synthetic aggregates. The three, Louisiana Synthetic Aggregates Inc., Geismar; Marine Shale Processors Inc., Amelia; and Dow Chemical U.S.A., Plaquemine, produced synthetic aggregates from a variety of waste materials. The Geismar operation mined and crushed a solidified calcium sulfate sludge for aggregate and agricultural purposes. The Amelia operation destroyed hazardous waste in a 275-foot-long kiln at temperatures in excess of 2,000° F. The resulting residue, classified as nonhazardous by the U.S. Environmental Protection Agency, was marketed for road base and fill. The Plaquemine operation gasified coal to produce a medium-Btu gas for Dow's chemical complex. Slag from the process was tested as an asphalt filler for road surfacing.

Sulfur.—Louisiana's leading mineral commodity, in terms of value, continued to be sulfur. Sales accounted for over 40% of the State's mineral value. Louisiana was one of two states with Frasch sulfur production and one of 26 with sulfur recovered during refinery operations. The State's 1.3 million metric tons of Frasch sulfur production ranked it second behind Texas's 2.4 million metric ton output. Louisiana ranked fifth in recovered sulfur production; output totaled 616,000 metric tons. Nationally, Louisiana ranked second in total sulfur production.

Freeport Minerals Co. produced all of Louisiana's Frasch sulfur from operations at Garden Island Bay, Grand Isle, and Caminada Pass. In March, Freeport announced that a sulfur discovery in the Gulf of Mexico at Main Pass, block 299, was "the largest proven Frasch sulfur reserve . . . in North America." The New Orleans company estimated reserves at 67 million long tons. Freeport drilled 19 wells on the 4,560-acre Federal lease and encountered reservoir rock containing 28% sulfur at depths ranging from 1,503 to 1,882 feet. Sulfur-bearing rock thicknesses varied from 41 to 230 feet.[8]

Construction was scheduled to begin in mid-1990 on a $300 to $500 million platform to produce the Main Pass find.[9]

Other Industrial Minerals.—In addition to the commodities listed in table 1, several minerals were recovered from process streams or shipped into the State for processing into higher value products.

Vinings Alumina Products, Inc., New Orleans, imported hydrated alumina from Ireland for the production of sodium aluminate. The material was sold to the titanium dioxide, water purification, paper, and aluminum industries.

Fourteen companies produced anhydrous ammonia. Their annual capacity exceeded more than 7 million short tons, about 40% of the Nation's capacity. Barite was crushed, ground, and bagged by Mil-Park Drilling Fluids at a plant in Houma. Both domestic and imported barite was processed. Much of the imported barite was from China and was shipped through the Lake Charles port.

Carbo Ceramics imported calcine bauxite to its New Iberia plant. The bauxite was used to manufacture proppants for the petroleum industry.

Synthetic calcium chloride was produced by Allied Signal Corp, Baton Rouge, and Texas United Chemical Corp., Lake Charles. Salt was the primary mineral raw material used in the calcium chloride process. The calcium chloride was used to speed concrete setup, for dust control, in oil and gas drilling, and for road deicing.

International Garnet Abrasives Inc. operated a garnet reclamation plant at Harvey. The company processed foreign garnet concentrates at the 10,000-ton-per-year facility.

Graphite (synthetic) was used by Reynolds Metals Company to produce car-

TABLE 2

LOUISIANA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse and fine aggregates:		
Graded road base or subbase	W	W
Unpaved road surfacing	W	W
Unspecified:[2]		
Actual	W	W
Total	3,206	24,414

W Withheld to avoid disclosing company proprietary data.
[1] Includes shell, sandstone, and miscellaneous stone.
[2] Data represents production reported without a breakdown by end use.

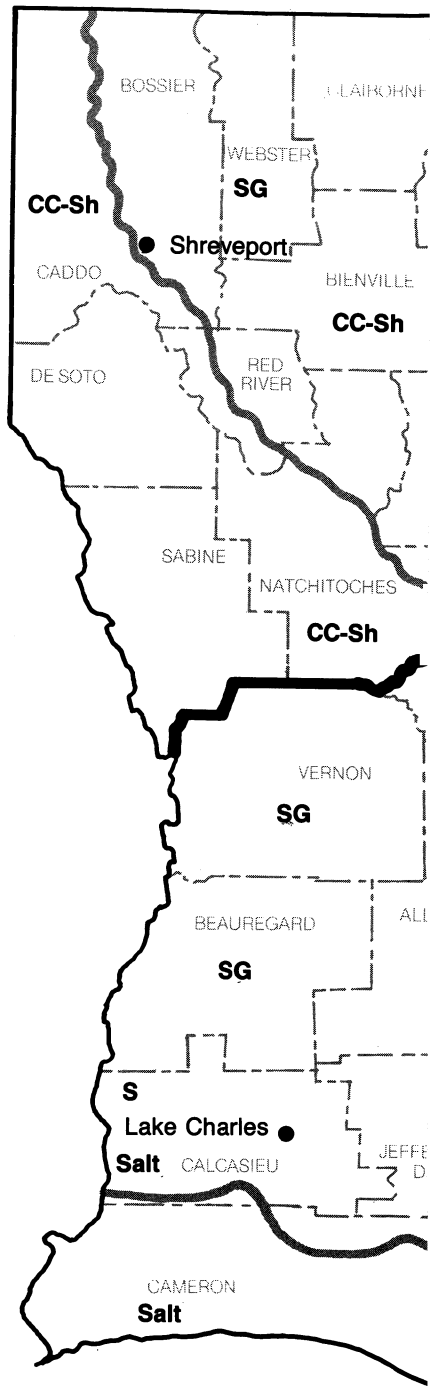
LOUISIANA

LEGEND

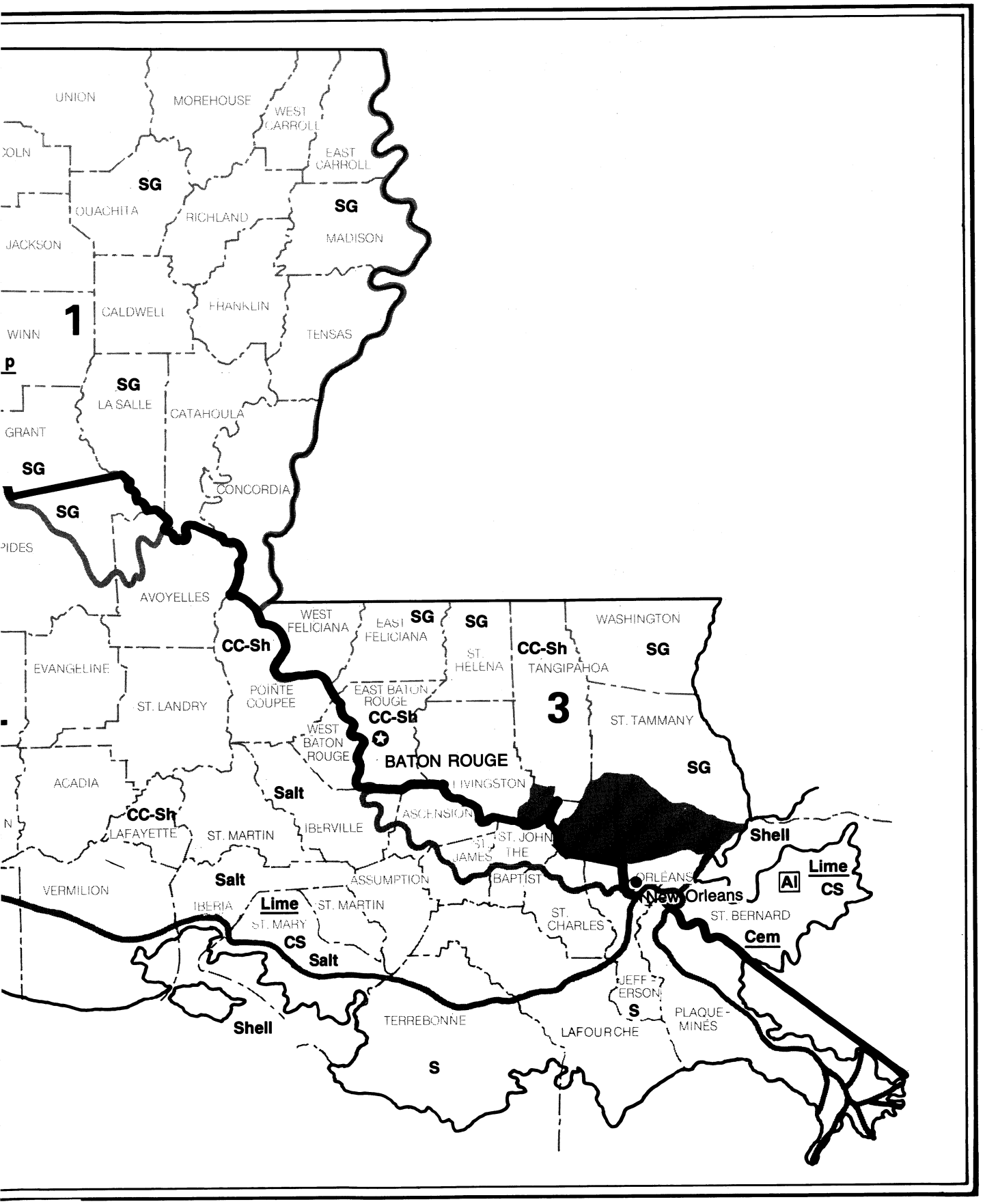
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

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


UNION
MOREHOUSE
WEST CARROLL
EAST CARROLL
SG
SG
OUACHITA
RICHLAND
MADISON
JACKSON
1
CALDWELL
FRANKLIN
WINN
TENSAS
SG
LA SALLE
CATAHOULA
GRANT
SG
SG
CONCORDIA
AVOYELLES
WEST FELICIANA
EAST FELICIANA
SG
SG
WASHINGTON
CC-Sh
ST. HELENA
CC-Sh
SG
TANGIPAHOA
EVANGELINE
POINTE COUPEE
EAST BATON ROUGE
3
ST. LANDRY
CC-Sh
ST. TAMMANY
WEST BATON ROUGE
BATON ROUGE
SG
ACADIA
LIVINGSTON
Salt
CC-Sh
ASCENSION
Shell
LAFAYETTE
ST. MARTIN
IBERVILLE
ST. JAMES
ST. JOHN THE BAPTIST
Lime
Al
CS
Salt
ASSUMPTION
ORLEANS
New Orleans
VERMILION
IBERIA
Lime
ST. MARTIN
ST. CHARLES
ST. BERNARD
ST. MARY
CS
Cem
Salt
JEFFERSON
S
PLAQUEMINES
Shell
TERREBONNE
LAFOURCHE
S

bon anodes at a plant in Lake Charles. During the year the company announced plans for a $47 million expansion for the Lake Charles facility that will include a furnace renovation and dock and ancillary facilities improvements. The modernization project was planned because of a projected need for more anodes in 1991 when an expansion of the Baie Comeau, Quebec, smelter is completed.[10]

Filter Media Co. Inc. expanded crude perlite at a plant in Reserve. The raw material was obtained from mines in New Mexico. Sales were to the filter, insulation, and lightweight concrete industries.

W. R. Grace & Co. operated a vermiculite exfoliation plant in New Orleans. Raw material was obtained from South Carolina. The exfoliated mineral was sold to the concrete, plastic aggregate, horticulture, and loose fill and block insulation industries.

Pumice pebbles from Turkey were imported through the Port of New Orleans. The pebbles were imported by clothing firms that wash new jeans with the Turkish material to produce the "stone-washed" appearance.

Metals

Alumina.—The Ormet Corp. operated a 600,000-short-ton-per-year smelter at Burnside. The plant reopened late in 1988 after being closed since 1985. The closure was due to a slump in aluminum demand. The facility converted bauxite to alumina under a 3-year tolling agreement with several companies, providing a guaranteed level of production at a fixed price. The Burnside facility is one of four domestic alumina producers.

Iron and Steel.—Bayou Steel Corp, LaPlace, operated the State's only steel mill. The LaPlace facility was a twin, 65-ton electric furnace minimill that used virtually 100% ferrous scrap during the year. The minimill had an annual capacity of 700,000 short tons of raw steel.

The steelmaker reported a steep decline in net income for the fourth quarter and the year ending September 30 compared with the last fiscal year. Net income fell 65.5% despite a 10.1% increase in sales over fiscal year 1988. The decline was due to a decrease in structural steel shipments and selling prices and an increase in unit manufacturing costs.

Structural steel shipments during FY 89 were 425,378 short tons, a 19% decrease from the 504,228 tons shipped in FY 88. Billet shipments, however, increased from 93,645 short tons in FY 88 to 247,815 short tons in FY 89.[11]

Uranium.—Freeport Uranium Recovery Co. closed its Sunshine Bridge uranium oxide plant near Donaldson in October and placed it on standby status until the uranium oxide market improves. The subsidiary of New Orleans-based Freeport-McMoRan Inc. produced an average of 400,000 pounds of uranium oxide annually. The uranium oxide was produced as a byproduct of a nearby fertilizer plant.

Freeport Uranium Recovery Co. continued to operate a 700,000-pound-per-year uranium oxide plant at Uncle Sam. Much of the plant's output was dedicated to long-term sales to electric utilities.[12]

Plans for a new uranium enrichment facility in Claiborne Parish were announced by Louisiana Energy Services (LES). LES was the joint effort of Duke Power Co., Charlotte, NC; Graystone Corp., a subsidiary of Minneapolis-based Northern States Power Co., and Louisiana Power and Light Co., New Orleans; Fluor Daniel Inc., Irvin, CA; and Urenco of Marlow, England.[13]

The Claiborne Parish facility will use 13-year old separation technology developed by Urenco. The enrichment facility will use a gas centrifuge to separate uranium by weight. Construction was expected to began in 1992.[14]

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[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL. He has 29 years of industry and government experience and has covered the mineral activities in Louisiana since 1989. Assistance in the preparation of the chapter was given by Maylene E. Hubbard, editorial assistant.

[2] Deputy State Geologist, Louisiana Geological Survey.

[3] Lafayette Daily Advertiser. Iberia Sues Dredgers, State for Royalties. May 11, 1989.

[4] Tampa Tribune. Florida Gypsum May Fuel Economy. Mar. 15, 1989.

[5] New Iberia Daily Iberian. Avery Island's History Going to Washington. Sept. 3, 1989.

[6] Vinton News. Public Hearing Held on Salt Dome Issue. Nov. 8, 1990.

[7] Rock Products. Mining Gravel in Swamps. V. 92, No. 6, June 1989, pp. 38–42.

[8] Plaquemine Gazette. Freeport Has New Sulfur Find. Apr. 28, 1989.

[9] New Orleans Times-Picayune. Sulfur, Copper Shine for Freeport. Apr. 3, 1989.

[10] American Metal Market. Reynolds Plans Spending $47 Million To Expand Carbon Anode Plant. V. 97, No. 76, Apr. 19, 1989, p. 6.

[11] American Metal Market. Bayou's Net Income Takes a Sharp Fall in 4th Quarter. V. 97, No. 250, Dec. 27, 1989.

[12] Baton Rouge Morning Advocate. Changes Affect Louisianians. Dec. 12, 1989.

[13] Haynesville News. Uranium Plant Site is Selected. Nov. 9, 1989.

[14] Homer Guardian-Journal. Uranium Plant Site Selected. Nov. 9, 1989.

TABLE 3

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.
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.
Domtar Industries Inc.	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:			
Freeport Minerals Co.	200 Park Ave. New York, NY 10166	Frasch process	Jefferson and Plaquemines.
Recovered:			
Cities Service Oil Co.	Box 300 Tulsa, OK 74102	Refinery	Calcasieu.
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 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 1989 was $64.7 million, a $3.1 million decrease compared to that of 1988. The decrease was primarily the result of lower sales of construction sand and gravel and of cement, the State's leading mineral commodities. Other minerals produced, in order of value, were crushed stone, dimension stone, gem stones, clay, and peat.

TRENDS AND DEVELOPMENTS

In 1989, Maine's construction industry, which used most of the State's mineral production, had experienced, like most of the industry in the New England States, a slowdown in the construction boom that started in 1983. Although all States in the region did proportionately well during the boom period from 1983 to 1988, only Rhode Island and Vermont posted moderate gains (slightly over 1%) in construction employment in 1989. Between 1983 and 1988, Maine's construction industry jobs doubled. However, after peaking at 34,100 jobs in 1988, employment in the industry fell by 600 in 1989. A decline of an additional 1,300 construction jobs was expected in 1990. An increase in interest rates was partially responsible for slowdowns in residential and commercial construction; road work also showed signs of decreasing. Total housing starts, which peaked at 9,800 in 1987, were down to 6,900 in 1989.[4] Construction declines were reflected in decreases of construction commodities produced.

Although base metals have not been mined in Maine since 1977, there was renewed interest in the known deposits of these metals in the State, notably copper, zinc, and nickel. In late September, a Swedish firm purchased a large copper-zinc mining tract in Aroostook County with the intention of starting up a long-term mining operation. Another internationally based firm announced that it may spend $35 million to start up another base metals mining venture in Somerset County. A Colorado-based firm expressed interest in mining a nickel deposit in Knox County. Also during the year, North America's first peat-fired powerplant began operating, and the world's largest gem morganite crystal was unearthed.

EXPLORATION ACTIVITIES

In the past decade, there has been considerable exploration activity in all of the New England States, with most of the activity in Maine. For the most part, the targets of interest have been massive sulfide-metal deposits.

In late September, Boliden Inc., a wholly owned U.S. subsidiary of Trelleborg AB, a Swedish corporation, signed an agreement with Chevron Resources Co. to purchase, for an undisclosed sum, Chevron's Bald Mountain mining project in northern Maine. The project is located in Township 12, Range 8, near Carr Pond, Aroostook County. In December 1988, Chevron announced it had completed a 2-year evaluation of the copper-zinc mining project. Chevron had done extensive drilling and metallurgical

TABLE 1

NONFUEL MINERAL PRODUCTION IN MAINE[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	$1,172	NA	$150	NA	W
Sand and gravel	thousand short tons	e8,600	e22,100	10,183	33,007	e8,600	e$30,100
Stone:							
Crushed	do.	2,010	7,532	e1,400	e5,300	1,591	8,801
Dimension	short tons	7,512	5,924	e7,512	e5,924	W	W
Combined value of cement, clay (common), garnet (abrasive 1987–88), peat (1988–89), and values indicated by symbol W		XX	28,729	XX	23,379	XX	25,753
Total		XX	65,457	XX	67,760	XX	64,654

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

LEGEND

State boundary

County boundary

Capital

City

MINERAL SYMBOLS

CC Common Clay

Cem Cement plant

CS Crushed Stone

D-G Dimension Granite

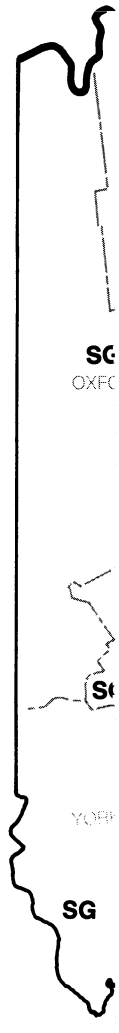
Gar Garnet

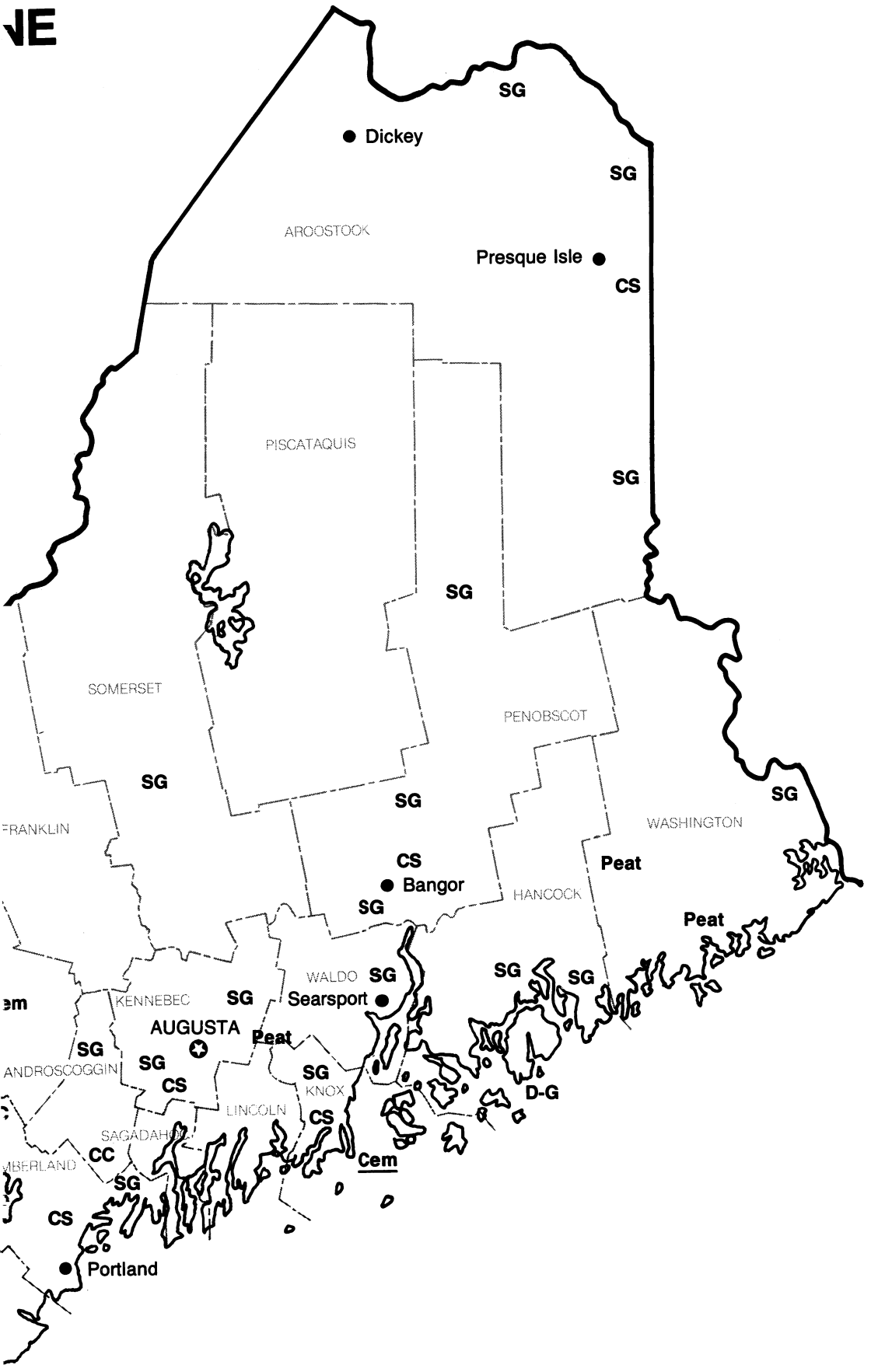
Gem Gemstones

Peat Peat

SG Sand and Gravel

Principal Mineral-Producing Localities

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testing and had defined "substantial mineralization," but said that the Bald Mountain project failed to meet the company's current criteria for a major mining operation. Boliden said that it expected the ore reserves at Bald Mountain to form the base for at least a 15-year surface mining operation producing considerable amounts of copper sulfide and zinc sulfide concentrates, as well as some gold and silver, during the initial years of mining.

BHP-Utah, a subsidiary of the Broken Hill Proprietary Co. of Melbourne, Australia, announced that it would move toward an advanced exploration program around Alder Pond, Somerset County, that could lead to a $35 million investment and employment of 100 people. The company had been taking core samples from a 90,000-acre tract since 1982. The first significant metal deposits of zinc and copper were found in 1985. The company announced that it had spent $2 million in the first stages of exploration. Another $1 million was expected to be spent in 1990 leading to an application to the Maine Department of Environmental Protection for a mining permit. BHP-Utah hoped to prove the existence of enough ore to support production of 1,000 short tons of ore per day for at least 10 years. Early estimates of samples indicated the presence of an ore reserve of 2 million short tons.

American Mine Services, Commerce City, CO, expressed interest in mining a nickel deposit near the towns of Union and Warren, but, by yearend, had not taken out a permit. The potential project would be a combination open pit and underground mine at the long-recognized Crawford Pond nickel deposit.

LEGISLATION AND GOVERNMENT PROGRAMS

A major comprehensive solid waste bill (Public Law 1989, Chapter 585, "An Act To Promote Reduction, Recycling, and Integrated Management of Solid Waste and Sound Environmental Legislation"), was signed into law in 1989. A new State agency, the Maine Waste Management Agency, was formed to implement the new approach to waste management created by the law. Under the recycling section, refundable deposits were required on every nondairy drink container up to a gallon in size. All nonreturnable containers were banned, as were the plastic "yokes" that hold six-packs together. Under this law, the goal of the State was to reduce municipal solid waste generated in the State by 25% by January 1992 and by 50% by January 1994.

Public Law 1989, Chapter 480, amended the Maine Low-Level Radioactive Waste Authority Act to clarify and assign responsibility for the disposal and storage of nuclear waste on generators of low-level nuclear waste.

The Northern Regional Planning Commission, Economic Development Division, conducted a survey of about 500 northern Maine communities and organizations to establish regional priorities. Based on preliminary survey results, those responding indicated that the first four priorities should be (1) business and industrial development assistance, (2) transportation system improvements, (3) agriculture diversification programs, and (4) tourism and recreational resources development. Mineral resource development was almost unanimously relegated to 10th place, although the top four priorities relied heavily on the availability of construction minerals.

The Maine Geological Survey (MGS), a bureau of the Department of Conservation, continued to map, interpret, and publish geological information and provide technical assistance to the minerals industry, planning and regulatory agencies, and the general public.

During September 1989, the Minnesota Air National Guard airlifted approximately 8,000 feet of New Hampshire and Maine drill core that was stored at the U.S. Bureau of Mines storage facility in Minneapolis, MN, to Pease Air Force Base in New Hampshire. Upon arrival, the Maine core was trucked to MGS's core storage facility in Augusta. Another 40,000 feet of core still remained in Minnesota, and plans were being made to ship more of the core in the spring of 1990. The core will be studied to gain a better understanding of the geology, mineralogy, and stratigraphy of the mineral deposits drilled. The principal minerals drilled for included asbestos, beryllium, copper, manganese, and pegmatites.

Mapping of the Inner Continental Shelf seabed, supported by a grant from the Minerals Management Service, continued during the year. Seismic reflection profiles, sidescan sonographs, and grab samples were collected from Deer Isle to Desert Island. The MGS also published the 1988 field season results for the Rockland to Deer Isle inner shelf region.

The geologic aspects of nuclear waste disposal continued to receive wide-scale attention in Maine because the State's Low-Level Radioactive Waste Authority was working on the complex issues of locating potential disposal sites. The MGS provided geologic input to the authority during the year.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Maine was the only New England State that produced cement. The Dragon Cement Co., a subsidiary of Coastal Cement, produced both portland and masonry cement at a plant in Thomaston, Knox County.

In October, Dragon purchased the Northern Division of Madawaska Brick & Block in Frenchville. The Northern Division included a ready-mixed concrete plant and a manufacturing facility for concrete products. With the Madawaska purchase and several other acquisitions, Dragon has 16 ready-mixed concrete plants throughout the State. Also during the year, Coastal Cement began construction of a $9.4 million scrubber that was expected to remove 90% of the pollutants from the cement plant's air-emission stream. Half of the cost of constructing the new scrubber was being funded through the Department of Energy's Innovative Clean-Coal Technology Programs. The new scrubber was expected to go on-line in 1990.

Clay.—Morin Brick Co., the State's only producer of clay, mined common clay at operations in Adroscoggin and Cumberland Counties, primarily for use in brick manufacturing.

Gem Stones.—What was believed to be the world's largest gem morganite crystal, estimated at 183,000 carats, was unearthed in October by prospectors at the old Buckfield quarry in Buckfield.

Morganite is a pale-pink to rose-red beryl named in honor of J. P. Morgan, the New York City financier. No official appraisal was made on the 80-pound crystal, dubbed the "Rose of Maine." Near Sweden, about 20 miles southwest of the Buckfield Quarry, the Plumbago Mining Co. began mining a large deposit of amethyst crystals discovered by accident when a backhoe operator was digging for gravel. By March of 1989, Plumbago had unearthed 5,000 carats of gem-quality stones among 1,000 pounds of amethyst crystals recovered and claimed that they just scratched the surface. Good-quality amethyst gems can fetch between $30 to $50 per carat. In 1989, this was the only active amethyst mining site in New England.

Graphite (Synthetic).—Synthetic graphite was produced by Fiber Materials Inc. at its plant in Biddeford, York County.

Peat.—In Deblois, North America's first peat-fired electric powerplant began to generate electricity in June 1989. General Peat Resources, which owned the 22.8-megawatt-per-hour plant, has been sending electricity to Boston Edison through a power-transmission arrangement with Bangor Hydro-Electric Co., Central Maine Power Co., and other New England utilities. Fuel for the plant was harvested from the surrounding 1,200-acre Denbo Heath peat bog. General Peat also proposed to build a 52-megawatt, peat-fired, electrical generating plant in Clifton, just east of Bangor. The new generating facility would be almost 2½ times the size of the Deblois plant and would cost about $56 million. This proposal would require permits from the air-quality section of the State Department of Environmental Protection (DEP) and would also have to be reviewed by the DEP's land quality section.

Perlite (Expanded).—Crude perlite shipped in from New Mexico was expanded by the Chemrock Corp. at a plant in Rockland, Knox County. The expanded perlite was sold locally, primarily as a filter aid.

TABLE 2

MAINE: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate: Other construction materials[2]	283	1,928
Chemical and metallurgical[3]	502	1,886
Other miscellaneous uses[4]	510	3,841
Unspecified:[5]		
Actual	296	1,146
Total	[6]1,591	8,801

[1] Includes limestone, quartzite, granite, traprock, and marl.
[2] Includes stone used in riprap and jetty stone, concrete aggregate, bituminous aggregate, railroad ballast, stone sand (concrete and bituminous mix or seal).
[3] Includes stone used in cement and lime manufacture.
[4] Includes stone used in agricultural limestone, asphalt fillers or extenders, and estimates for nonrespondents.
[5] Data represents production reported without a breakdown by end use.
[6] Data do not add to total shown because of independent rounding.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Sand and gravel was the State's leading mineral commodity in terms of value and accounted for nearly one-half of the State's mineral value. The estimated output of 8.6 million short tons of construction sand and gravel was 16% lower than that produced in 1988, but equal to 1987 production. The estimated decrease in 1989 can be attributed generally to slowdowns in residential, commercial, and road-work contracts that occurred during the year because the major uses for sand and gravel were for construction and roadbuilding.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Although crushed-stone production rose 14% over the 1988 estimated tonnage, production in 1989 was 21% lower than that of 1987. Cumberland, Knox, and Penobscot counties accounted for most of the stone produced. Types of stone quarried were limestone, marl, traprock, and quartzite. Leading uses were for cement manufacture, concrete aggregate, and railroad ballast.

Dimension.—New England Stone Industries Inc. quarried dimension granite at Crotch Island, Hancock County. Figures for both production and value were withheld in 1989. Most of the stone was used for veneer, flagging, curbing, and rough blocks.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in Maine for 4 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] New England Business. The Bridesmaid Syndrome. V. 12, No. 2, Feb. 1990, pp. 37–43.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Dragon Cement 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) (1988):			
W. E. Cloutier Co. Inc.	Box 1849 Lewiston, ME 04240	Pit	Androscoggin.
Harry C. Crooker & Sons Inc.	Old Bath Rd. Brunswick, ME 04011	Pits and plants	Androscoggin, Lincoln, Sagadahoc.
Dragon Products Co.	Box 101 Thomaston, ME 04861	do.	Androscoggin, Hancock, Oxford, Somerset.
R. J. Grondin & Son	Rural Route 4 Gorham, ME 04038	Pits	Cumberland and York.
Maine Department of Transportation	Augusta, ME 04333	Pits and plants	Androscoggin, Kennebec, Knox, Oxford, Penobscot, Waldo.
Portland Sand & Gravel	94 Walnut St. Portland, ME 04091	Pit	Cumberland.
Tilcon Inc.	Box 209 Fairfield, ME 04937	Pits	Penobscot and York.
Stone:			
Crushed:			
Blue Rock Industries	58 Main St. Westbrook, ME 04092	Quarries and mill	Cumberland and Kennebec.
The Cook Concrete Co.	960 Ocean Ave. Portland, ME 04103	Quarry and mill	Cumberland.
Dragon Cement Co.	Box 191 Thomaston, ME 04861	Quarries	Aroostook and Knox.
Lane Construction Corp.	Box 103 Bangor, ME 04401	do.	Aroostook and Penobscot.
Dimension:			
New England Stone Industries Inc.	Providence Pike Smithfield, RI 02917	Quarry	Hancock.

[1] Also stone.

THE MINERAL INDUSTRY OF MARYLAND

This chapter has been prepared under a Memorandum of Understanding between the 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 1989 was about $342 million. Value of mineral output declined for the first time in 6 years, primarily resulting from a moderation in demand for construction aggregates. Although the quantity and value declined, production of crushed stone, the State's leading mineral commodity, remained above the 30-million-short-ton level for the third consecutive year.

TRENDS AND DEVELOPMENTS

Maryland's mineral industry expanded significantly during the decade of the 1980's despite the slight decline in value in 1989. Compared with 1980 production, output in 1989 of sand and gravel increased by 57% and crushed stone by 63%. In the decade of the 1980's, the total value of nonfuel mineral production in Maryland was about $2.6 billion. Production of crushed stone and sand and gravel accounted for about $1.9 billion of the total or 73%.

The strong demand for construction aggregates in Maryland reflected an expanding economy and a population that increased from 4.2 million in 1980 to 4.7 million in 1989. New roads, homes, and commercial buildings were needed, and aggregates were an essential raw material used in this construction. However, the pronounced increase in construction resulted in opposition to mine development, particularly in areas where residential development existed. Local and State government officials were faced with numerous land use decisions involving the opening or expansion of mining operations.

According to a report by the University of Maryland, "Future development in the State, along with long-term maintenance of highways and buildings, signifies potentially serious aggregate cost problems arising from having to go increasing distances between point of production to point of use. Distances of more than a few tens of miles greatly increases the overall cost of the aggregate material because of its high bulk mass and low bulk value."[2] Other concerns for the aggregate industry identified in the report were encroachment on prime mineral deposits by urban and suburban growth. Also noted were land use conflicts that occur because of insufficient buffer zones between residential developments and mining areas.

REGULATORY ISSUES

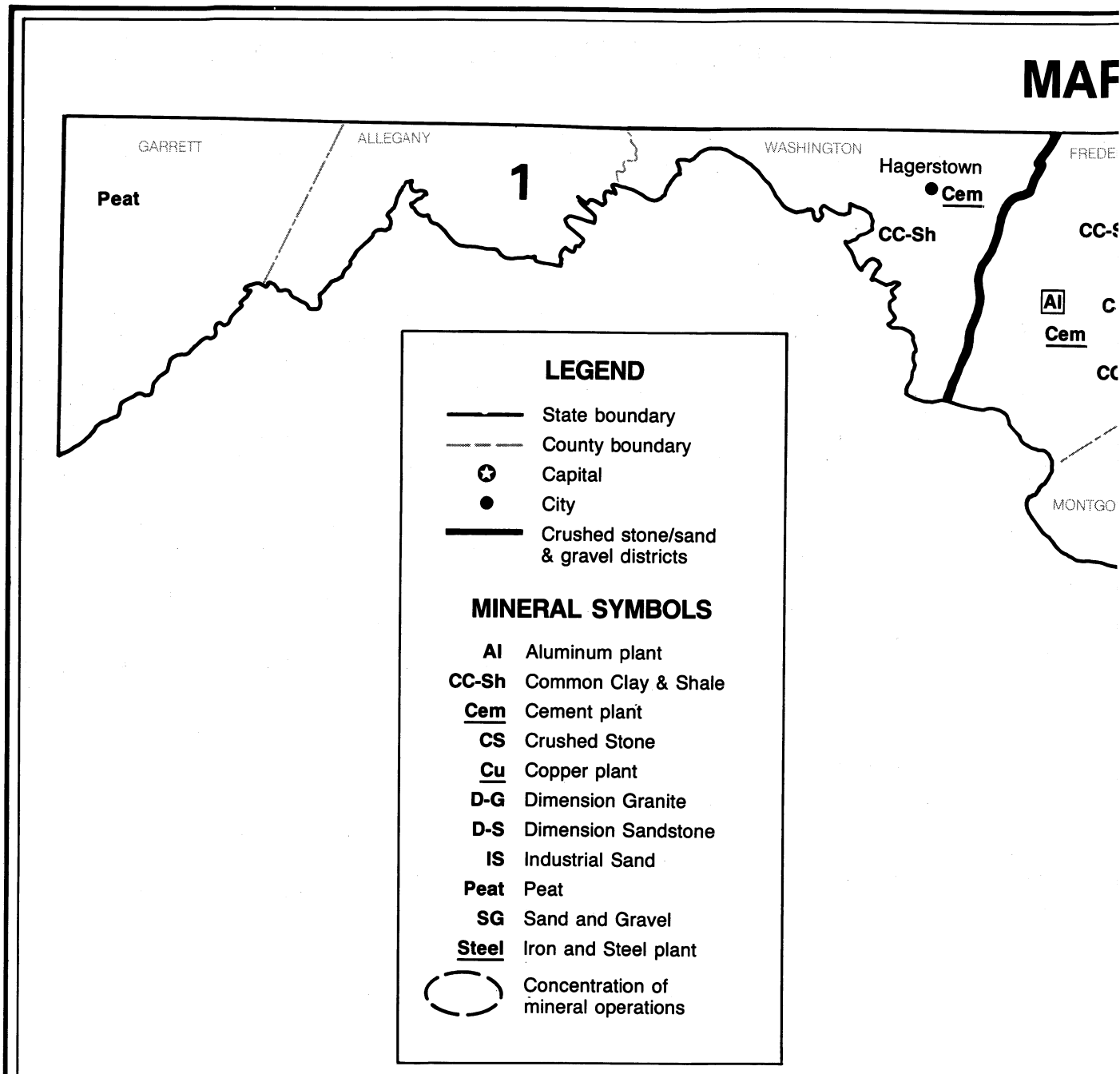
In June, Maryland's leading steel producer, Bethlehem Steel Corp., began a 5-year, $92 million air pollution control program at its Sparrows Point plant. The program is expected to reduce total emissions by nearly 60% from coke oven, chemical recovery, and hot-metal-dumping operations. Bethle-

TABLE 1

NONFUEL MINERAL PRODUCTION IN MARYLAND[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	1,829	$90,020	1,808	$89,083	1,871	$94,002
Clays	metric tons	347,501	1,940	357,833	2,016	351,464	1,882
Gem stones		NA	5	NA	5	NA	3
Lime	thousand short tons	9	486	6	329	—	—
Peat	do.	W	W	7	W	3	W
Sand and gravel (construction)	do.	e19,600	e92,900	19,266	95,169	e16,900	e84,500
Stone:							
Crushed	do.	30,136	151,579	e32,700	e167,000	30,841	153,375
Dimension	short tons	22,843	1,516	e20,729	e1,515	27,529	2,072
Combined value of other industrial minerals and values indicated by symbol W		XX	6,688	XX	7,804	XX	6,216
Total		XX	345,134	XX	362,921	XX	342,050

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).



Principal Mineral-Producing Localities

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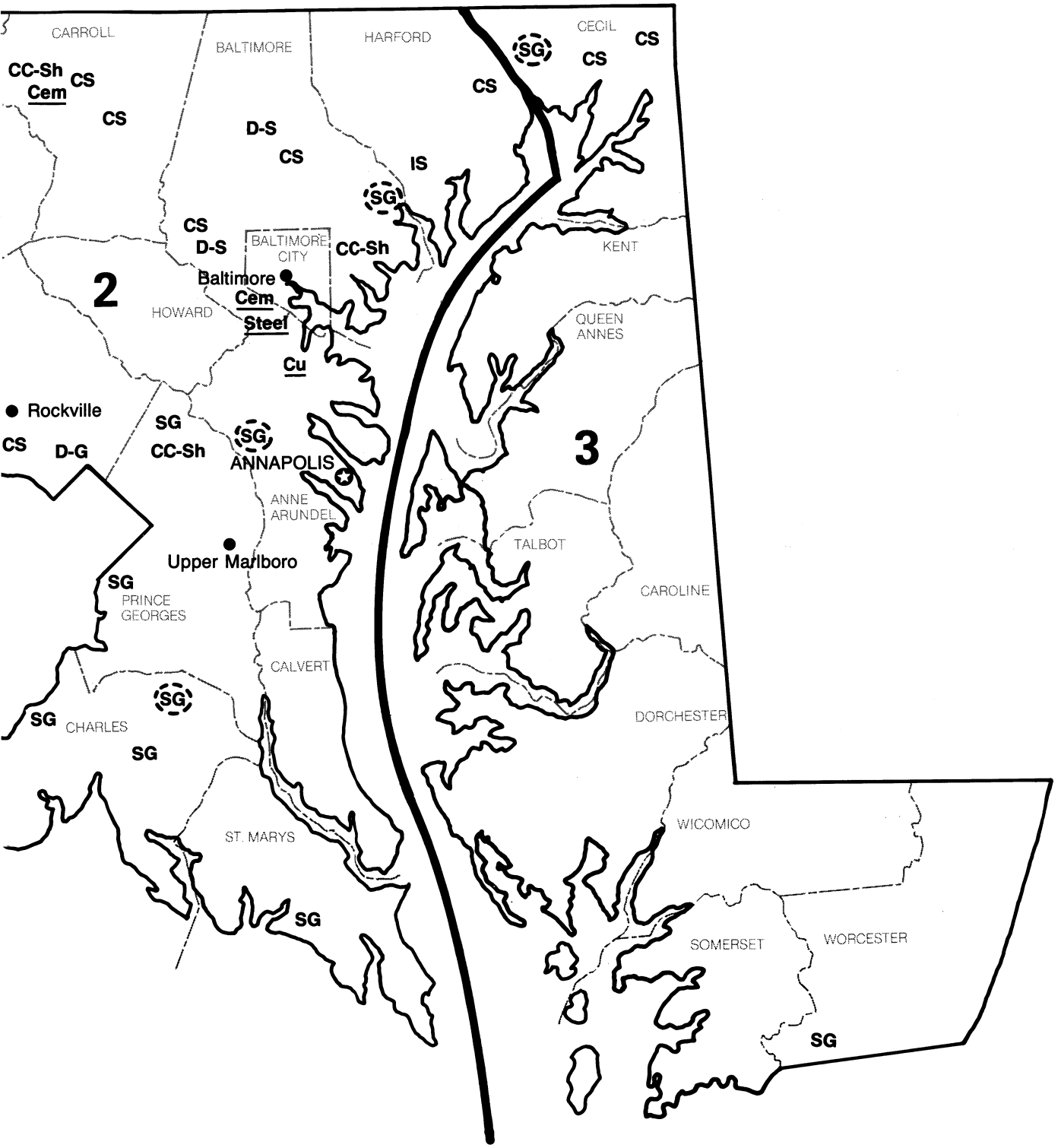
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Upper Marlboro
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CAROLINE
CALVERT
DORCHESTER
CHARLES
ST. MARYS
WICOMICO
SOMERSET
WORCESTER

hem Steel agreed to the program with the Maryland Department of the Environment and the Baltimore County Department of Environmental Protection and Resource Management as a way to continue to improve the environment around the Sparrows Point plant.

Polymer Resource Group Inc. opened Maryland's first plastic bottle recycling plant near Baltimore. Used bottles were converted into plastic pellets, which were sold to Proctor & Gamble Co. for use in making detergent containers. Initial plant capacity allowed for recycling of 1,200 tons to 1,500 tons of plastic bottles per year. Plant capacity can be expanded by Polymer Resources to 7,000 tons per year. The primary objective of the plastic recycling was to save solid waste landfill space.

LEGISLATION AND GOVERNMENT PROGRAMS

Citizens perceiving mining as detracting from their quality of life organized groups seeking legislation to restrict or ban mining. Public opposition, particularly in Carroll County, resulted in the introduction of four bills aimed at restricting or increasing regulation of mining. All four of the bills were defeated in 1989, but similar measures were expected to be reintroduced in 1990.

Beginning in 1991, nontidal wetlands legislation becomes effective. Grading, filling, and dredging in nontidal wetlands will require a permit from the State Department of Natural Resources. Public hearings were conducted on the regulations in 1989. It is possible that these regulations will restrict some sand and gravel mining.

The Maryland Geological Survey (MGS) conducted geologic and mineral-related studies at facilities in Baltimore. In 1989, the MGS continued preparation of mineral resource maps for eight counties along the Eastern Shore. A directory of nonfuel mineral producers in Maryland was scheduled for publication in 1990, updating the 1986 version. The MGS also continued a cooperative study with the U.S. Geological Survey on the geologic framework and resources of the State's coastal environments. A complete list of publications is available from the MGS (see Mineral-Related Government Agencies).

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Output of crushed stone, portland cement, and construction sand and gravel accounted for $332 million, about 97% of Maryland's value of nonfuel mineral production in 1989. The remaining 3% of the State's value of nonfuel minerals was from the production of clays, masonry cement, peat, dimension stone, and industrial sand.

In addition to the minerals mined in Maryland, other raw materials were processed in the State and manufactured into products. W. R. Grace & Co., at Muirkirk in Prince Georges County, exfoliated crude vermiculite that was mined in South Carolina. SCM Chemicals Inc., Baltimore, operated one of eight domestic titanium dioxide plants in the United States.

Crude gypsum imported from Canada was calcined by National Gypsum Co. and USG Corp. at wallboard plants in the Baltimore area. In 1989, about 860,000 short tons of crude gypsum was received at the Port of Baltimore according to the Maryland Port Administration (MPA). The 1989 total represented a 32% increase over that of 1988. Other minerals imported at the Port of Baltimore included cement (420,000 tons), clays (62,000 tons), salt (347,000 tons), and slag (209,000 tons).[3] These figures were compiled and published by the MPA.

Cement.—Output of portland cement in Maryland exceeded 1.8 million short tons in each of the past 3 years. Also during the 1987–89 period, the State's cement producers utilized about 90% of plant capacity compared with the national rate of about 75%. Most of the portland cement was used in ready-mixed concrete.

Lehigh Portland Cement Co. continued to seek State Department of Natural Resources approval to expand limestone quarrying operations at Union Bridge. The limestone would be used as a raw material in cement manufacture. Public hearings were held in 1989, and Lehigh Portland also contributed to a $200,000 study on the impact of mining on the area. Local citizens were concerned that the quarrying would eventually result in sinkhole damage or affect ground water supplies. At yearend, a decision on the quarry remained pending.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Output of sand and gravel in 1989 dropped by 12% compared with that of 1988. However, from 1985 through 1989, the average annual output of sand and gravel in Maryland was 18.2 million tons. In comparison, from 1975 to 1984, the average yearly production was about 11.8 million tons.

During the year, some sand and gravel producers began proceedings to open or expand mining operations. Genstar Stone Products Inc. proposed mining sand and gravel at a site about ½ mile from the Jug Bay Wetlands Sanctuary. On completion of mining and reclamation, the land would be donated to the State for a recreation and wildlife area. County, State, and company officials studied the proposal throughout the year.

In Prince Georges County, near Piscataway, Southern Maryland Sand & Gravel received local government approval to mine on a 360-acre site. However, a local citizens group appealed the approval decision to the Circuit Court, thus delaying the mining until at least 1990. In Charles County, a mining proposal by CMDC-St. Charles Ltd. Partnership was denied by the local zoning board. CMDC had planned to mine sand and gravel from a deposit on a 60-acre site near Waldorf. Later in the year, CMDC received approval to mine 20 acres at a site adjacent to the one that was previously denied. At yearend, no mining had occurred as both decisions had been appealed by the respective parties involved, CMDC and a local citizens group.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Maryland stone statistics are com-

piled by geographical districts as depicted in the State map. Table 3 presents end-use statistics for Maryland's three districts.

By 1989, production of crushed stone accounted for almost one-half of Maryland's total value of mineral production. From 1980 through 1983, an average of 17.5 million tons of crushed stone was produced annually. In 1984, production of 22.1 million tons of crushed stone surpassed the previous record output of 21.6 million tons in 1979. Each year since, a new production record for stone had been established, until 1989, when output declined by less than 2 million tons. Despite the decline in 1989, production had averaged 31.2 million tons for the past 3 years.

This high level of crushed stone demand brought about a corresponding level of interest in opening and expanding stone operations in the State. Output of crushed stone in Maryland averaged 6.4 tons per person in 1989 versus 4.5 tons per person in 1980. As a result of the increase in production, more people were exposed to mining.

The need for mining to generate the raw materials used in construction was generally accepted by the public. However, for the most part, people did not want mining in the community where they lived. Thus, most proposals for opening or expanding quarries were delayed at the local government level through court cases.

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.[4] The leading import in 1989 was iron ore at 6.7 million short tons, a decline from 8.1 million tons in 1988. Imports of ferroalloys also dropped, from 245,000 tons to 193,000 tons. Shipments of bauxite from overseas increased to 369,000 tons from 346,000 tons in 1988; manganese ore shipments also were higher in 1989 at 76,000 tons compared with 35,000 tons in 1988. These data were published by the MPA in a report on foreign commerce.

Aluminum.—Eastalco Aluminum Co., a subsidiary of Alumax Inc., continued to produce aluminum at its smelter near Frederick.

Iron and Steel.—Maryland's iron and steel industry was dominated by one producer, Bethlehem Steel Corp., at Sparrows Point. In 1989, the firm began an air pollution control program in cooperation with State and Federal environmental agencies (see Regulatory Issues).

The Sparrows Point plant, which covers approximately 3,500 acres, is along the Chesapeake Bay near Baltimore. The principal products of the Sparrows Point plant are hot- and cold-rolled sheets, tin mill products, coated sheets, plates, and semifinished steel products. Principal markets included service centers and the container, construction, and appliance industries. Facilities included a sintering plant, three coke oven batteries, four blast furnaces, two basic oxygen furnaces, a four-furnace open-hearth operation with a combined annual raw steel production capability of 5.5 million tons, a 45- by 90-inch slabbing mill, a 54-inch blooming mill, and a 30- by 24-inch billet mill. Also included were a two-strand continuous slab caster with an annual production capability of 2.9 million tons, a 60-inch universal plant mill, a 160-inch sheared plate mill, a 68-inch hot strip mill, four cold reducing mills (66-, 56-, 48-, and 42-inch), continuous and batch annealing facilities, a galvanizing line, two Galvalume lines, and tin mill facilities.[5]

TABLE 2

MARYLAND: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	439	1,922
Riprap and jetty stone	653	2,910
Coarse aggregate, graded:		
Concrete aggregate, coarse	2,372	10,537
Bituminous aggregate, coarse	866	4,569
Coarse and fine aggregates:		
Graded road base or subbase	2,429	13,667
Unpaved road surfacing	123	666
Crusher run or fill or waste	1,902	5,980
Other construction materials[2]	851	3,794
Chemical and metallurgical: Cement manufacture	2,710	5,209
Other miscellaneous uses[3]	285	18,248
Unspecified:[4] Actual	18,211	85,874
Total	30,841	[5]153,375

[1] Includes granite, limestone, miscellaneous stone, quartzite, shell, sandstone, and traprock.
[2] Includes stone used in filter stone, bituminous surface-treatment aggregate, railroad ballast, stone sand (concrete and bituminous mix or seal), and screening, undesignated.
[3] Includes stone used in flux stone, whiting or whiting substitute, other fillers or extenders, roofing granules, and minor amounts used for building products and paper manufacture.
[4] Data represents production reported without a breakdown by end use.
[5] Data do not add to total shown because of independent rounding.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in Maryland for 5 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2] Tuthill, D. F. and J. Fellows. Natural Resources in Maryland. Dep. of Agriculture and Resource Economic, Univ. of Md., College Park, MD 20742, Oct. 1989, p. 29.

[3] Maryland Port Administration. Foreign Commerce Statistical Report 1989. World Trade Center, Baltimore, MD 21201-3041, 311 pp.

[4] Work cited in footnote 3.

[5] Bethlehem Steel Corp. 1989 10-K and Annual Report, p. 10.

TABLE 3

MARYLAND: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	47	W	726	2,539	329	W
Coarse aggregate, graded[2]	205	1,043	W	W	1,100	W
Fine aggregate (−3/8 inch)[3]	W	W	W	W	100	625
Coarse and fine aggregates[4]	731	W	1,855	6,274	1,870	W
Other construction aggregates	163	4,010	2,510	9,663	—	20
Chemical and metallurgical[5]	([6])	([6])	([6])	([6])	—	—
Special[7]	—	—	([6])	([6])	—	—
Other miscellaneous	783	2,061	2,210	21,186	—	—
Unspecified: Actual[8]	1,762	6,369	16,098	76,695	351	2,810
Total[9]	3,692	13,483	23,399	116,358	3,750	23,534

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[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), and fine aggregate (screening-undesignated).
[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, crusher run or fill or waste, and building products.
[5] Includes crushed stone for cement manufacture and flux stone.
[6] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[7] Includes crushed stone for whiting or whiting substitutes, other fillers or extenders, roofing granules, and paper manufacture.
[8] Includes production reported without a breakdown by end use.
[9] Data may not add to totals shown because of independent rounding.

TABLE 4

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:			
Coplay Cement Co., (Societe des Ciments Francais)	4120 Buckeystown Pike Lime Kiln, Box D Frederick, MD 21701	Quarry and plant	Do.
Portland and masonry:			
Independent Cement Corp. (St. Lawrence Cement Inc.)	Box 650 Hagerstown, MD 21740	do.	Washington.
Lehigh Portland Cement Co.[1] (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.
Maryland Clay Products Inc. (Boren Brick & Tile Co.)	7100 Muirkirk Rd. Beltsville, MD 20705	Pit and plant	Prince Georges.
Victor Cushwa & Sons 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.[2]	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.
Peat:			
Garrett County Peat Products	R.F.D. 1, Box 91 Accident, MD 21520	Bog and plant	Garrett.
Sand and gravel:			
Construction:			
Charles County Sand & Gravel Inc.	Box 322 Waldorf, MD 20601	Pits and plant	Anne Arundel, Charles, St. Marys.
Florida Rock Industries Inc.	Box 273 Leonardtown, MD 20670	Pits	Harford and St. Marys.
Genstar Stone Products Inc.	1000 Beaverdam Rd. Cockeysville, MD 21030	Pits and plants	Baltimore.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued			
Construction—Continued			
Laurel Sand & Gravel Inc.	Box 719 Laurel, MD 20810	Pits	Anne Arundel and Prince Georges.
York Building Products Co. Inc.	Box 1708 York, PA 17405	Pit	Cecil.
Industrial:			
Harford Sands Inc.	Box 25 40 Fort Hoyle Rd. Joppa, MD 21085	Pits	Harford.
Stone:			
Crushed:			
The Arundel Corp.[3]	110 West Rd. Baltimore, MD 21204	Quarries and plants	Baltimore, Frederick, Harford.
Genstar Stone Products Inc.[3]	Executive Plaza 4 11350 McCormick Rd. Hunt Valley, MD 21031	do.	Baltimore, Carroll, Frederick, Harford.
Maryland Materials Inc.	Box W North East, MD 21901	Quarry and plant	Cecil.
Rockville Crushed Stone Inc.	Box 407 13900 Piney Meetinghouse Rd. Rockville, MD 20850	do.	Montgomery.
Dimension:			
Patapsco Natural Stone Quarry Inc.	Marriotsville Rd. Marriotsville, MD 21104	do.	Baltimore.
Stoneyhurst Quarries	Box 34463 8101 River Rd. Bethesda, MD 20817	do.	Montgomery.
Weaver Stone Co.	15027 Falls Rd. Butler, MD 21023	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 titanium dioxide (pigments).
[3] Also sand and gravel.

THE MINERAL INDUSTRY OF MASSACHUSETTS

This chapter has been prepared under a Memorandum of Understanding between the 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 1989 was $144.1 million, a decrease of $48.1 million compared to the 1988 value. The decrease was largely the result of lower output of crushed stone and construction sand and gravel, the State's two leading mineral commodities. In 1989, the State ranked fifth among 34 States that produced dimension stone. Massachusetts ranked 23d of the 50 States that produced construction sand and gravel, even though the State ranked 45th in the Nation in total land area. In 1988, the State had ranked 11th nationally in sand and gravel, but output of this commodity dropped 37% in 1989.

TRENDS AND DEVELOPMENTS

Because demand for mineral aggregates is almost totally dependent on construction activity, there is usually a correlation between aggregate output and construction activity. Although the long-term construction outlook for the State was favorable, with nearly $10 billion slated for the Boston Harbor Cleanup and the Boston Central Artery Project, construction activity was sluggish in 1989. The slow start in bid letting for the Boston Central Artery Project, combined with a slowdown in overall building contracts during the year, severely curtailed output of the State's two primary minerals, construction sand and gravel and crushed stone. In 1989, overall residential construction dipped 29.2% below 1988 levels. Construction employment during the same period also decreased by 2,900 jobs primarily because of residential housing declines. Also, because of budgetary constraints, the State had passed a moratorium on all new highway and public works projects until July 1, 1989. In 1989, crushed stone production and value decreased 32% and 26%, respectively, compared to that of 1988. Decreases of 37% in volume and 28% in value were also reported for construction sand and gravel during the same period. However, unit prices rose for both of these commodities. The average unit value of crushed stone rose 45 cents per short ton to $5.70 f.o.b.; the average unit value of construction sand and gravel rose 52 cents to $4.10 per short ton f.o.b.

LEGISLATION AND GOVERNMENT PROGRAMS

Under the State Mining and Mineral Resources Research Institute Program Act, the Bureau of Mines awarded an allotment grant of $292,138 to the Massachusetts Institute of Technology (MIT) to support basic research in the mineral sciences. MIT was one of 34 universities nationally that received a grant under the program. Since the program was initiated in 1978, MIT has received more than $3.4 million from the Bureau of Mines. Under stipulations of the Act, the State of Massachusetts was required to match this grant on a 2:1 basis.

In August, the Massachusetts Water

TABLE 1

NONFUEL MINERAL PRODUCTION IN MASSACHUSETTS[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	$1	NA	$1	NA	$3
Sand and gravel:							
Construction	thousand short tons	e21,800	e75,300	22,168	79,364	e13,900	e57,000
Industrial	do.	56	922	W	W	34	601
Stone:							
Crushed	do.	14,907	78,969	e17,500	e91,900	11,880	67,768
Dimension	short tons	76,579	12,747	W	W	67,533	10,302
Combined value of clays (common), lime, peat, and values indicated by symbol W		XX	8,583	XX	20,973	XX	8,452
Total		XX	176,522	XX	192,238	XX	144,126

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Resources Authority (MWRA) announced that it would not use the Rowe crushed stone quarry on the Malden/Revere Township line as a sludge disposal site for the proposed Boston Harbor Cleanup. In 1988, MWRA had narrowed its choice of sites to the one at Rowe Quarry and the other near the town of Walpole. The Walpole site was tentatively chosen, but must still receive approval from other State officials.

Researchers from the University of Massachusetts, with support from both State and Federal fisheries and wildlife agencies, developed a system to add lime to a stream to reduce its acidity. Whetstone Brook in Wendell was chosen as the site of a pilot project involving the machine, called a limer, which will continuously release appropriate amounts of neutralizing lime into the water. The machine was considered by University of Massachusetts researchers as a "first of its kind" in the world. Although each machine will cost $70,000, the total cost of the project was estimated to be $700,000, with 85% of the funding provided by the Federal Fish and Wildlife Service and 15% provided by the Massachusetts Division of Fisheries and Wildlife.

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.—Two companies, both in Plymouth County, mined common clay for the manufacture of face brick.

In March, the K-F Brick Co., North Middleboro, was ordered to stop mining clay near wetlands without State Conservation Commission approval. When the commission issued the stop order, K-F had only a week's supply of clay stockpiled to mill into brick. However, town selectmen, who issued the company a mining permit in May 1988, allowed the company to continue to dig clay where the work would not harm wetlands. The State Conservation Commission would still have to approve any mining near wetlands. If the town had not allowed the company to continue to mine, the company indicated it would have had to close, laying off as many as 55 workers.

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 a plant in Suffolk County 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. Both output and value in 1989 remained essentially the same as that of 1988. Markets for the lime included western New York and New England, with the majority shipped by truck.

Pfizer Inc., which operated one of the State's lime plants at Adams, reported that it had spent $17 million on improvements during the past decade. The company also indicated it expected to spend $4 million to $6 million per year over the next 10 years to upgrade the Adams facility. In 1989, the plant had net sales of $40.1 million.[3]

Peat.—Reed-sedge peat was produced by Sterling Peat Co., 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 Products Inc. at a plant in Essex County. The expanded perlite was used in lightweight aggregate and as a horticultural medium.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

In 1989, construction sand and gravel was the second leading mineral commodity produced in terms of value, accounting for 40% of the State's total mineral value. In 1989, both production and value of construction sand and gravel decreased 37% and 28%, respectively, from 1988 levels. However, average unit price rose 52 cents per short ton to $4.10 f.o.b. in 1989. More than 100 companies mined construction sand and gravel in 12 counties. Leading counties in order of output were Worcester, Middlesex, and Plymouth. Main uses for the material were for concrete aggregate, road base, and coverings and fill.

As in past years, the opening of new sand and gravel pits and continuance of existing operations continued to stir controversy, especially at the local government levels. Citizen complaints concerning increased truck traffic, noise, dust, and aquifer protection had resulted in the enactment of zoning laws prohibiting or limiting sand and gravel mining in many communities.

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 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 1987 and 1989 and estimates for 1988.

Massachusetts 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.—Although both production and value of crushed stone decreased significantly in 1989, it was the State's leading mineral commodity, accounting for 47% of the total mineral value. Traprock (basalt) accounted for the ma-

TABLE 2

MASSACHUSETTS: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	291	2,042
Riprap and jetty stone	60	232
Coarse aggregate, graded:		
Concrete aggregate, coarse	607	3,445
Bituminous aggregate, coarse	1,730	12,442
Bituminous surface-treatment aggregate	612	5,172
Railroad ballast	62	253
Fine aggregate (−3/8 inch):		
Stone sand, concrete	170	1,023
Stone sand, bituminous mix or seal	260	1,908
Screening, undesignated	136	609
Coarse and fine aggregates:		
Graded road base or subbase	337	1,323
Crusher run or fill or waste	196	628
Other construction materials[2]	523	3,482
Other miscellaneous uses[3]	1,192	8,657
Unspecified:[4]		
Actual	3,585	15,021
Estimated	2,119	11,531
Total	11,880	67,768

[1] Includes traprock, granite, limestone, sandstone, dolomite, and miscellaneous stone.
[2] Includes stone used in filter stone and unpaved road surfacing.
[3] Includes stone used in agricultural limestone, poultry grit and mineral food, cement and lime manufacture, and other fillers or extender.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.

jority of the stone produced, followed by granite, limestone, and sandstone. Crushed stone was produced in 9 of the 14 counties in the State. Leading counties in order of output were Hampden, Norfolk, Middlesex, and Bristol. Major uses were for road construction and concrete aggregate.

The Bardon Group, a British aggregate firm, purchased the Simeone Corp., a Massachusetts-based crushed stone producer with operations in Wrentham, Taunton, Raynham, and Stoughton for $45 million in cash. In 1988, Bardon also purchased the assets of Trimont Bituminous Products Co. in Danvers, an aggregate producer with plants in Ashland, Swampscott, and Saugus.

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 fireproofing.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in Massachusetts for 4 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] Berkshire Eagle (Pittsfield, MA). Pfizer Invests. Mar. 25, 1990.

MASSAC

LEGEND

State boundary

County boundary

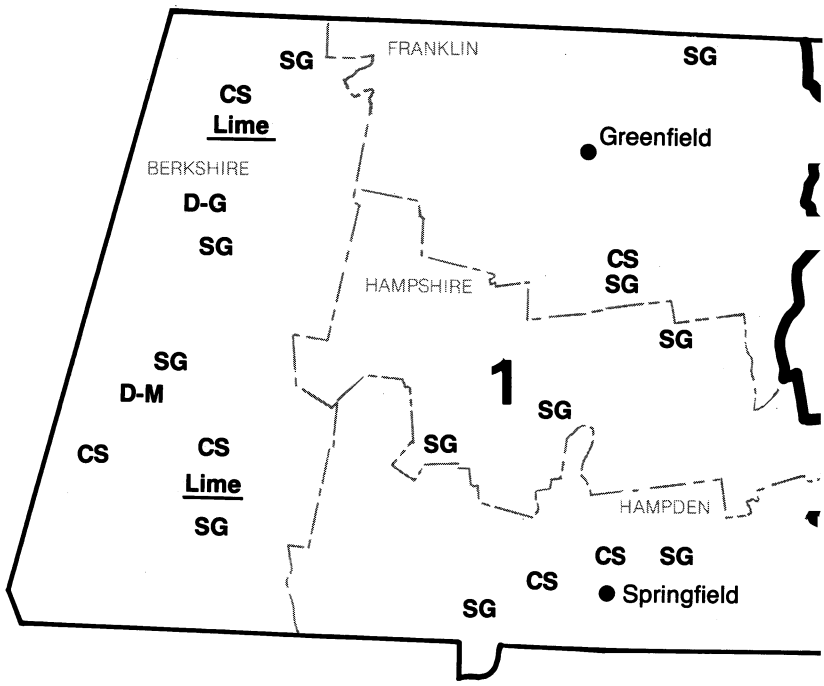
Capital

City

Crushed stone/sand & gravel districts

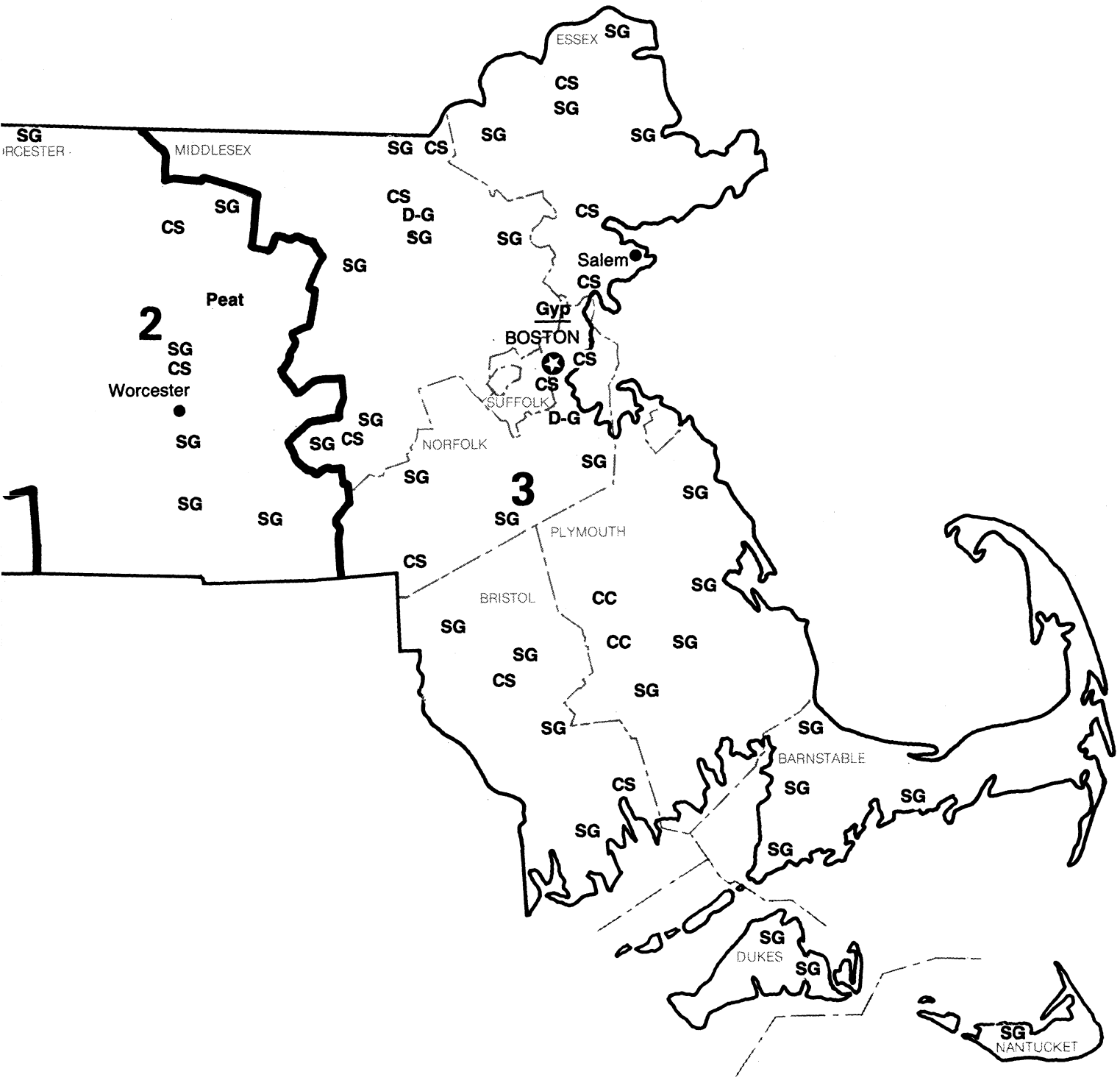
MINERAL SYMBOLS

CC	Common Clay
CS	Crushed Stone
D-G	Dimension Granite
D-M	Dimension Marble
Gyp	Gypsum plant
Lime	Lime plant
Peat	Peat
SG	Sand and Gravel



Principal Mineral-Producing Localities

HUSETTS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NANTUCKET

TABLE 3

MASSACHUSETTS: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	W	W	W	W	313	1,988
Coarse aggregate, graded[2]	W	W	W	W	2,815	20,076
Fine aggregate (−3/8 inch)[3]	W	W	W	W	504	3,123
Coarse and fine aggregates[4]	W	W	W	W	506	1,876
Other construction aggregates	161	777	241	1,867	444	2,853
Agricultural[5]	(6)	(6)	—	—	—	—
Chemical and metallurgical[7]	(6)	(6)	—	—	—	—
Special[8]	(6)	(6)	—	—	—	—
Other miscellaneous	1,192	8,657	—	—	—	—
Unspecified:						
Actual[9]	2,251	9,025	667	2,955	667	3,040
Estimated[10]	—	—	268	1,279	1,851	10,253
Total[11]	3,604	18,460	1,176	6,100	7,100	43,208

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[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 crushed stone for graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[5] Includes agricultural limestone and poultry grit and mineral food.
[6] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[7] Includes crushed stone for cement manufacture and lime manufacture.
[8] Includes crushed stone for other fillers or extenders.
[9] Includes production reported without a breakdown by end use.
[10] Includes estimates for nonrespondents.
[11] Data may not add to totals shown because of independent rounding.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
K-F Brick Co. Inc.	River St. Middleboro, MA 02346	Pit	Plymouth.
Stiles & Hart Brick Co.	Box 367 Bridgewater, MA 02324	Pit	Do.
Graphite (synthetic):			
Avco Corp.	1275 King St. Box 9000 Greenwich, CT 06836	Plant	Middlesex.
The Stackpole Corp.	Foundry Industrial Park Lowell, MA 01852	do.	Do.
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 Co.	Sterling Junction, MA 01565	Bog	Worcester.
Sand and gravel:			
Construction (1988):			
Kimball Sand Co. Inc.	Providence Rd., Box 29 Mendon, MA 01756	Pit	Do.
P. A. Landers Inc.	Box FF Hanover, MA 02339	Pit	Plymouth.
Lone Star Industries Inc.	Ayer Rd. Littleton, MA 01460	Plant	Middlesex.
S. M. Lorusso & Sons Inc.	230 West St. Walpole, MA 02081	Pit	Norfolk.
Nemasket Sand & Gravel Corp.	Box 131 North Carver, MA 02355	Pit	Plymouth.
Industrial:			
Whitehead Bros. Co.	Box 259, River Rd. Leesburg, NJ 08327	Pit	Do.
Stone:			
Crushed:			
Keating Materials Corp.	2140 Bridge St. Dracut, MA 01826	Pit	Middlesex and Worcester.
John S. Lane & Son Inc.	730 East Mountain Rd. Westfield, MA 01085	Quarries	Berkshire, Hampden, Hampshire.
S. M. Lorusso & Sons Inc.	331 West St. Walpole, MA 02081	do.	Middlesex, Norfolk, Suffolk.
Simeone Corp.	1185 Turnpike St. Stoughton, MA 02072	do.	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.	West Chelmsford, MA 01863	Quarry	Middlesex.
Williams Stone Co. Inc.	Box 278 East Otis, MA 01029	do.	Berkshire.
Vermiculite (exfoliated):			
W. R. Grace & Co.	62 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 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 Leon E. Esparza[1] and Milton A. Gere, Jr.[2]

Michigan's nonfuel mineral production was valued at $1.6 billion in 1989, about the same as in 1988. Significant increases in the values of calcium chloride, portland cement, and iron ore were the main factors in offsetting decreases reported for several commodities, including bromine, gold, lime, magnesium compounds, salt, and construction and industrial sand and gravel. Iron ore was the State's leading commodity, followed by portland cement; construction sand and gravel, and crushed stone. Industrial minerals accounted for 57% of the total nonfuel mineral production. Michigan ranked fifth, nationally, in the value of nonfuel mineral production, accounting for 5% of the U.S. total. Michigan was the Nation's leading producer of natural calcium compounds, crude iron oxide pigments, magnesium compounds, and peat. It was the second leading producer of iron ore, construction sand and gravel, and industrial sand, behind Minnesota, California, and Illinois, respectively; the third leading producer of gypsum; and the fourth leading producer of masonry and portland cement and potash.

The number of private and public residential units authorized for construction increased nearly 2% to 45,687 units in 1989.[3] However, this seemingly healthy signal was not reflected in the value of nonresidential construction, which fell nearly 11%. This listless performance also was evident in the 13% drop in value of awards of State road contracts.[4]

EMPLOYMENT

The State's civilian work force totaled 4.7 million in 1989, an increase of nearly 2% over the 1988 total, according to the Michigan Employment Security Commission. Michigan's Upper Peninsula, long an area of high unemployment and home to most of the State's primary metals industry, posted an employment

TABLE 1

NONFUEL MINERAL PRODUCTION IN MICHIGAN[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Cement:							
Masonry	thousand short tons	263	$23,004	265	$22,915	255	$22,286
Portland	do.	4,755	207,332	5,253	231,141	5,449	253,324
Clays	metric tons	1,209,730	5,338	1,248,121	4,432	1,249,198	4,599
Gem stones		NA	25	NA	25	NA	10
Gypsum	thousand short tons	1,977	12,190	1,958	11,630	2,089	15,589
Iron ore	thousand metric tons	12,509	W	14,623	W	15,045	W
Lime	thousand short tons	569	30,320	714	36,088	621	32,479
Peat	do.	281	5,290	r322	6,256	286	6,082
Sand and gravel:							
Construction	do.	e42,800	e105,300	53,508	138,171	e48,000	e132,000
Industrial	do.	2,792	22,451	3,045	27,150	2,865	24,577
Stone (crushed)	do.	37,909	109,514	e38,800	e120,300	40,905	123,678
Combined value of bromine (1987–88), calcium chloride (natural), copper, gold, iron oxide pigments (crude), magnesium compounds, potassium salts (1989), salt, silver, stone (dimension), and values indicated by symbol W		XX	844,846	XX	989,453	XX	984,347
Total		XX	1,365,610	XX	1,587,561	XX	1,598,971

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

level increase of almost 3%, which meant a work force of 138,000 persons. Unemployment levels in the Upper Peninsula and statewide, however, were among the Nation's highest, at 8.2% and 7.1%, respectively. Although high, these figures did represent a downward trend for the seventh consecutive year, statewide. In the Upper Peninsula, the rate has declined each year since 1985, when it was 15.1%. Mining employment statewide and in the Upper Peninsula mirrored the positive changes reported for the total work force. Statewide, mining provided 10,700 jobs, 3,700 of which were in the Upper Peninsula.

There were three labor contract disputes in Michigan's metals processing industry in 1989, all of which were relatively short lived. Strikes occurred at the Universal Steel Company of Michigan in Lansing, Grand Haven Brass Foundry at Grand Haven, and West Michigan Steel Foundry at Muskegon.

REGULATORY ISSUES

The Environmental Protection Agency (EPA) continued efforts on a work plan to define the scope of cleanup operations for Torch Lake on the Keweenaw Peninsula in Houghton County. A draft of the report was expected in 1990. Torch Lake had been included on the EPA Superfund priority list since 1986 for containing heavy metal contaminated sediments. Some researchers believed that the contamination resulted from metals discharged into this and other nearby lakes, including Lake Superior. Torch Lake is in Michigan's historic native copper mining region. For about 125 years, the lake was the site of copper smelters and was used as a depository for mining and milling wastes and for transport of mining materials. In the early 1980's, an unusually large number of fish taken from Torch Lake were found to have abnormal tumorous growths. Researchers then conducted several studies trying to establish a link between the copper industry waste products and the growths. A connection was never proved. The lake and the Keweenaw Waterway were shown to have high levels of arsenic, chromium, copper, nickel, and zinc. Additionally, some areas also had high lead concentrations. Some researchers observed that these concentrations may be naturally occurring. Cleanup costs for Torch Lake and the entire Keweenaw Waterway could reach $1 billion, according to preliminary estimates, potentially making this the most costly project in Superfund history.[5] Following completion of the work plan, the EPA planned to conduct a feasibility study to determine various alternatives, including full remediation, partial cleanup, or no cleanup at all.

EXPLORATION ACTIVITIES

Nonfuel exploration drilling activity fell from that of a year ago, with only 23 holes drilled in 1989 for a total of 7,341 feet. In 1988, 84 holes were drilled totaling nearly 40,470 feet in six counties. Seven companies were active in 1989, drilling in five counties. Marquette County had the greatest amount of activity with 16 holes drilled. Diamonds, precious metals, iron ore, and graphitic slates were the target commodities. Michigan's Natural Resources Commission held a sale of metallic mineral leases in mid-May, offering nearly 14,000 acres in Baraga, Dickinson, Marquette, and Menominee Counties. Eight bidders registered for the sale, and seven were successful in placing high bids on 7,764 acres. Bids ranged from $1.12 to $35.50 per acre, with the average bid $3.86. Crystal Exploration Inc. was the successful bidder for the most acreage with 2,300, followed by Callahan Mining Corp. (2,291), Exmin Corp. (1,160), Chevron U.S.A. (960), Jack V. Everett (260), Resource Exploration Inc. (320), and Christopher C. Boyd (90). Nearly one-half of the acreage bid upon was in Dickinson County, near an area that in recent years has been targeted for diamond-bearing kimberlite pipe exploration by Crystal and Exmin. Crystal is a subsidiary of Australia-based Crystal Mining N.L. Exmin is a subsidiary of Sibinter, S.A. of Luxembourg, Belgium. Sibinter is in turn wholly owned by Sibeka (Societe d'Entreprises et d'Investissements S.A.), a part of Societe Generale de Belgique, both of Brussels. Bonuses bid and rental payments were expected to result in revenue of $53,298 paid to the State and deposited in the Michigan Natural Resources Trust Fund.

Callahan Mining Corp. entered a joint-venture exploration agreement with Western Mining Corp. (USA) Inc., a wholly owned subsidiary of Western Mining Corp. Holdings Ltd., a large Australian mineral producer. The joint venture covered precious metals and other minerals on properties in the Ishpeming-Marquette area to which Callahan had rights under an agreement with Cleveland-Cliffs Inc.

LEGISLATION AND GOVERNMENT PROGRAMS

Two mineral-related pieces of legislation were enacted into law in 1989. Each strove to protect Michigan's sand dune areas.

Public Act 146 designated 70,000 of Michigan's 275,000 acres of sand dunes as critical sand dune areas. The act required the Department of Natural Resources (DNR) to notify local units of government in critical dune areas that they may adopt a zoning ordinance regulating dunes within their jurisdiction. If the local government failed to adopt an ordinance by June 30, 1990, the DNR would regulate critical dune areas under a model zoning law. Surface drilling operations that explore for, or produce, hydrocarbons or natural brine and their production facilities were prohibited in critical dune areas.

Public Act 147 established model zoning ordinances for sand dune areas. Provisions included allowing construction within a 100-foot setback area without a variance if erosion preventive measures were established; allowing local level regulation of single-family construction—special use projects were subject to DNR review; and designating 250-foot buffer zones around critical dune areas by local government units that had an approved ordinance.

The Michigan Geological Survey Division (GSD) of the DNR acquired more than 350,000 feet of Michigan drill core that had been stored at the Bureau of Mines Research Center core repository in Minneapolis, MN. The rock was placed in the DNR's Geological Core and Sample Repository in Marquette for geologic research by academia, government, and industry. Most of the core resulted from government or industry drilling programs conducted in Michigan 30 to 50 years ago.

GSD also helped support the Michi-

gan Technological University (Michigan Tech) study of the graphitic slates in Baraga and Marquette Counties. This was a multidisciplinary study of the geology and potential economic uses for a resource. One of the most promising uses was as a replacement for shale in cement manufacturing. The graphitic carbon content contributes to the fuel in the cement-making process. More study is needed of this potentially vast resource. GSD continued support for mapping of the northern greenstones belt near Marquette by Michigan Tech's Department of Geology and Geological Engineering.

During 1989, the writing of rules began for Act 188, P.A. 1988, the Forest and Mineral Resource Development Fund Act. Eventually, this act would provide certain grants and loans to stimulate the forest products industry and the mineral extraction and utilization industry in Michigan. Individuals, industry, and academia would be eligible to apply for grants and loans for projects that pertain to new technologies, innovative technologies or procedures, products, and marketing techniques. The GSD was given the lead, with the Forest and Mineral Resource Development Fund Board, to develop rules for the Act.

GSD regulated various mineral industry activities through the sand dune mining and reclamation, mine reclamation, and coal mine reclamation acts. Exploration drilling was regulated under the Mineral Well Act of 1969. The staff also worked on metallic mine taxation and assisted DNR's Real Estate Division in its metallic and nonmetallic mineral leasing program.

In July, the Gerald E. Eddy Geology Center in the 18,000-acre Waterloo State Recreation Area in Washtenaw County was dedicated. The center features interpretive displays about the State's mineral resources dating back to prehistoric times and offers hands-on exhibits and a hiking trail that features explanations about the area's geology. The center was a cooperative effort between the Natural Resources Commission and the DNR's Geological Survey and Parks divisions. It was named in honor of the late Gerald E. Eddy, former State Geologist and longest serving DNR Director, whose career with the DNR spanned 37 years.

Mineral industry research by Michigan Tech at Houghton worked toward advances in mine health and safety engineering and advanced materials, including powder metallurgy, ceramics, composites, metal castings, alloys, forging, and surface treatments. Michigan Tech was a member of the Michigan Polymer Consortium, whose membership also included Central Michigan University and the Michigan Molecular Institute. The consortium allowed the three member institutions to share resources in personnel and facilities in research on lightweight, high-strength, low-cost polymeric composites. These composite materials were seen as potential replacements for some metals used in the automobile, aerospace, aircraft, and defense industries, and in microelectronics and compact discs.

The Mining and Mineral Resources Research Institute at Michigan Tech received an allotment grant of $262,528, passed through the Bureau of Mines under provisions of Public Laws 98–409 and 100–483. Those funds were made available to assist the Institute in coordinating and administering training and research in mining, mineral resources, mineral development, and minerals processing.

Research by the Bureau of Mines in Michigan included a study of mine safety at the White Pine Copper Mine in Houghton County. Specifically, the study involved revising blasting methods to reduce overbreak, which could reduce ground-fall hazards. Falls of ground have been a leading cause of fatalities and injuries in underground mines. The Bureau also provided technical advisors to the EPA for planning work on the Torch Lake Superfund Site.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Calcium Chloride.—Calcium chloride was produced from well brine in two counties by two companies. Michigan was again the Nation's leading producer, far ahead of California, its closest rival. The Dow Chemical Co. had operations in Mason County, and Wilkinson Chemical Corp. operated in Lapeer County. In 1989, production and value increased about 20% and 180%, respectively. Calcium chloride was used as a drying and dehumidifying agent. In a hydrated state, it was used to suppress dust, deice roads, and accelerate concrete curing.

Cement.—In 1989, Michigan ranked fourth, nationally, in sales of masonry and portland cement. In 1988, it ranked fourth in portland cement and fifth in masonry cement. Value of portland cement shipments, the State's second most valuable nonfuel mineral, increased nearly 10% and averaged about $46.49 per short ton, compared with a U.S. sales average of $48.41 per ton. Value of masonry cement shipments decreased almost 3% and averaged about $87.50 per ton, compared with a U.S. sales average of $68.93 per ton. Part of this rather large price variation may be attributed to the comparatively large demand of Illinois customers.

Michigan's four cement plants operated at 93% of their clinker production capacity in 1989, unchanged from 1988. Apparent annual capacity of all Michigan plants was about 4.9 million short tons. Wet-process plants were operated by Dundee Cement Co. and St. Mary's Peerless Cement Co. Dry-process plants were operated by Lafarge Corp. and Medusa Cement Co. Aetna Cement Corp. operated only a grinding plant.

Portland cement produced in Michigan had the following end uses in 1989: ready-mixed concrete (75%), concrete product manufacturers (12%), highway contractors (7%), building material dealers (4%), and other uses (2%).

About 9.5 million short tons of raw materials were consumed in the manufacturing process, including 6.8 million tons of limestone, 1.6 million tons of clay and shale, 538,000 tons of clinker, 270,000 tons of gypsum, and lesser quantities of anhydrite, fly ash, iron ore, sand, and other materials.

Lafarge continued the $70 million modernization project begun at its Alpena cement plant in 1987. The project was scheduled for completion by mid-1990. Plant improvements would increase the annual capacity to 2.5 million tons. The company's stated objective was to make Alpena the largest and lowest cost facility in North America. The renovation would include replacement of equipment, built in 1920, by upgrading the raw material grinding circuit. Addi-

tional improvements would be made in raw materials handling, installation of state-of-the-art roller press technology, and new storage facilities. Lafarge bought the National Gypsum Co.'s Huron Cement Division, including the Alpena operations, for about $30 million in 1987. Lafarge is a Maryland corporation with a majority of its stock owned by the French corporation, Lafarge Copee, and certain of its affiliates known collectively as the Lafarge Copee Group.

Dundee Cement, as part of an agreement with the Michigan Air Pollution Control Commission (MAPCC) began construction of a "baghouse" to reduce visible emissions from its smokestack. Construction was expected to be completed in 1990.

St. Mary's Peerless Cement won approval from the MAPCC to test burn hazardous wastes in the kiln at its Detroit plant. The flammable waste would include mostly industrial ink and plating wastes. Other plants in the U.S. also have sought permits to burn these waste materials, a process that helps reduce operating costs by providing a partial substitute for fossil fuels used to fire the clinker-making kilns. State officials reported that toxins are destroyed in high kiln temperatures. Other pollutants become combined in the clinker, which ultimately is ground and mixed with gypsum to make cement.

Clays.—Production of common clay and shale in Michigan during 1989 increased slightly compared with 1988 levels; value increased about 4% during the same period. Alpena County led the State's production and was one of four counties yielding clay from pits mined by five companies. Most of the clay output was used in cement production, with the remainder used in brick and pottery manufacturing.

Gem Stones.—The value of gem stones was estimated to have decreased about 60% in 1989. Specimens were collected by dealers, rockhounds, mineral collectors, and other hobbyists. Gem stones common to the State include: small, colorful, richly banded agates; ankerite; chlorastrolite; domeykite; jasper; laumontite; native copper; petoskey agates (fossilized coral); and prehnite. Many of these were collected on the Keweenaw Peninsula and along the beaches of Lake Superior.

Gypsum.—Michigan ranked 3d of 21 States in crude gypsum production and 12th of 28 States in the output of calcined gypsum. Crude gypsum output increased about 7%, and calcined gypsum decreased about 4% in 1989 after posting virtually no changes the 2 previous years. Value of crude production was up about 34%, and calcined value decreased nearly 6%. Two underground mines in Kent County and three open pit mines in Iosco County were operated by five companies. Four companies operated calcining plants, including Domtar Gypsum Inc., Georgia-Pacific Corp., National Gypsum Co., and USG Corp. Michigan Gypsum Co. did not operate a calcining plant. National Gypsum Co.'s Tawas Mine and USG Corp.'s Alabaster Mine ranked second and fifth, respectively, of 65 active domestic mines.

Lime.—Michigan was 11th of 32 States in lime production. In 1989, quantity sold or used decreased about 13% and value decreased 10%. Five companies operated eight plants in six counties. Production included both hydrated and quicklime types. Wayne County led the State's production.

Magnesium Compounds.—Michigan ranked first of six producing States in production of magnesium compounds. Well brine operations were reported by The Dow Chemical Co. in Mason and Midland Counties and Martin Marietta Chemicals and Morton Chemical Co. in Manistee County. Production and value fell about 8% and 7%, respectively, in 1989. Compounds produced were caustic-calcined magnesia, magnesium carbonate, magnesium hydroxide, magnesium sulfate, and refractory magnesia.

Peat.—Michigan maintained its position as the Nation's leading producer of peat in 1989. This was in spite of an 11% decrease in sales. Michigan accounted for 37% of the Nation's sales. Peat was harvested at 14 locations by 12 companies in 10 counties. Sanilac County was the State's leading producer. About 90% of the peat sold was used for soil improvement. Reed-sedge accounted for 69% of the harvested peat, followed by humus and sphagnum. Most of the State's peat was sold in packaged form; the remainder was sold in bulk.

Potassium Salts.—Kalium Chemicals Co. at yearend was near startup of a potash solution mine and refinery pilot facility in Hersey Township in southwestern Osceola County. The primary objective of the 36,000-metric-ton-per-year test facility was to demonstrate a technical ability to extract and refine potash from the Salina A-1 Formation of Middle Silurian age.

Salt.—Salt sales declined 2% in 1989 compared with 1988 figures. Salt was solution-mined by Akzo Salt Inc. in Manistee and St. Clair Counties, and by Morton International Inc. in Manistee County.

Morton International was formed in July following a one-for-one tax-free stock distribution (spinoff) by Morton Thiokol Inc. The Morton firm assumed control of the previous corporation's commercial businesses, including salt, specialty chemicals, and inflatable restraint systems. Thiokol Corp. continued to handle aerospace operations.

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Nationally, Michigan ranked second, behind California, in production of construction sand and gravel. The State was estimated to have decreased its 1989 production by about 10% compared with the 1988 figure.

Antimining movements in Michigan were not dissimilar to those experienced by the aggregate industry nationwide. However, a dispute between the Detroit Area Council of Boy Scouts of America and residents of Metamora, in Lapeer County was unique. The Scouts entered an agreement in 1982 with Ajax Paving Industries Inc. to mine gravel from the D-Bar-A Scout Ranch. Since then, Metamora residents have fought the project because of concern over increased noise and traffic levels, potential air and water pollution, and decreased property values. Ajax and the Scouts have sought a rezoning decision on 95 acres to allow mining of about 100,000 cubic yards of gravel per year for as many as 15 years. The resulting pit would be landscaped for

use as a 10-acre lake to enhance Scout activities on the ranch. The Scouts would net more than $1 million on gravel sales. At yearend, the issue was under litigation in U.S. District Court.

Industrial.—Michigan was also the Nation's second leading producer of industrial sand, behind Illinois. Production and value decreased about 6% and 9%, respectively. Sand was mined by 8 companies in 12 counties from 16 pits. The leading counties in terms of value of production were Muskegon, Ottawa, Van Buren, Wayne, and Wexford.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Crushed stone production increased about 5% in 1989. Demand for crushed stone used in iron ore pelletizing and steelmaking supported the gain. Value of production reached a record high of $123.7 million. This was an increase of nearly 3% over the 1988 estimated value.

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

Inland Steel Co. closed its 190-employee Inland Lime & Stone subsidiary near Gulliver in southern Schoolcraft County at yearend. Inland planned to try to sell the operation in 1990. Earlier in 1989, Inland had announced plans to sell the operation to St. Mary's Cement Co., of Toronto, Ontario, Canada. The sale was to be contingent on an agreement by employee-members of Local 4032 of the United Steel Workers of America, and St. Mary's commitment to meet customers' needs for 5 years. St. Mary's and the Union had agreed on all but the seniority clause of a new contract signed in August by the Union and Inland. The clause had provided for a pension of $800 to $1,000 monthly for employees 45 years old or older with 20 years of seniority, if the plant closed. St. Mary's offered a $400 monthly benefit and retirement eligibility at age 62.

Dimension.—Dimension stone production was reported to have increased about 62%; however, value decreased 41%.

Other Industrial Minerals.—Perlite from out-of-State sources was expanded by Harborlite Corp. at its Kalamazoo County plant. Perlite sales and value decreased about 1% and 10%, respectively. Processed iron and steel slag was sold mostly for road base material or asphalt and concrete aggregate. Sales decreased about 9%. Sulfur, recovered from two of the State's petroleum refineries, posted a sales decrease of 6%; however, value increased 3%. W. R. Grace & Co. produced exfoliated vermiculite from out-of-State raw material sources at its Wayne County plant. Shipments and value both decreased about 7%.

Metals

Copper, Gold, and Silver.—Michigan's national rankings for production of copper, gold, and silver were 5th, 13th, and 9th, respectively. Production was from two underground mines. Copper and silver were produced in Ontonagon County at the White Pine Mine by Copper Range Co. Gold and silver were produced by Callahan Mining Co. in Marquette County at its Ropes Mine. Gold and silver production decreased in both quantity and value, mostly because of production problems at the Ropes Mine.

Copper output at White Pine fell about 7%, but value of production increased 1%, because of increased copper prices. Copper Range reported it had produced 92 million pounds or

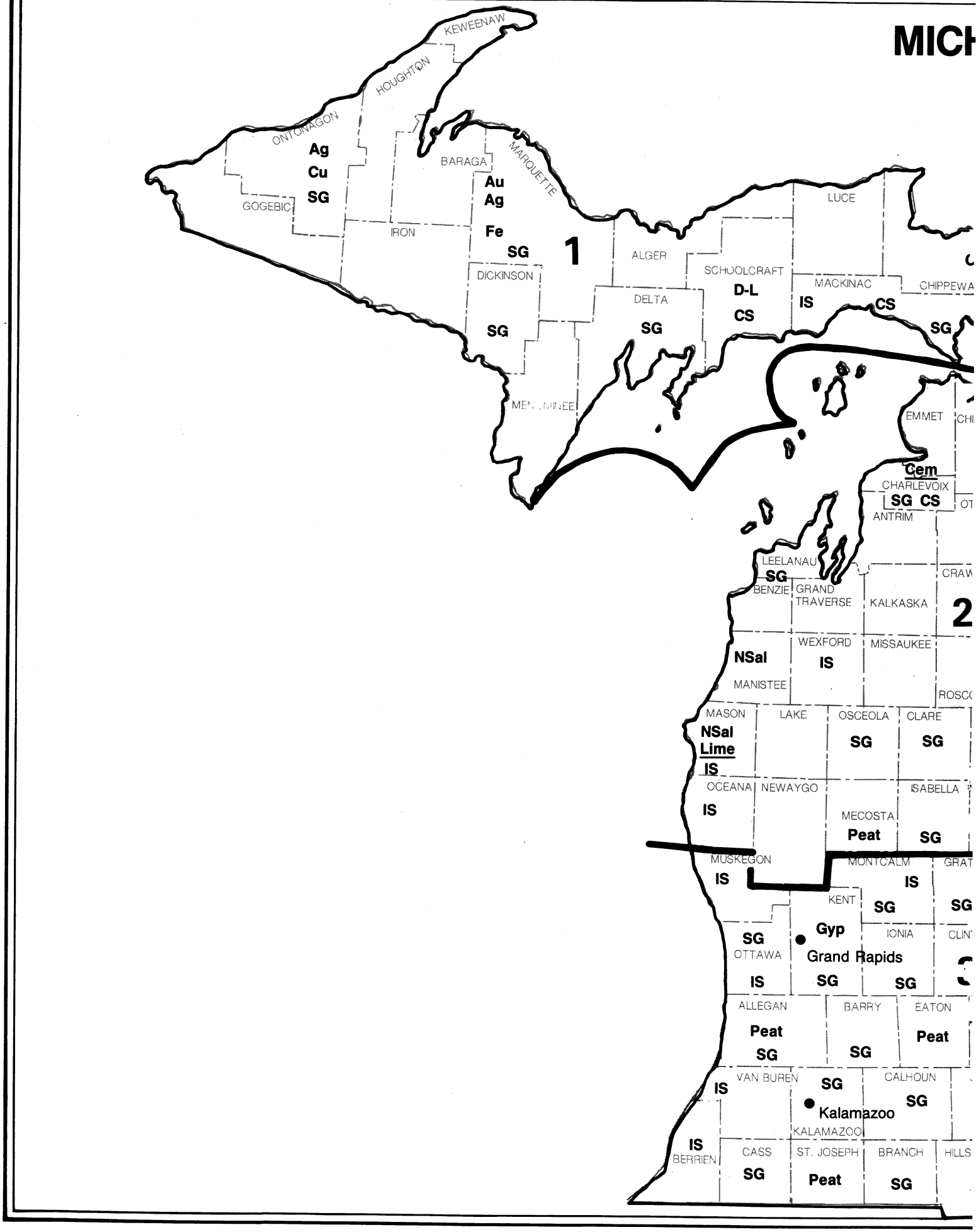
TABLE 2

MICHIGAN: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	186	1,057
Filter stone	2,134	7,621
Coarse aggregate, graded:		
Concrete aggregate, coarse	3,956	11,941
Bituminous aggregate, coarse	918	2,450
Railroad ballast	194	659
Fine aggregate (−3/8 inch):		
Stone sand, concrete	176	533
Stone sand, bituminous mix or seal	120	177
Screening, undesignated	286	1,032
Coarse and fine aggregates:		
Graded road base or subbase	2,977	8,806
Unpaved road surfacing	1,493	5,614
Crusher run or fill or waste	35	133
Other construction materials[2]	1,193	3,711
Agricultural: Agricultural limestone	237	1,192
Chemical and metallurgical:		
Cement manufacture	6,118	10,717
Flux stone	2,724	10,273
Other miscellaneous uses[3]	1,752	5,681
Unspecified:[4]		
Actual	15,992	49,555
Estimated	412	2,528
Total[5]	40,905	123,678

[1] Includes limestone, dolomite, marl, sandstone, quartzite, traprock, marble, and miscellaneous stone.
[2] Includes stone used in macadam, bituminous surface-treatment aggregate, and terrazzo and exposed aggregate.
[3] Includes stone used in poultry grit and mineral food, other agricultural uses, lime manufacture, and sulfur oxide removal.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.


MICH
KEWEENAW
HOUGHTON
ONTONAGON
Ag
Cu
SG
GOGEBIC
IRON
BARAGA
Au
Ag
Fe
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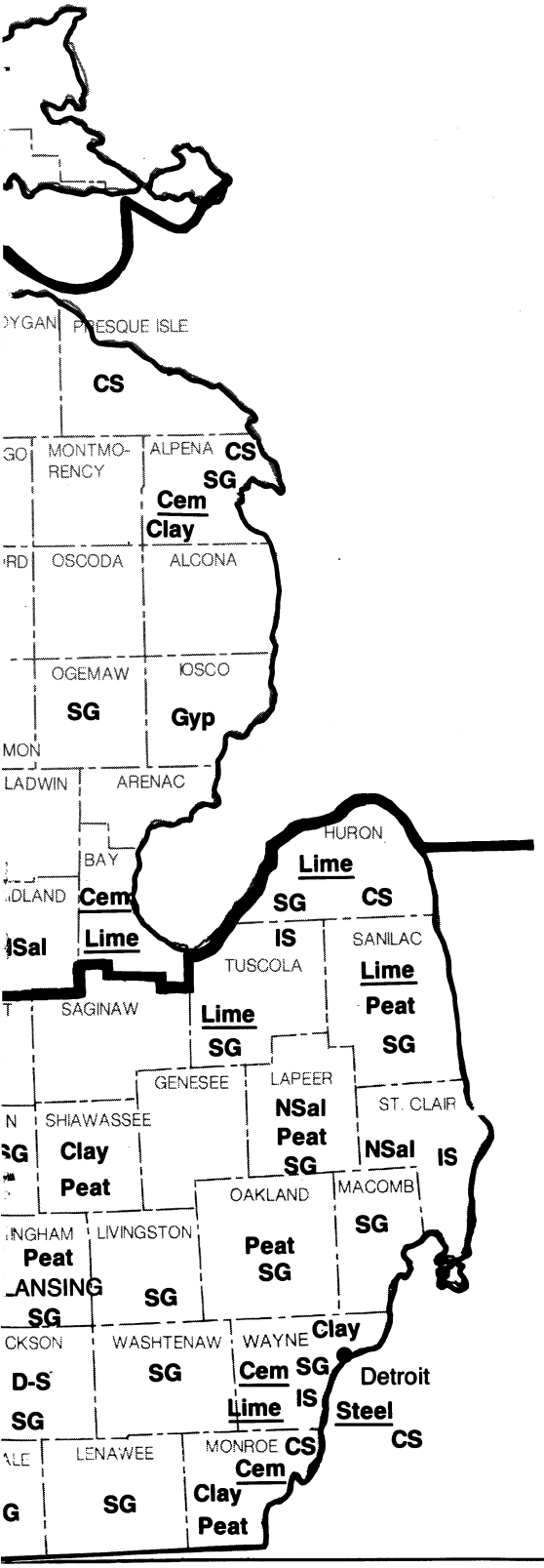
MARQUETTE
1
DICKINSON
SG
MENOMINEE
ALGER
DELTA
SG
SCHOOLCRAFT
D-L
CS
LUCE
MACKINAC
IS
CS
SG
CHIPPEWA
EMMET
Cem
CHARLEVOIX
SG CS
ANTRIM
LEELANAU
SG
BENZIE
GRAND TRAVERSE
KALKASKA
2
WEXFORD
IS
MISSAUKEE
NSal
MANISTEE
MASON
NSal
Lime
IS
LAKE
OSCEOLA
SG
CLARE
SG
OCEANA
IS
NEWAYGO
MECOSTA
Peat
ISABELLA
SG
MUSKEGON
IS
MONTCALM
IS
KENT
SG
SG
Gyp
Grand Rapids
IONIA
SG
OTTAWA
IS
SG
ALLEGAN
Peat
SG
BARRY
SG
EATON
Peat
VAN BUREN
IS
SG
Kalamazoo
CALHOUN
SG
KALAMAZOO
IS
BERRIEN
CASS
SG
ST. JOSEPH
Peat
BRANCH
SG

GAN



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 3

MICHIGAN: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	73	315	3,042	10,305	352	1,650
Coarse aggregate, graded[2]	1,327	3,695	W	W	W	W
Fine aggregate (−3/8 inch)[3]	218	668	125	343	238	730
Coarse and fine aggregates[4]	979	1,470	863	2,305	2,671	10,803
Other construction aggregates	—	—	3,016	7,940	767	3,509
Agricultural[5]	107	399	—	—	181	973
Chemical and metallurgical[6]	3,168	12,250	(7)	(7)	(7)	(7)
Other miscellaneous	—	—	6,158	9,987	1,218	4,252
Unspecified:						
Actual[8]	3,281	10,074	9,391	24,393	3,320	15,088
Estimated[9]	—	—	15	65	397	2,463
Total[10]	9,154	28,871	22,609	55,338	9,142	39,469

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[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 fine aggregate (screening-undesignated).
[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run or fill or waste.
[5] Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[6] Includes crushed stone for cement manufacture, lime manufacture, flux stone, and sulfur oxide removal.
[7] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[8] Includes production reported without a breakdown by end use.
[9] Includes estimates for nonrespondents.
[10] Data may not add to totals shown because of independent rounding.

41,700 metric tons (mt) of copper in 1989.[6] Reserves were reported to be 180.7 million short tons or 163.9 million metric tons (MMmt) containing 4.5 billion pounds (2 MMmt) of extractable copper, or enough for a 30-year mine life.

Metall Mining Corp., a Canadian-based subsidiary of Metallgesellschaft A.G. of the Federal Republic of Germany, completed the purchase of Copper Range Co. and its White Pine facilities in late May. The company had agreed in principle to purchase the operations in February, and, shortly thereafter, union workers at the White Pine facilities agreed to a new 4-year contract that paved the way for the sale. The White Pine unit was unique in that it operated under an employee stock ownership plan in which union workers owned 70% of the company and management owned 30%. Sale price of the operations was $83 million; this could increase to $98 million if certain goals and operating profits are achieved through 1993. Employees purchased the operation in 1985. As a result of the Metall buyout, each employee-owner was to receive $80 per share, or an average of $60,000.

Ore at White Pine occurs in a zone that generally ranges in thickness from 8 to 15 feet at depths from about 1,500 to 2,600 feet, in the Late Proterozoic Nonesuch Shale. Finely disseminated chalcocite with some native copper was mined by room-and-pillar methods. Facilities at White Pine included the mine and a 15,000-short-ton-per-day (13,600 mt per day) mill. Concentrate was processed at the 500-short-ton-per-day (450 mt per day) refinery purchased in January 1989 from a previous White Pine owner, Louisiana Land & Exploration Co., for $14.3 million. Operations at the mine have been intermittent since its opening in 1915. At yearend 1989, the operation had about 1,000 workers.

Peninsula Copper Industries (PCI) of Hubbell continued production of copper oxide for use in manufacturing wood preservatives and propellants for automobile safety airbags. During 1989, PCI used copper scrap from circuit boards, copper wire, and copper-clad sheet steel as source materials.

MICHCAN Inc., an investor group including PCI, Keweenaw Copper Co., and Torch Lake Holdings Co., announced plans in August to reopen the Centennial No. 6 Mine in Houghton County. The copper mine was last operated in 1976 by a subsidiary of Homestake Mining Co. in a joint venture with American Copper & Nickel Co. A planned May 1990 reopening of the Centennial would provide 100 new jobs and a native (raw) copper source for the PCI operation. MICHCAN received a State loan of $350,000 to begin dewatering the mine.

In late September, Callahan Mining Corp. closed indefinitely its Ropes Mine because of a continued slump in gold prices and ground control problems near the main production shaft. The closure idled most of the 150-person work force. The Marquette County gold and silver operation began operations in 1985 and, from the outset, had ground stability problems. Gold production and value from Ropes, the State's only gold mine, dropped 24% and 33%, respectively. Callahan reported that it had milled 590,382 short tons (535,586 mt) of ore

grading 0.069 ounce of gold per ton or 2.237 grams per mt (g/mt) and 0.143 ounce of silver per ton (4.90 g/mt) in 1989.[7] Cash operating costs were $322 per ounce of gold. Company-reported ore reserves were 482,355 short tons (437,585 mt) grading 0.093 ounce of gold per ton (3.19 g/mt). At yearend, the company continued to study various options to bring the mine back into production.

Iron Ore.—Michigan, as in past years, ranked second behind Minnesota in shipments of iron ore, the State's most valuable nonfuel mineral commodity. Shipments in 1989 were up about 3% to 15 million metric tons (14.8 million long tons), compared with 14.6 million metric tons (14.4 million long tons) in 1988. Value of shipments increased about 4%. With a softening of automobile sales in the second half of 1989, many industry observers were forecasting declines in steel demand for 1990.

Michigan's iron ore producers mined taconite, a hard, metasedimentary rock containing varying amounts of hematite and magnetite, from open pits in the Negaunee Iron Formation of Middle Precambrian age. Taconite ore was drilled and blasted, then loaded with large electric- or diesel-engine-powered shovels with 10-cubic-yard (7.7-cubic-meter) buckets into 85- to 190-long-ton (77 to 172 mt) capacity trucks. Ore was then transported to a mill for crushing to a fine powder and treated in flotation circuits to remove impurities such as silica. The resulting concentrate was mixed with a binder—generally bentonite clay—and passed through a pelletizing system that formed iron ore pellets, spherical nodules less than 0.5 inch in diameter. These pellets, depending on customer needs, were produced as either acid or fluxed pellets. Finished pellets were generally railed to shipping docks at Escanaba or Marquette. Once loaded on ships, the ore was moved to various Great Lakes steel mills where the pellets become feedstock for large steelmaking blast furnaces. Smaller, all-rail shipments were made to a steel mill at East St. Louis, IL.

According to the American Iron Ore Association, the average analyses for acid and fluxed pellets were:

	Acid (percent)	Fluxed (percent)
Iron	64.46	61.36
Phosphorus	.01	.08
Silica	4.93	4.37
Manganese	.05	.54
Alumina	.24	.16
Moisture	1.83	2.12

The Empire Mine at Palmer was owned by the Empire Iron Mining Partnership, which was composed of Cleveland Cliffs Inc. (CCI) (25%), Inland Steel Industries Inc. (40%), LTV Steel Corp. (25%), and Wheeling-Pittsburgh Steel Corp. (10%). In 1989, the Empire reached an alltime high in magnetite pellet output by producing 8.1 million long tons (8.2 MMmt); or slightly above an annual rated capacity of 8.0 million long tons (8.1 MMmt). The Empire produced both fluxed and acid pellets. There were 1,214 people employed at the Empire in 1989. CCI reported that it had enough ore reserves to ensure operations for about 37 years, assuming production at the rated capacity.[8] To enhance production capabilities and reduce production costs at the Empire, the operator incorporated a new and innovative pebble-crushing circuit and a computerized system for mine planning and design.

Iron ore shipments from the Tilden Mine totaled 7.1 million long tons (7.2 MMmt).[9] The Tilden Mine was operated by CCI under agreements with the Tilden Mining Co. (TMC) and the Tilden Magnetite Partnership (TMP). The agreements allocated hematite production to Algoma Steel Corp. (25%), Stelco Inc. (8.3%), and CCI (66.7%). Magnetite production was allocated to Algoma (50%), Stelco (16.7%), and CCI (33.3%). Based on a production rate of 8.0 million long tons of annual hematite pellet output, ore reserves were sufficient for an additional 33 years of operations. About 980 people were employed at the Tilden operations

TABLE 4

MICHIGAN IRON ORE[1] PRODUCED (DIRECT SHIPPING AND 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		
				Gross weight		Iron content (percent)
				Ore[2]	Iron content	
1854–1984	561,172	[3]321,307	[4]253,631	1,136,109	NA	NA
1985	12,679	—	—	12,679	8,181	64.52
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
Total[2]	627,270	[5]321,307	[5]253,631	1,202,207	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 1967.
[5] Distribution by range partly estimated before 1906.

in 1989.

In August, CCI completed a $30 million project at the Tilden to produce fluxed and standard iron ore pellets from either magnetite or hematite. Magnetite pellets offered lower energy production costs, did not require extensive chemical separation, and had lower phosphorus content; however, they had an increased silica content. Steelmakers want phosphorus to be as low as possible in the pellets; although increased phosphorus content increases the strength of the steel, it decreases ductility. Hematite pellets accounted for about 75% of Tilden's production.

Although CCI considered reopening the Republic Mine in Marquette County for most of the year, hopes of this occurring seemed lost by late summer. Republic had been mothballed since its closing in October 1981. Company officials indicated that a reopening would be contingent on the strength of the steel market and competition. Other possibilities were to increase Tilden's production or to reopen the Reserve Mine at Silver Bay, MN. By late summer, Republic's fate appeared to be sealed when a newcomer to the iron ore industry, Cyprus Northshore Mining Corp., a subsidiary of Cyprus Minerals Co., purchased the Silver Bay operation, including the Babbitt taconite mine, and readied them for reopening.

CCI and the United Steel Workers Union, representing Empire and Tilden Mine employees, entered early contract negotiations in October. The intent was to prevent a labor dispute when the current contract expires on August 1, 1990.

CCI also shipped iron oxide pigments from stockpiles at the Mather Mine in Marquette County. Quantity and value of iron oxide sales decreased less than 1% in 1989.

Iron and Steel.—Michigan again ranked fourth in raw steel production, behind Indiana, Ohio, and Pennsylvania. The American Iron and Steel Institute, a trade organization based in Washington, DC, reported that Michigan's output totaled 8.2 million short tons, or about 8.4% of the 97.9 million tons produced nationally in 1989. Michigan's 1989 production was about the same as that reported in 1988.

Ford Motor Co. completed the sale of its subsidiary, Rouge Steel Co., the Nation's eighth-largest steel producer, to Marico Acquisition Co. on December 15. Marico Acquisition was formed in July to make a bid for Rouge Steel. Principals in the company were Carl L. Valdiserri, a former Weirton Steel Co. executive, with about a 40% interest; Chase Manhattan Bank of New York with a 20% interest; and Worthington Industries Inc., a steel processor, with about a 20% interest. Ford Motor retained a 20% interest in the company. The company planned to continue to operate under the Rouge Steel Co. name.

National Steel Corp., a joint-venture company owned by National Intergroup Inc. and NKK Corp., through its Great Lakes Division, operated a steel producing facility at Ecorse and a plant for manufacturing processed steel products at Detroit. In 1989, the Ecorse plant's basic oxygen-furnace facility reached a record-high production of 3.3 million short tons. Work continued on a $140 million continuous caster, scheduled to come on-line in 1990, at the Ecorse facility. Caster completion would make National the first American steelmaker to continuous cast all of its product. This would also complete a transition to total continuous casting begun earlier in the decade. In 1989, construction continued on a $70 million vacuum degasser circuit used to process liquid steel. Scheduled to be completed in 1990, the circuit would have an annual capacity of 1.8 million short tons of ultra-low-carbon steels. The products would have a carbon content under 0.02% and would be used in automotive and appliance manufacturing. Through a direct linkup to a long-distance natural gas pipeline, Great Lakes Division became fully independent of a local utility. Estimated annual savings to be achieved from the linkup were expected to be about $7 million.

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[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN. Assistance in the preparation of the chapter was given by Wanda J. West, editorial assistant.

[2] Regional geologist, Geological Survey Division, Michigan Department of Natural Resources, Marquette, MI.

[3] U.S. Department of Commerce, Bureau of the Census. Private communication, 1989; available upon request from L. E. Esparza, BuMines, Minneapolis, MN.

[4] Highway and Heavy Construction. Market Update: Battle Lines Form Over Gridlock, Gas Tax. V. 132, No. 3, Mar. 1989, p. 34.

[5] The Daily Mining Gazette, Houghton, MI. Torch Lake: What Unknowns Lie Below the Surface? Mar. 30, 1989, p. D6.

[6] Skillings' Mining Review. Copper Range Co. Purchases a Mill from Echo Bay Subsidiary. V. 79, No. 21, May 26, 1990, p. 13.

[7] Callahan Mining Corp. (Phoenix, AZ). 1989 Form 10-K Annual Report, p. 8.

[8] Cleveland-Cliffs Inc. (Cleveland, OH). 1989 Annual Report to Stockholders. 41 pp.

[9] Work cited in footnote 8.

TABLE 5

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Aetna Cement Corp., a subsidiary of Societe des Ciments Francais	Box 80 Essexville, MI 48732	Grinding plant	Bay.
Dundee Cement Co., a division 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]	4000 Town Center Suite 200 Southfield, MI 48075	do.	Alpena.
Medusa Cement Co., Medusa Corp. a subsidiary of Crane Co.[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.[3]	Box 100 White Pine, MI 49971	Underground mine, concentrator, smelter, refinery	Ontonagon.
Gold:			
Callahan Mining Corp.[3]	11811 North Tatum Blvd. Suite 4055 Phoenix, AZ 85028	Underground mine and plant	Marquette.
Gypsum:			
Domtar Gypsum Inc.	Box 1670 Grand Rapids, MI 49501	do.	Kent.
Georgia-Pacific Corp.	133 Peachtree St., NE Atlanta, GA 30303	do.	Do.
Michigan Gypsum Co.	2840 Bay Rd. Saginaw, MI 48603	Open pit mine	Iosco.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	Open pit mine and plant	Do.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	Open pit mine Plant	Do. Wayne.
Iron ore:			
Cleveland-Cliffs Iron Co.[4]	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., Ludington Div.	2020 Dow Center Midland, MI 48640	do.	Mason.
Marblehead Lime Co., a division of General Dynamics Corp.	222 North LaSalle St. Chicago, IL 60601	do.	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	do.	Bay.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
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.
Fletcher & Rickard	25800 Haas Rd. New Hudson, MI 48165	do.	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 Co.	Hersey, MI 49639	Solution mine and plant	Osceola.
Salines (natural):			
The Dow Chemical Co.:	2020 Dow Center Midland, MI 48640		
Ludington plant[5 6]		Brine wells and plant	Mason.
Midland plant[6]		do.	Midland.
Martin Marietta Corp., Magnesia Specialties Div.[6]	Executive Plaza II Hunt Valley, MD 21030	do.	Manistee.
Morton International Inc.[6]	110 North Wacker Dr. Chicago, IL 60606	do.	Do.
Wilkinson Chemical Corp.[5]	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 (1988):			
ARC America Corp.	67500 Mound Rd. Romeo, MI 48065	Pits and plants	Kalamazoo, Livingston, Macomb, Oakland.
Holloway Sand & Gravel Co. Inc.	29250 Wixom Rd. Wixom, MI 48096	do.	Oakland, Washtenaw, Wayne.
Edward C. Levy Co. Lyon Sand & Gravel Co.	4780 South Hill New Hudson, MI 48165	do.	Oakland.
Natural Aggregates Corp.	65545 Mound Rd. Romeo, MI 48065	Pit and plant	Livingston.
Portable Aggregates Producers	1401 Souter Blvd. Troy, MI 48084	Pits and plants	Livingston and Oakland.
Searles Construction Inc.	2265 West Park Rd. St. Johns, MI 48879	Pit and plant	Clinton.
Bill Smith Sand & Gravel Inc.	Box 23 Otsego, MI 49078	Pits and plants	Allegan and Cass.
South Kent Gravel Inc.	8255 South Division Byron Center, MI 49315	do.	Kent and Ottawa.
Tri-City Aggregates Inc.	1401 Souter Blvd. Holly, MI 48442	Pit and plant	Oakland.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued			
Industrial:			
Cheyenne Sand Corp., a subsidiary of Construction Aggregates Corp.	Box 68 Ferrysburg, MI 49409	Pits and plants	Ottawa.
Manley Bros. of Indiana Inc.	Box 538 Chesterton, IN 46304	do.	Berrien and Van Buren.
Nugent Sand Co. Inc.	Box 1209 Muskegon, MI 49443	Pit and plant	Muskegon.
Sargent Sand Co.	Box 6280 Saginaw, MI 48603	Pits and plants	Mason, Tuscola, Wexford.
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	Pit and plant	Wayne.
Slag (iron and steel):			
International Mill Service Co.	1818 Market St. Philadelphia, PA 19103	Plant	Monroe.
Edward C. Levy Co.	8800 Dix Ave. Detroit, MI 48209	Plants	Wayne.
Stone:			
Crushed:			
Limestone-dolomite:			
Beazer USA	1850 Koppers Bldg. Pittsburgh, PA 15219	Quarry and plant	Monroe.
Holloway Sand & Gravel Co. Inc.	29250 Wixom Rd. Wixom, MI 48096	Quarries and plants	Do.
Inland Lime & Stone Co., a division of Inland Steel Co.	Gulliver, MI 49840	do.	Mackinac and Schoolcraft.
Michigan Mineral Associates	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.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
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.
Vermiculite (exfoliated):			
W.R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	Processing plant	Wayne.

[1] Also clays.
[2] Also crushed limestone.
[3] Also silver.
[4] Also crude iron oxide pigments.
[5] Calcium chloride.
[6] Magnesium compounds.

THE MINERAL INDUSTRY OF MINNESOTA

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

By Leon E. Esparza[1]

Minnesota's nonfuel mineral production in 1989 was valued at more than $1.4 billion, an increase of about $170 million over that of 1988. The 13% increase in value paralleled a 13% rise in the value of iron ore shipments, which accounted for 89% of the State's nonfuel mineral production value. Significant increases also were reported in the value of lime, construction and industrial sand and gravel, and crushed and dimension stone production. Minnesota ranked seventh nationally in nonfuel mineral production value and accounted for 4% of the U.S. total. The State supplied 70% of the Nation's usable iron ore shipments.

Minerals used in construction accounted for 11% of the State's nonfuel mineral production value. According to the U.S. Department of Commerce, Bureau of the Census, authorized private and public residential units in 1989 dropped 11% to 25,127 units, down from 28,380 units in 1988. Value of nonresidential construction totaled more than $1.5 billion, an increase of 16% over that of 1988. Value of State road contract awards increased 29% to $814 million.[2]

The State's mining economy is largely dependent on a vibrant, growing national economy. By mid-1989, there was growing apprehension about the Nation's economy. Economic indicators were hinting at rising unemployment, slowing automobile sales, higher interest rates, and a stalling real estate market. If an economic recession should develop, it could deflate growth in the State's mining industry by late 1990 or 1991. In 1989, the State generally, and the iron ore industry in particular, had been only slightly affected by a growing nationwide savings and loan scandal. However, this could change. Northern Minnesota's taconite industry provides the basic raw material for steelmaking. A severe downturn in the economy or yet unknown impacts of the savings and loan crisis would probably result in further declines in building construction and consumer purchases. This, in turn, would lead to less demand for a wide range of steel products, including appliances, used in new construction. The Nation's automobile industry, a major steel products user, also could become a victim.

EMPLOYMENT

Minnesota's mining industry employed 7,500 people in 1989, an increase of about 4% over the 1988 figure. The metal mining sector provided 5,800 of these jobs, an increase of 5% during the period. Average wages for all mining jobs was $13.70 per hour, up about 3%. Metal mining wages averaged $14.14, compared with $14.10 in 1988.[3] Several of the State's taconite operations added personnel during the year. USX Corp.'s Minntac operation in Mountain Iron announced openings for entry level (laborer) positions for

TABLE 1

NONFUEL MINERAL PRODUCTION IN MINNESOTA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	$40	NA	$40	NA	$42
Iron ore	thousand metric tons	34,274	1,012,788	40,735	1,134,539	41,044	1,285,807
Peat	thousand short tons	30	W	29	r1,414	27	1,415
Sand and gravel (construction)	do.	e25,200	e67,400	33,769	72,678	e33,700	e82,600
Stone:							
Crushed	do.	8,995	29,246	e8,300	e28,200	8,760	30,218
Dimension	short tons	41,354	12,967	e45,000	e13,000	44,605	16,031
Combined value of clays (common, kaolin), lime, sand and gravel (industrial) and value indicated by symbol W		XX	20,308	XX	18,015	XX	22,022
Total		XX	1,142,749	XX	1,267,886	XX	1,438,135

e Estimated. r Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

the first time since 1981. Eveleth Mines and Hibbing Taconite Co. also added personnel in 1989. Cyprus Northshore Mining Corp. began hiring workers to rehabilitate and staff the former Reserve Mining Co. operations at Babbitt and Silver Bay. By the end of December, more than 300 persons were onboard, and employment was expected to reach about 340 when shipping begins in the spring of 1990. Employment at LTV Steel Mining Co.'s Hoyt Lakes operations dropped during the year because of a buildup of inventories in 1988. On November 5, the company trimmed production by 50% and laid off between 400 to 450 workers for a 2-week period because of excessive inventories.

Contract agreements were ratified at three iron range taconite operations in 1989—Inland Steel Co.'s Minorca operations near Virginia, Hibbing Taconite Co.'s operations at Hibbing, and National Steel Pellet Co.'s operations at Keewatin. The new 4-year pacts were similar in that they provided increases in hourly wages, settlement bonuses, additional vacation time, and significant increases in pension benefits for veteran employees.

REGULATORY ISSUES

In December, LTV Steel Mining received a violation notice from the Minnesota Pollution Control Agency (MPCA) charging that metals seeping from the Dunka Pit waste-rock stockpiles exceeded water quality standards. The company contested the notice. The mine, 4 miles east of Babbitt, provided iron ore for LTV's Hoyt Lakes pellet plant. In recent years, elevated concentrations of copper, nickel, and zinc in area waters have been widely reported. Early in 1989, researchers determined that rainwaters percolating through an estimated 77 million long tons (78 million metric tons—MMmt) of stockpiled waste rock were apparently leaching the metals. The discovery focused concern on potential damage to wildlife habitat, fisheries, and area ground and surface waters, resulting from formation of acid waters. Of particular concern was the potential affect on nearby Birch Lake and the waterways leading to the regionally popular Boundary Waters Canoe Wilderness Area.

The Dunka waste rock, however, was only one of several potential sources of water contamination, because there had been a local history of copper-nickel prospecting as well. Additionally, the geology of the area's rocks, specifically the Precambrian Duluth Gabbro Complex, had been widely described as containing discontinuous lenses and layers of disseminated copper and nickel sulfide minerals. This fact opened speculation that the elevated metals concentrations in area waters could, in part, be naturally occurring.

At yearend, monitoring of water chemistry continued under a 1986 agreement between LTV and MPCA. Additionally, research was underway by LTV and the State Department of Natural Resources (DNR) to mitigate development of acidic water and its drainage. Area ground water flow patterns were studied to determine if water diversion around the rockpile would solve the problem. Other studies included capping the rockpile to prevent water percolation and adding limestone or other carbonate materials to the pile to neutralize acidic runoff and then using peat filters to absorb the pollutants.

EXPLORATION ACTIVITIES

Exploration activity in Minnesota during 1989 continued at the brisk pace witnessed in recent years. Ten companies drilled 81 holes for a total of 37,132 feet in 8 counties on private, State, and Federal lands. Exploration targets included potential deposits of cobalt, copper, diamonds, gold, manganese, nickel, palladium, platinum, titanium, and zinc. Drilling activity was the greatest in St. Louis County where 8 companies drilled 52 holes for a total of 22,534 feet. St. Louis County was followed by Koochiching County (8,884 feet), Itasca County (2,900 feet), and Marshall County (1,653 feet). In addition, the Minerals Division, Minnesota Department of Natural Resources (MDNR), drilled 20 holes totaling 4,247 feet in Lake of the Woods County. The MDNR drilling was to establish information for geologic mapping that ultimately could be used by minerals explorationists.

The MDNR held its 12th metallic mineral lease sale in October. The competitive sale on nearly 1.4 million acres drew bids from 10 parties on about 35,000 acres. Successful bidders pay $1

TABLE 2

MINNESOTA: EXPLORATION DRILLING IN 1989, BY COUNTY

County	Number of drill holes	Total footage drilled	Company or agency
Chippewa	1	225	Exmin Corp.
Itasca	7	2,900	Lehmann Exploration Management Inc. and Normin Mining Co.
Koochiching	14	8,884	BHP-Utah International Inc., Exploration Ltd., Normin Mining Co.
Lac Qui Parle	1	387	Exmin Corp.
Marshall	4	1,653	Newmont Exploration Ltd.
Redwood	2	269	Exmin Corp.
Renville	2	280	Do.
St. Louis	52	22,534	BHP-Utah International Inc., Eveleth Mines, FMC Minerals Corp., International Nickel Co., Lehmann Exploration Management Inc., Newmont Exploration Ltd., Noranda Exploration Inc., Rhude & Fryberger Inc.
Total	83	37,132	

Source: Minnesota Department of Natural Resources, Division of Minerals, Hibbing, MN.

per acre per year to lease State land for the first 5 years of exploration; thereafter, the lease rate increases to $5 per acre.

At yearend, State mineral leases were held by 32 lessees in 8 counties. According to MDNR, 504 metallic mineral leases, totaling nearly 200,000 acres, were in effect.

County	Number of lessees (Number of leases)	Gross acres leased
Aitkin	1 (9)	2,071
Beltrami	2 (42)	23,895
Carlton	1 (2)	244
Itasca	9 (97)	41,092
Koochiching	5 (48)	19,896
Lake	4 (21)	7,233
Roseau	1 (2)	634
St. Louis	24 (283)	104,356
Total	32 (504)	199,422

LEGISLATION AND GOVERNMENT PROGRAMS

The 1989 State legislature enacted several laws of specific interest to the mining industry. Chapter 27, Article 1, of the 1989 Session Laws made technical corrections to the Unmined Ore Property Tax. The revisions require a notice to taxpayers of unmined iron ore market value and clarification of the computation of mining occupation taxes. It also retroactively provided a corporate franchise tax modification for mining income or gains.

Chapter 116 authorized the commissioner of natural resources to dispose of certain low-grade, State-owned, iron-bearing materials for highway construction or maintenance purposes. The intent of this law was to allow material containing 45% or less iron, by dry analysis, to be used as construction material. Previously, the iron content was limited to 40%.

Chapter 182 provided for the confidentiality of information submitted by mining firms in nominating lands for mineral lease sales. Chapter 335, the Omnibus State Departments' Appropriations Law, allocated money for mineral diversification and research. Funding for this plan was begun in 1987 and was intended to direct, coordinate, and set priorities for mineral-related research that could expand the State's mineral base and enhance its mineral economy. The appropriations law also established a legislative task force on minerals to study issues relating to environmentally sound development of the minerals industry.

The Minerals Coordinating Committee (MCC) directed, coordinated, and set priorities for State-funded mineral-related research that could expand Minnesota's mineral base and enhance its mineral economy. Ten research institutions were at least partially dependent on State funding for their efforts. The institutions included six State agencies, two State universities, and two Federal agencies. The MCC functions under provisions of the Minnesota Minerals Diversification Plan, which was created and initially funded by the 1987 legislature. Members of the MCC included the directors of the Minerals Division, Department of Natural Resources (MDNR), Minnesota Geological Survey (MGS), Mineral Resources Research Center (MRRC), and the Natural Resources Research Institute (NRRI).

In late November, the Governor convened a Blue Ribbon Task Force on Mining Taxes. The group was composed of representatives from industry and all levels of government. The task force's objective was to determine ways to enhance and encourage investment in the State's minerals industry through modifications in current tax laws. One aspect expected to be reviewed would be replacement of the current taconite production tax with an ad valorem tax on facilities and reserves.

Earlier in November, the 25-year-old "taconite amendment" to the Minnesota State Constitution expired. In 1964, State voters approved a constitutional guarantee that Minnesota taxes on the taconite industry would not surpass levies on other industries in the State. It was the hottest political issue of the day. Detractors labeled it a sell-out to the mining industry, while supporters hailed it as a must for northeastern Minnesota's economic future. Since then, taconite taxes have been reduced. In the early 1980's, taxes were cut to enhance State producers' position with worldwide competition. In 1987, tax laws again were modified, effective in 1991, to lower rates. There was no known move to renew the amendment.

The Sixth Annual Current Minerals Activities Forum, sponsored by the MCC, was convened in October at Ironworld in Chisholm. Attendees included representatives from industry, government, academia, and the general public. The purpose of the forum was to disseminate mineral-related information about State-funded projects under the Minerals Diversification Plan. Mineral information generated by other interested groups also was available.

MDNR programs were diverse but focused on meeting goals of the MCC. Studies of particular interest included examination of official land records to determine the mineral rights ownership on most of the approximately 5 million acres of land acquired through real estate tax forfeiture.

An inventory of industrial mineral operations, excluding sand and gravel pits, was begun. Information collected included mineral type, geologic description, location, and ownership.

A regional geochemical survey of drill core collected from thick glacial drift overlaying Precambrian bedrock in Lake of the Woods County was begun. The primary objective of the MDNR and MGS cooperative study was to identify the glacial drift stratigraphy, preexisting weathering profiles, and bedrock. Information collected ultimately was to be used in land planning and decisions about future exploration.

The Iron Ore Cooperative Research Committee (IOCRC), established in 1985, was supported by the MDNR in cooperation with Cleveland-Cliffs Iron Co., Inland Steel Mining Co., National Steel Pellet Co., Oglebay Norton Co., USX Corp., and Minnesota Power. Short-term projects funded by the committee were aimed at reducing operating costs and improving pellet quality, with an overall goal of increasing the competitiveness of Minnesota's taconite industry. The committee research was conducted by the Corrosion Research Center, M.A. Hanna Research Center, MRRC, NRRI, Pickands Mather Services, Inc., and the Bureau of Mines.

An example of the type of IOCRC-sponsored studies in progress in 1989 was a study of metallurgical properties of fluxed and acid iron ore pellets. Specific parameters studied included iron ore pellet size, silica content, binder type, flux blend, flux particle

size, and the use of solid fuels in the concentrate mix. Another IOCRC-sponsored study involved production of iron ore pellets with low-silica content. Magnetite concentrates produced from Minnesota taconite commonly carry 5% silica and 66.5% iron. Recent trends toward external desulfurization at steel mills and a move toward fluxed pellets have increased demand for pellets with lower silica content. The objective of this study was to develop information on costs of producing concentrates with 3% to 4% silica using conventional flotation, regrind, and magnetic concentration technology.

The IOCRC also sponsored a study by the Bureau of Mines at Minneapolis. It involved development of a computer digital image interpretation sensing system for on-line particle characterization. Mining and metallurgical processes require accurate size control for process stability, product quality, and productivity. To provide effective process adjustments such as crusher settings, water, binder, and feed adjustments in balling drums, and adjustment of blasting parameters, accurate and timely particle size feedback information is needed. Relationships between green ball size distribution and water and binder additions to the balling process were studied, and a visual size characterization technique for monitoring blasted ore and crusher discharge particle size was investigated.

The MGS contributions to the Minerals Diversification Plan included studies of Cuyuna Range manganese deposits in central Minnesota, kaolin resources in east-central and southwestern Minnesota, industrial uses for the limestone of southeastern Minnesota, and southwestern Minnesota's kimberlite rocks. Kimberlite rocks elsewhere in the world are occasionally diamond-bearing. Work continued on compiling an aeromagnetic map of the State that could provide new information on bedrock geology and structure and that could be used in mineral exploration. This study, done in cooperation with the U.S. Geological Survey (USGS), was scheduled for completion in 1991.

The MGS, NRRI, and USGS cosponsored a workshop on the applicability of gold and platinum-group-element ore deposit models to exploration in Minnesota.

Studies by the NRRI at the University of Minnesota at Duluth included evaluations of Minnesota's clays and shales to determine their respective firing characteristics. The study objective was to demonstrate potential applications for ceramics, brick and tile manufacturing, or lightweight aggregate. NRRI conducted geophysical tests at a test drilled project in Redwood County to evaluate gravity and magnetic and electrical resistivity methods in kaolin exploration. Platinum-group mineral occurrences in three copper-nickel deposits in northern Minnesota were studied to establish a preliminary mineralization model for use in exploration.

Research and education programs at the University of Minnesota's MRRC, Minneapolis, were legislatively mandated to promote the wise use of mineral resources. MRRC engaged in research related to development, improvement, and control of processes in the minerals, energy, and basic metals manufacturing and processing industries. Funding for MRRC activities was from the Legislative Commission on Minnesota Resources, the Minerals Diversification Plan, and pass through allotment grant funding from the Bureau of Mines under the Federal Mineral Institute Program.

MRRC was designated the Minnesota Mining and Mineral Resources Research Institute in the Federal Mineral Institute Program in 1978. The allotment grant funding of $435,527 was provided in fiscal year 1989 under provisions of Public Laws 98–409 and 100–483. Those funds were to be available to assist the Institute in coordinating and administering training and research in mining, mineral resources, mineral development, and mineral processing.

As the State's lead agency for the study of Minnesota clays, the MRRC worked with the MDNR, MGS, and NRRI to increase opportunities for commercial development of clays. MRRC studies toward this goal included clay processing research to remove coarse silica and paramagnetic impurities. If successful, this research could make the products useful for coatings in paper manufacturing.

MRRC continued work to develop a range of synthetic lightweight aggregates from sludge ash generated by sewage sludge incineration at the metro plant of the Metropolitan Waste Control Commission, St. Paul. Waste lime from the Minneapolis waterworks and fly ash from Northern States Power Co. plants were incorporated in various combinations with the sludge ash. By yearend, studies indicated some combinations have typical or superior characteristics to other commercial lightweight aggregates.

Studies of the Bureau of Mines Twin Cities Research Center in Minneapolis dovetailed with work underway in several areas by various members of the MCC and IOCRC. Research continued on samples of manganese-bearing rocks from Minnesota's Cuyuna Range. The laboratory leaching tests were begun to determine the feasibility of in situ leach mining methods for extracting manganese from low-grade ores.

Progress continued in a Bureau-IOCRC study of an oxygen-enriched commercial pelletizing system. Traditionally, in the grate-kiln system, only about 60% of the magnetite is oxidized on the grate, with the balance being oxidized in the cooler, resulting in the release of large quantities of heat during cooling. Successful application of oxygen enrichment early in the induration process could yield improved energy efficiency, greater pellet throughput, and pellets with improved physical and metallurgical properties.

The Bureau completed a study on the effectiveness of organic binders for iron ore pelletization in 1989. The study concluded that carboxyl methyl cellulose and a gelled starch binder offered superior metallurgical properties compared with traditional bentonite clay binders and most of the other 30 organic binders tested. Gelled starch binders were the most cost effective. Use of organic binders as substitutes for bentonite in agglomerating iron ore concentrate helps reduce silica content of the pellets.[4] Decreasing silica levels in the blast furnace burden results in lower slag volumes, lower coke consumption, and higher productivity.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

In 1989, shipments of iron ore from northern Minnesota's Mesabi Range increased slightly less than 1% to about 41 million metric tons (40 million long tons). The State produced 70% of the Nation's total usable iron ore in 1989.

Production was from six taconite operations and one natural ore mine in Itasca and St. Louis Counties. A seventh taconite operation, the former Reserve Mining Co. facility at Silver Bay, was renovated and expected to begin shipping pellets by early 1990. Value of shipped ore increased from about $1.1 billion to nearly $1.3 billion, a rise of slightly more than 13%. Shipments and value were at their highest levels since 1981 and 1985, respectively. Minnesota's six pellet producers operated at 91% of effective capacity.

According to the Lake Superior Industrial Bureau, Minnesota's taconite industry generated $943 million in economic activity in 1989. Included in the figure were payroll costs of $220 million, $650 million in goods and services purchased, and State and local taxes of $73 million.

Minnesota's iron ore producers mined taconite, a hard metasedimentary rock containing varying amounts of hematite and magnetite, from open pits in the Biwabik Iron Formation of Early Proterozic age. Taconite ore was drilled, blasted, and then loaded with large electric or diesel engine-powered shovels equipped with 12-cubic-yard (9-cubic-meter) buckets into large, 120- to 240-short-ton-capacity (109- to 221-metric-ton capacity) trucks or 90-short-ton-capacity (82-metric-ton-capacity) rail cars. The ore was transported to a mill for crushing to a fine, powdery material and treated in a flotation circuit to remove impurities such as silica and phosphorus. The resulting concentrate was mixed with a bentonite clay or organic binder and frequently a limestone or dolomite fluxstone. The material then was passed through a pelletizing system that formed iron ore pellets, spherical nodules less than 0.5 inch in diameter. These pellets, depending on customer requirements for silica content and presence or absence of fluxstone, were produced either as acid pellets, fluxed pellets, or partially fluxed pellets. According to the American Iron Ore Association, the average analyses for acid and fluxed pellets were:

TABLE 3

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)
1985	1,485	33,985	35,470	64.20	1,481	34,057	35,538	95.83
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

[1] Exclusive of ore/containing 5% or more manganese.
[2] Data may not add to totals shown because of independent rounding.

TABLE 4

SALIENT STATISTICS FOR PORTS SHIPPING MINNESOTA IRON ORE

Year, port, and dock	Date of first shipment	Date of last shipment	Number of shipments	Total shipments (gross tons)	Average shipment (gross tons)	Largest shipment (gross tons)
1988:						
Duluth, MN: DM&IR	Apr. 2	Dec. 24	239	6,918,963	28,950	57,760
Superior, WI: Burlington-Northern	Mar. 28	Jan. 9	314	11,996,794	38,206	58,810
Taconite Harbor, MN: LTV Steel	Apr. 1	Jan. 4	167	7,718,500	46,219	59,006
Two Harbors, MN: DM&IR	Mar. 24	Jan. 14	258	10,808,214	41,892	59,871
Total or average			978	37,442,471	38,285	59,871
1989:						
Duluth, MN: DM&IR	Apr. 1	Dec. 19	260	7,291,267	28,043	60,244
Superior, WI: Burlington-Northern	Mar. 25	Dec. 22	275	10,877,547	39,554	60,402
Taconite Harbor, MN: LTV Steel	Mar. 26	Dec. 19	177	8,086,808	45,688	60,483
Two Harbors, MN: DM&IR	Mar. 14	Dec. 25	217	9,352,595	43,100	60,193
Total or average			929	35,608,217	38,330	60,483

Source: Annual Reports of the Lake Carriers' Association, 1988 and 1989.

	Acid (percent)	Fluxed (percent)
Iron	64.46	61.36
Phosphorus	.01	.08
Silica	4.93	4.37
Manganese	.05	.54
Alumina	.24	.16
Moisture	1.83	2.12

Most of the State's production was transported by rail car to ore docks at Duluth, Superior, Taconite Harbor, or Two Harbors where it was loaded on ships for transport to various steel producers around the Great Lakes. Other shipments were made by rail to steel producers to a variety of U.S. destinations, including Bessemer, AL, East St. Louis, IL, Pittsburgh, PA, and Provo, UT.

The major development in the State's iron ore industry came in mid-June. Cyprus Minerals Co. of Denver, a newcomer to the iron ore industry, won purchase rights for the Reserve Mining Co. properties at Babbitt and Silver Bay at a bankruptcy auction in New York City. Cyprus was a major worldwide producer of base and precious metals and industrial minerals. The purchase agreement was finalized in late August, and operations under the name of Cyprus Northshore Mining Corp. formally began on December 27 at the Babbitt taconite mine. The event was celebrated with a formal dedication ceremony attended by company and government officials, including the Governor. Crushed ore was expected to begin arriving at the Silver Bay pelletizing plant by early January 1990. Cyprus bid $52 million, $2 million less than Pickands Mather & Co., a Cleveland-Cliffs Inc. subsidiary. A Federal bankruptcy judge ruled in favor of Cyprus because of demonstrated support by Reserve's creditors and the State of Minnesota. The Cyprus bid, unlike that of its competitor, guaranteed $45 million to Reserve's secured bondholders. Additionally, Cliffs would not agree to liability for the operation's Mile Post 7 tailings disposal site under the State's environmental laws. Instead, its subsidiary would have assumed this responsibility. The State of Minnesota assumed ownership of the tailings disposal delta, but Cyprus agreed to provide basic maintenance for at least 5 years. Additionally, Armco Inc., a former co-owner of Reserve, agreed to buy 1.5 million long tons (1.5 MMmt) of pellets annually for 7 years from Cyprus.

Reserve was jointly owned by LTV Steel Co., a subsidiary of LTV Corp. and Armco Inc. In July 1986, LTV Corp., then the Nation's second largest steel producer, filed for reorganization under Chapter 11 of the Federal Bankruptcy Code. In late July, Reserve announced an indefinite shutdown. In early August 1986, Armco's subsidiary, First Taconite Corp., part owner of the Reserve operation, also filed for Chapter 11 bankruptcy. Reserve's fate was then sealed as the operation became a charge of the bankruptcy court.[5]

The United Steel Workers of America attempted to unionize Cyprus employees, but at yearend Cyprus remained the Nation's only nonunion iron ore mining and processing operation. This was an anomaly for Minnesota where most large labor forces traditionally have been strong labor union supporters, especially in the iron ore industry. Additional attempts to unionize the employees were expected for 1990. Cyprus employees supported the company's job cross-training system. Cyprus has demonstrated at its other domestic mining operations that the system increases productivity by encouraging employees to learn multiple jobs. The expanded experience has offered workers opportunities to step up to higher wage rates. This contrasted with the usual rigid job classification system generally featured in union contracts. Wages offered were reported by the company to be between $12.70 and $16.00 per hour, plus benefits, comparable to other Minnesota iron ore producers.[6] Employees also participated in a profit-sharing plan. In early June, Cyprus began accepting employment applications for up to 350 positions, down from the 750 jobs Reserve provided before shutting down in July 1986. More than 90% of those hired were former Reserve employees.

In August, Cyprus began a $29.9 million rehabilitation of the Reserve operations. Work included restoring and replacing equipment at the Babbitt Mine. The 47-mile railroad between the mine and the Silver Bay plant also was readied for operation. New equipment purchases or leasing arrangements were necessary because part of the mine and plant equipment had been sold by the bankruptcy trustee to meet expenses. A large expense, however, was in retrofitting the pelletizing plant furnaces with a new hearth layer system. This was the first time this type of retrofit had been done in the iron ore industry. The Reserve plant had been the only domestic pelletizing facility without the hearth layer system. A change in the pellet binder system and associated materials handling equipment will make possible production of a pellet using limestone and an organic binder instead of bentonite. Pellets were expected to have a dry analysis of about 65% iron, 5% silica, and 1% lime. By 1991, production was expected to be fully fluxed pellets.

Crude taconite mine production for 1990 was expected to be 6 million long tons (6.1 MMmt), averaging 25.3% magnetic iron. Taconite pellet production for 1990 was anticipated to be about 2 million long tons (2 MMmt) or 48% of plant capacity. The annual pellet capacity of 4.2 million long tons (4.3 MMmt) was expected to be reached by 1992. The Babbitt Mine had company-estimated ore reserves sufficient for 35 to 40 years of operation. The company also will benefit from a 12- to 14-year supply of prestripped ore left by Reserve.[7]

The USX Corp. reported its Minnesota Ore Operations Minntac plant at Mountain Iron had production of 13.7 million short tons (12.4 MMmt) of fluxed and acid pellets in 1989. Minntac maintained its position as the largest domestic iron ore pellet producer. Fluxed pellet production was 11.1 million short tons (10.1 MMmt), and acid pellet output was 2.6 million short tons (2.4 MMmt).[8] Total pellet production increased about 2%. Minntac completed its first full year of fluxed pellet production in July 1989. Fluxed pellet production began in July 1988. In 1989, the Minntac mining area provided crude ore to attain an annual pellet production capacity of 14.0 million long tons (14.2 MMmt) of acid pellets and slightly less than this for fluxed pellets. Fluxed pellets produced at Minntac were reported to have an average dry analysis of 63.8% iron and 4% silica; acid pellets carried 65.5% iron and 5.4% silica.[9]

In August, pellet production from the No. 3 pelletizing line was resumed. It had been shut down in June 1982, along with many other pelletizing lines on Minnesota's iron range, because of

a severe economic recession. The No. 3 line startup added 2 million long tons (2 MMmt) of annual fluxed pellet production to Minntac's operations. In 1989, Minntac had five of its seven pelletizing lines in operation. All 16 concentrator lines were in service. Fourteen of these lines were used to process taconite; one was used to process limestone and dolomite into fluxstone and the other to regrind flotation concentrate.

By yearend, Minntac had on order, or had received, 12 new 170-short-ton-capacity (154-metric-ton-capacity) ore haulage trucks to replace old or smaller equipment.

Finished pellets were hauled by rail about 75 miles to the Two Harbors loading terminal. Pellets were then directly loaded onto ore carriers or stored for later transport to lower Great Lakes ports. Pellet shipments were made to the steelworks of USX at Gary, IN, and Pittsburgh (Mon Valley), PA; USS/Kobe Steel Ltd. at Lorain, OH; and Weirton Steel Corp. at Weirton, WV. All-rail shipments also were made to the Geneva Steel works in Utah, a distance of about 1,650 miles.

Hibbing Taconite Co. (Hibtac) produced 8.2 million long tons[10] (8.3 MMmt) of iron ore pellets in 1989, a decrease of about 6% from the record output of 8.7 million long tons (8.8 MMmt) in 1988.[11] Hibtac was jointly owned by Bethlehem Steel Corp. (70.3%), Cleveland-Cliffs (15%), and Stelco (14.7%). The operations were managed by Pickands Mather, a wholly owned subsidiary of Cleveland-Cliffs. The operation employed 846 people in 1989, up nearly 5% over the 1988 employment figure.

The Hibtac Mine and processing plant, about 4 miles north of Hibbing, had an annual capacity of about 9.0 million long tons (9.1 MMmt) of acid pellets. The plant began operating in August 1976. In 1989, it operated nine circuits to grind the magnetite ore and three pelletizing lines. After installation of triple deck fine screens in the concentrator, the dry analysis of Hibtac's pellets was about 66.3% iron and 4.5% silica. Previously, iron content had been 66.1% and silica, 4.8%.

Hibtac also began all-rail shipment of part of its pellet production to the USX Fairfield steel plant at Bessemer, AL. Shipping began in early February in 120-car unit trains, with about 11,000 long tons (11,200 metric tons—mt) per 1,390-mile trip. In 1989, total Hibtac pellet shipments were about 8.1 million long tons (8.2 MMmt), about 5% of which was railed to Alabama. Most of the production was transported by rail, about 100 miles, to the Allouez ore docks at Superior, WI, for transport on ore carriers to other Great Lakes ports. In May, Hibtac commissioned a precision loading system to provide exact weights and automated railcar loading. The new system became necessary because of the increasing all-rail shipments and the frequent use of different railcar sizes, other than those with 90-long-ton (91-mt) load capacity. Also in May, a 240-short-ton-capacity (218-mt-capacity) haulage truck was added to the fleet of mine production equipment. In December, overburden stripping was begun at the new Mahoning Group 4 Pit, formerly a part of a natural iron ore mine last mined by Pickands Mather in 1970. Mine production was expected to begin in the late summer of 1990. Hibtac mines were reported to have enough ore reserves to sustain operations until the year 2022.[12]

In 1989, LTV Steel Mining Co. continued operations at its Hoyt Lakes Mines and pellet plant under the management of Pickands Mather. LTV is a wholly owned subsidiary of LTV Steel Co., which is a wholly owned subsidiary of LTV Corp. The operation has an annual effective capacity of 8.0 million long tons (8.1 MMmt) of standard iron ore acid pellets produced from an ore that grades about 23% magnetic iron. Pellet production in 1989 was about 7.6 million long tons[13] (7.7 MMmt), a 6% decline from the 8.1 million long tons (8.2 MMmt) produced in 1988.[14] The 1988 production had been the highest since 1981. A partial reason for the decline in 1989 was a 2-week production halt in November because of lower pellet demand at LTV steel mills and a large inventory of pellets. Ore reserves at the Hoyt Lakes Mines were reported by Cliffs[15] to be sufficient until the year 2034. In 1989, the Hoyt Lakes operations employed 1,529 people, down nearly 3% from that of 1988.

About 60,000 long tons (61,000 mt) of taconite was mined daily at four Hoyt Lakes pits. In May, a new truck-train computerized dispatch system was commissioned. This system, a first for North American producers, would improve the productivity of mining and rail transportation. Productivity of drilling operations also would benefit from the computerized system.

Improvements in ore beneficiation also were made in 1989. The plantwide flotation circuit installed in 1987 was upgraded from four lines to five. This addition enabled processing of ore with higher silica content. The cationic flotation system, combined with the partial use of organic binders instead of all bentonite, reduced pellet silica content to 5%. Iron content for the finished acid pellets was about 65.6%, on a dry basis. Daily pellet production averaged 21,000 long tons (21,000 mt). Pellets were hauled by rail about 75 miles to the port of Taconite Harbor, then loaded on ore carriers bound for the Lorain, OH, terminal.

National Steel Pellet Co. reached a 10-year high in pellet production at nearly 4.7 million long tons (4.8 MMmt), 4% more than in 1988. National operated its 630-employee taconite mining operation and pelletizing plant at Keewatin. On January 1, in an effort to cut costs, National assumed management of the operations from M. A. Hanna Co., who had been the operator under a contract. Hanna held a 15% interest in the Keewatin operations up until the 1982 recession precipitated Hanna's selling its equity to National. In 1982, National became a wholly owned subsidiary of National Steel Corp., which was owned in equal shares by National Intergroup Inc. and NKK Corp. (formerly known as Nippon Kokan K.K.). Hanna's departure from Keewatin marked the end of the company's 103-year affiliation with the domestic iron ore industry. It has since made heavy investments in the rubber and plastic polymers industries. In the early 1950's, Hanna had been one of Minnesota's largest iron ore producers, owning or operating 27 mines on the Mesabi and Cuyuna Iron Ranges. It had been the Keewatin facility's operator since the project's inception in November 1964.

Acid pellets produced at Keewatin had a dry analysis of 65.9% iron and 5% silica. Annual pellet production capacity had been rated at 4.7 million long tons (4.8 MMmt), and the concentrator at 5.8 million long tons[16] (5.9

MINNESOTA

LEGEND

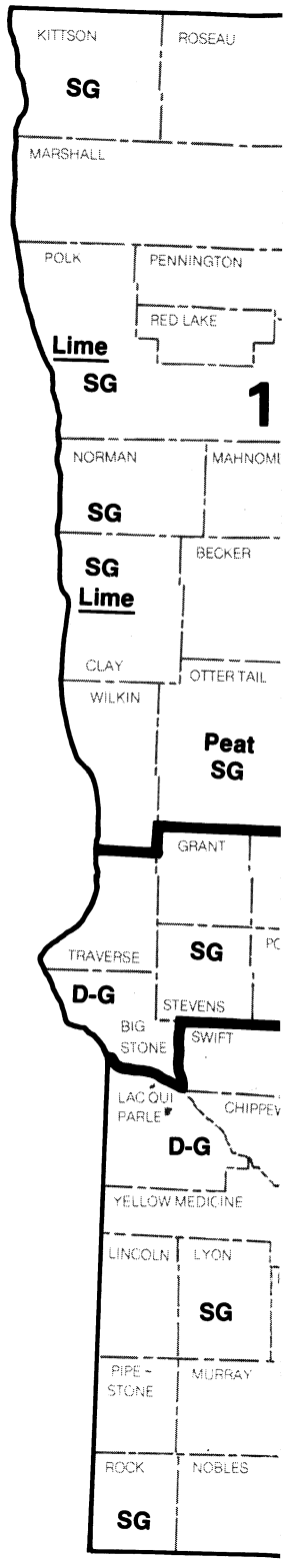
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

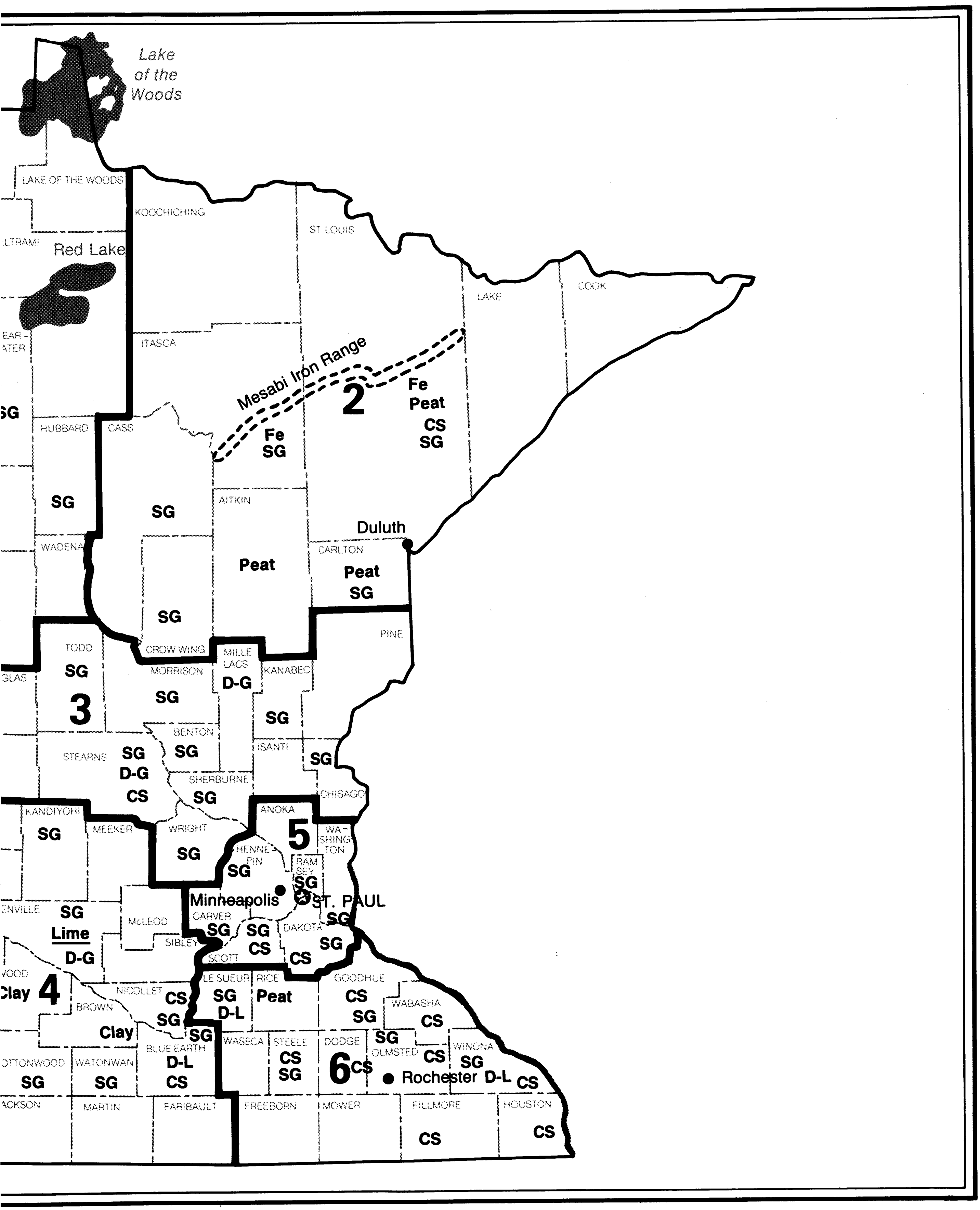
MINERAL SYMBOLS

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





Lake of the Woods
LAKE OF THE WOODS
KOOCHICHING
ST LOUIS
Red Lake
LAKE
COOK
ITASCA
Mesabi Iron Range
2
Fe
Peat
CS
SG
Fe
SG
HUBBARD
CASS
SG
SG
AITKIN
Duluth
WADENA
CARLTON
Peat
Peat
SG
SG
PINE
TODD
CROW WING
MILLE LACS
SG
MORRISON
D-G
KANABEC
3
SG
SG
BENTON
STEARNS
SG
SG
D-G
ISANTI
SG
CS
SHERBURNE
SG
CHISAGO
KANDIYOHI
ANOKA
SG
MEEKER
WRIGHT
5
WASHINGTON
HENNEPIN
SG
SG
RAMSEY
SG
Minneapolis
ST. PAUL
SG
SG
CARVER
Lime
McLEOD
SG
SG
DAKOTA
D-G
SIBLEY
CS
SG
SCOTT
CS
4
NICOLLET
CS
LE SUEUR
RICE
GOODHUE
SG
Peat
CS
BROWN
SG
D-L
SG
WABASHA
CS
Clay
SG
SG
WASECA
STEELE
DODGE
BLUE EARTH
OLMSTED
CS
WINONA
WATONWAN
D-L
CS
SG
CS
6
CS
SG
SG
SG
CS
Rochester
D-L
CS
MARTIN
FARIBAULT
FREEBORN
MOWER
FILLMORE
HOUSTON
CS
CS

MMmt). In April, the operation was shut down for 3 weeks for routine maintenance. National rail transported most of its pellets about 80 miles to the Allouez terminal at Superior, WI. Pellets were then transported by Great Lakes carriers to the Great Lakes Steel Div. at Detroit. All-rail shipments were made to National's Granite City Steel Div. at East St. Louis, IL, a distance of 840 miles from Keewatin.

In 1989, Eveleth Mines, managed by Oglebay Norton Co., produced about 4.9 million long tons (5.0 MMmt) of iron ore pellets, the highest since 1981 when about 5.9 million long tons (6.0 MMmt) were produced.[17] Eveleth Mines consists of two companies, Eveleth Taconite Co. and Eveleth Expansion Co. Eveleth Taconite is owned by Rouge Steel Co. (85%) and Oglebay (15%). In December, Ford Motor Co. sold Rouge, its wholly owned subsidiary, to Marico Acquisition Corp. for an undisclosed price. Eveleth Expansion was owned by Virginia Horn Taconite Co., a wholly owned subsidiary of Armco (56%), Stelco Inc. (23.5%), and Oglebay (20.5%). Eveleth employed about 750 salaried and hourly employees in 1989.

Eveleth produced pellets averaging about 65% iron, 5% silica, and 0.8% lime on a wet basis. Production capacity for its two pelletizing lines was about 6.0 million long tons (6.1 MMmt). In April, the No. 1 pelletizing line resumed operation; it had been reactivated in 1988 for about a 4-month period after being idled in 1982. Mining at the Spruce Hill Pit, west of Eveleth, completed its first full year after production commenced in November 1988. Preproduction mine stripping began in 1986. Ore from the Spruce Hill and the nearby Thunderbird North and South Mines was hauled to the Fairlane crushing and pelletizing plant at Forbes. In 1989, the ore screening system was replaced with state-of-the-art equipment to improve output, reduce maintenance costs, and improve pellet quality. Daily pellet production averaged about 16,200 long tons (16,500 mt). Finished pellets were railed to ore docks at Duluth. In January, all-rail shipments were begun to the USX Corp. Fairfield steelworks at Bessemer, AL, about 1,355 miles away. Weekly rail shipments to Alabama consisted of three-unit trains, each hauling about 12,000 long tons (12,200 mt).

In October, Eveleth Mines and Minnesota Power agreed on a new electric power contract, good through May 1996. The contract will allow Eveleth Mines to run its two pelletizing lines at full capacity in 1990 and 1991, if needed. Under the agreement, power rates would be frozen, with savings to be expended on installation of a heat-recuperation system on the No. 1 pelletizing line. The renovation would help lower production costs and increase the plant's energy efficiency.

The Minorca Mine and pelletizing plant at Virginia posted a record-high production of 2.5 million long tons (2.5 MMmt) of fluxed pellets.[18] This was an increase of about 2% compared with 1988 production and about equaled the plant's rated annual capacity. The operation was managed by Inland Steel Mining Co., a wholly owned subsidiary of Inland Steel Co., which is a wholly owned subsidiary of Inland Steel Industries Inc. Minorca pellets had a dry analysis of 61.5% iron and 4.2% silica.[19] Pellets were railed 38 miles to the Duluth terminal, then loaded on ore carriers for transport to Inland's steelworks at Indiana Harbor, IN. About 320 people were employed at Minorca.

In July, Inland announced that it had acquired a lease from fee holders of the Biwabik West taconite reserve, 6 miles southeast of its Minorca Mine and near Gilbert. Inland reported intentions to spend $20 million toward mining the deposit. This would be the State's first new iron ore mine in 10 years. At yearend, an environmental review was in progress. An April 1991 mine production startup was targeted. Taconite produced at the Laurentian Mine, as it would be called, would be phased in gradually to make up for rapidly dwindling ore reserves at the Minorca pit. Minorca ore reserves have been widely reported to be sufficient until 1992 or as late as 1996, depending on production rates. Minable reserves at the Laurentian were reported to be 285 million long tons (290 MMmt) of crude ore, or enough to support a 40-year mine life.[20] Laurentian Mine ore will be trucked to the Minorca pelletizing plant via a company-constructed, controlled-access haulage road. Inland, in deciding to mine the Biwabik West reserves, suspended considerations to mine the Ordean Reserve, west of the Minorca Mine, and the East Rouchleau pit, near Virginia.

In early February, a warehouse fire at the Minorca Mine destroyed about $5 million in spare mining equipment. The warehouse and equipment, including mining machinery, motors, pumps, and other items, were a total loss. There were no injuries, even though the fire was battled in -37° F temperatures.

The LTV Steel Co., Northwest Ore Div., produced natural iron ore from its McKinley Extension operation, north of Aurora. Ore reserves are expected to be depleted at the McKinley by 1992. It has been one of three North American natural ore operations still active. Others are in Utah (Geneva Steel Co.) and Ontario (Algoma Steel Corp. Ltd.). The McKinley ore was crushed mostly to -⅜-inch size and used as sinter feed for LTV's Indiana Harbor Steel Works. The sinter feed averaged 59.5% iron and 7% silica. The mine provided jobs for 95 people in 1989.

Industrial Minerals

About 11% of Minnesota's total nonfuel mineral value was attributed to the production of eight industrial minerals. Six of these were used largely in building or road construction. Peat was used mostly in horticultural products, and semiprecious gem stones were collected mainly by hobbyists. In 1989, the value of industrial minerals produced in the State increased about 14% to about $152 million, compared with $133 million in 1988.

Clays.—In 1989, clay production decreased about 3%, but value increased about 3%. There were two producers in southern Minnesota. Ochs Brick & Tile Co. produced kaolin clay in Redwood County and common clay in Brown County. Both clay types were used by Ochs for manufacturing bricks at its Springfield plant. The plant has been producing about 30 million red bricks annually. Sales prices ranged from $265 to $525 per thousand. Ochs provided employment for about 55 people. It remained the State's last brick operation out of a group of about 70 at the turn of the century. Most of its products were sold in the Upper Midwest and have been since 1891.

Northwestern States Portland Cement Co. produced low-grade kaolin clay from a pit in Redwood County for use in manufacturing cement at its Mason City, IA, plant. In late December, Northwestern was sold to Dundee Cement Co. of Michigan, pending stockholder approval, which was expected at a meeting to be held in January 1990. Dundee is a subsidiary of Holderbank Financiere Glaris Ltd., a publicly held Swiss corporation.

Two companies received permits to mine clay. Nova Natural Resources Corp. of Salt Lake City, UT, received a permit to mine 9.3 acres adjacent to the Northwestern operation. In Brown County, Northern Con-Agg Inc. of Maple Grove received a permit to mine 70 acres.

In addition to the previously discussed State government-funded research on kaolin in the Minnesota River Valley, deposits also were explored by drilling. Hecla Mining Co., a Coeur d' Alene, ID, firm, drilled areas on private property. Hecla had been active in the area since 1988. Other companies reported to have conducted various forms of exploration included: ECC America Inc., Georgia Kaolin Corp. Inc., and J. M. Huber Corp. Although specific exploration results have not been made available, some industry sources reported that preliminary results indicated the bluish-white clay generally had too much silica to be suitable for use in paper coating, a major application for kaolin clay. However, there could be exceptions, and other uses could be made for lesser quality ball clay used in ceramics.

The Minnesota River Valley Kaolin Coalition continued to promote kaolin exploration and development. The coalition was formed in 1988 with representatives from eight south-central Minnesota communities. In late October, its members participated in State legislature minerals task force public hearings. The hearings sought ideas on diversifying the State's minerals production. Coalition members suggested creation of a drill-core library to store mineral samples, including kaolin, collected from public and private lands. The MDNR already maintains such a facility in Hibbing, but kaolin samples have not been a significant part of the collection. Another suggestion was for the State to coordinate a list of mineral leases at each county recorder's office, thereby facilitating searches for potential clay resources. This information had been readily available from the MDNR, with the exception of severed mineral interests, acquired through real estate tax forfeiture. The MDNR was studying the severed mineral ownership problems at yearend.

Lime.—Lime production dropped about 4%, reversing the recorded high posted in 1988. Value of production, however, increased nearly 20%. All production was used in processing sugar beets. American Crystal Sugar Co. operated three plants; one in Clay County and two in Polk County. Southern Minnesota Sugar Co-op. operated a plant in Renville County. Quicklime and hydrated lime were produced from limestone shipped from out-of-State sources. Lime consumed within the State from all domestic sources was about 301,000 short tons, a drop of 7% from the 324,000 short tons reported in 1988.

Peat.—Minnesota ranked seventh of 21 peat-producing States in 1989. Quantity of peat produced was down 7%, the second consecutive year of decline. Value of production, however, remained virtually unchanged at about $1.4 million. Peat was produced in six counties by seven producers. Carlton County, with two producers, led in production. Other producing counties were Aitkin, Hennepin, Isanti, Otter Tail, and St. Louis. All of the production was used in horticultural activities. Leading end uses, in declining order of output, were general soil improvement, potting soil ingredient, and nursery. About 58% of the sales were in packaged form. Varieties and relative percent of total production were sphagnum, 61%; reed-sedge, 25%; and hypnum, 14%.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Minnesota ranked seventh of all States in construction sand and gravel production. Following iron ore, this was the second leading mineral commodity produced in the State in terms of value. Although quantity produced in 1989 was estimated to have remained at the 1988 level, value was estimated to have increased 14%.

Industrial.—Industrial sand production and value increased 22% and 25%, respectively. Industrial sand was mined from the Jordan Sandstone of Upper Cambrian age in three counties by two companies. Unimin Corp. operated in Le Sueur and Scott Counties, and Twin City Silica Ltd. operated in Washington County. The greatest amount was used in hydraulic fracturing, followed by glass container manufacturing, sand blasting, and foundry molding and core.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Production and value increased 6% and 7%, respectively. Minnesota crushed stone statistics are compiled by geographical districts as depicted in the State map. Table 6 presents end-use statistics for Minnesota's six districts.

Dimension.—The quantity of dimension stone produced in 1989 was relatively unchanged from the 1988 estimate. Value, however, increased 23%. Five producers operated 11 quarries. Granite was quarried by Cold Spring Granite Co. and Field Financial Inc. Limestone was quarried by Biesanz Stone Co. Inc., Minnesota Quarries Inc., and Vetter Stone Co. Quarried rock most frequently was used as cut veneer stone, followed by sawed blocks, dressed monumental stone, and rough blocks. Cut veneer stone, with a unit value of $291 per short ton, accounted for 63% of the total stone value. Sawed blocks provided 30% of the total stone value and had a unit value of $832 per short ton. The sawed stone block unit value was the highest of all stone types produced in Minnesota and irregular-shaped stone was the lowest at $87 per short ton.

Other Industrial Minerals.—Gem stones and mineral specimens were estimated to have contributed $42 thou-

TABLE 5

MINNESOTA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	71	361
Filter stone	154	521
Coarse aggregate, graded:		
Concrete aggregate, coarse	467	1,897
Bituminous aggregate, coarse	159	470
Fine aggregate (−3/8 inch):		
Stone sand, bituminous mix or seal	281	923
Screening, undesignated	100	497
Coarse and fine aggregates:		
Graded road base or subbase	2,244	7,238
Unpaved road surfacing	430	1,288
Other construction materials[2]	1,202	5,268
Agricultural: Agricultural limestone	221	780
Other miscellaneous uses[3]	237	1,358
Unspecified:[4]		
Actual	2,490	8,197
Estimated	704	1,420
Total	8,760	30,218

[1] Includes limestone, dolomite, granite, traprock, and miscellaneous stone.
[2] Includes stone used in macadam, other coarse aggregate, bituminous surface-treatment aggregate, railroad ballast, terrazzo and exposed aggregate, and crusher run or fill or waste.
[3] Includes stone used in cement manufacture and other fillers or extenders.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.

sand to the total State nonfuel mineral value, an increase of 5% over that of 1988. Perlite from out-of-State sources was expanded by USG Interiors Inc. at its plant in Cloquet. Steel slag production and value posted steep declines for the second consecutive year. Sulfur was recovered by two petroleum refineries, one each in Dakota and Washington Counties. Quantity sold or used and value of sulfur increased 2% and 7%, respectively. The W. R. Grace & Co. vermiculite operation in Minneapolis was inactive in 1989.

[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN. Assistance in the preparation of the chapter was given by Wanda J. West, editorial assistant.

[2] Highway and Heavy Construction. Market Update: Battle Lines Form Over Gridlock, Gas Tax. V. 132, No. 3, Mar. 1989, p. 34.

[3] Minnesota Dept. of Jobs and Training, Research and Statistics Office. Employment, Hours, and Earnings, 1980–1989. May 1990, 37 pp.

[4] Haas, L. A., J. A. Aldinger, and R. K. Zahl. Effectiveness of Organic Binders for Iron Ore Pelletization. BuMines RI 9230, 1989, 21 pp.

[5] Hill, J. J. Minnesota. Ch. in BuMines Minerals Yearbook 1986, v. 2. pp. 255–266.

[6] American Metals Market. Court to Consider Bids on Reserve Mining Units. V. 97, No. 109, June 6, 1989, pp. 2 and 16.

[7] Mesabi Daily News. Blast Opens New Era for Babbitt, Cyprus. Dec. 28, 1989, pp. 1 and 10.

[8] USX Corp. (Pittsburgh, PA). 1989 Annual 10K Report. 70 pp.

[9] Skillings' Mining Review. North American Iron Ore Production in 1990 Expected To Decline Only Slightly From 10-Year Peak Reached in 1989. V. 79, No. 30, July 28, 1990, pp. 14–30.

[10] Cleveland-Cliffs Inc. (Cleveland, OH). 1989 Company Annual Report to Stockholders. 42 pp.

[11] ———. 1988 Company Annual Report to Stockholders. 37 pp.

[12] Work cited in footnote 10.

[13] Work cited in footnote 10.

[14] Work cited in footnote 11.

[15] Work cited in footnote 10.

[16] Work cited in footnote 9.

[17] Skillings' Mining Review. North American Iron Ore Industry To Approach 100 Million Gross Ton Production Mark in 1989. V. 78, No. 30, July 29, 1989, pp. 14–28.

[18] Inland Steel Industries Inc. (Chicago, IL). 1989 Annual Report to Stockholders. P. 7.

[19] Work cited in footnote 9.

[20] Minnesota Department of Natural Resources, Office of Planning Services. Laurentian Taconite Mine Scoping Environmental Assessment Worksheet and Draft Scoping Decision. Aug. 1989, p. 4. Available upon request from L. E. Esparza, BuMines, Minneapolis, MN.

TABLE 6

MINNESOTA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	—	—	W	W	W	W
Coarse aggregate, graded[2]	—	—	W	W	W	W
Fine aggregate (−3/8 inch)[3]	—	—	W	W	W	W
Coarse and fine aggregates[4]	—	—	W	W	W	W
Other construction aggregates	—	—	—	—	W	W
Agricultural[5]	—	—	—	—	—	—
Chemical and metallurgical[6]	—	—	—	—	—	—
Special[7]	—	—	—	—	—	—
Other miscellaneous	—	—	—	—	—	—
Unspecified:						
Actual[8]	—	—	—	—	—	—
Estimated[9]	—	—	—	—	W	W
Total[10]	—	—	W	W	W	W

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	W	W	231	927	6	18
Coarse aggregate, graded[2]	W	W	354	1,188	78	([11])
Fine aggregate (−3/8 inch)[3]	W	W	127	566	—	—
Coarse and fine aggregates[4]	W	W	2,049	6,767	316	882
Other construction aggregates	—	—	86	447	207	749
Agricultural[5]	W	W	89	244	107	436
Chemical and metallurgical[6]	—	—	—	—	([12])	([12])
Special[7]	—	—	([12])	([12])	—	—
Other miscellaneous	—	—	157	998	80	360
Unspecified:						
Actual[8]	—	—	1,395	4,393	1,095	3,804
Estimated[9]	—	—	12	45	320	817
Total[10]	W	W	4,501	15,576	2,208	7,066

W Withheld to avoid disclosing company proprietary data.
[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 (bituminous mix or seal) and fine aggregate (screening-undesignated).
[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run or fill or waste.
[5] Includes agricultural limestone.
[6] Includes crushed stone for cement manufacture,
[7] Includes crushed stone for other fillers or extenders.
[8] Includes production reported without a breakdown by end use.
[9] Includes estimates for nonrespondents.
[10] Data may not add to totals shown because of independent rounding.
[11] Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[12] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."

TABLE 7

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.	Silver Bay, MN 55614	Mine and primary crusher	St. Louis.
Do.	do.	Concentrator and agglomerator	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.	do.	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.
Michigan Peat Co.	Box 980129 Houston, TX 77098	do.	Carlton.
Minnesota Sphagnum Inc.	Box 58 Goodhart, MI 49737	do.	St. Louis.
Peatrex Ltd.	10162 93d Ave. North Maple Grove, MN 55369	do.	Carlton.
Quostar Products Inc.	Route 1, Box 669 Ogilvie, MN 56358	do.	Isanti.
Perlite (expanded):			
USG Interiors Inc., a subsidiary of USG Corp.	Arch St. Cloquet, MN 55720	Plant	Carlton.
Sand and gravel:			
Construction (1988):			
Bauerly Brothers Inc.	Route 2 Sauk Rapids, MN 56379	Pits and plants	Benton.
Fairway Construction Co.	Box 426 Hector, MN 55342	do.	Meeker and Renville.
Fisher Construction Co. Inc.	6801 West 150th St. Apple Valley, MN 55124	do.	Dakota.
Northwestern Aggregates, Model Stone	400 West 61st St. Minneapolis, MN 55419	Pit and plant	Do.
J. L. Shiely Co.	1101 North Snelling Ave. St. Paul, MN 55108	Pits and plants	Dakota and Washington.
Thorson Inc.	Box 40 Bemidji, MN 56601	do.	Beltrami and Polk.

TABLE 7—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued			
Construction (1988)—Continued			
Tri-City Paving Co.	Box 326 Little Falls, MN 56345	Pits and plants	Morrison.
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.
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):			
Arrowhead Blacktop Co.	Box 6568 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.
Field Financial Inc.	3434 Heritage Dr. Edina, MN 55435	Quarry and plant	Lac Qui Parle.
Limestone:			
Biesanz Stone Co. Inc.	Box 768 Winona, MN 55987	do.	Winona.
Minnesota Quarries Inc.	Box 1358 Mankato, MN 56002	do.	Blue Earth.
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 Bureau of Mines, U.S. Department of the Interior, and the Bureau of Geology and Energy Resources, Mississippi Department of Natural Resources, for collecting information on all nonfuel minerals.

By Doss H. White, Jr.[1] and S. Cragin Knox[2]

Mississippi's nonfuel mineral production was valued at $107.6 million in 1989, according to information reported by the State's mineral producers to the Bureau of Mines, U.S. Department of the Interior. This was an increase of $4.2 million over that reported in 1988. The higher value was due to increased production of sand and gravel, which more than compensated for a significant decrease in crushed stone. The State ranked 42d nationally in total mineral value.

The State's extractive mineral output was used principally by the construction industry. Construction sand and gravel accounted for almost 50% of Mississippi's mineral value, clays accounted for about 22%, and stone for 4%. Much of the remaining 24% was cement value; cement was also a basic raw material for the construction industry. In 1989, the value of residential and commercial building permits increased from $322 million to $423 million, reflecting the health of the State's construction industry and the underlying demand for construction mineral commodities.

TRENDS AND DEVELOPMENTS

During the past 10 years, Mississippi's mineral value varied from a low of $72.7 million during the recession of the early 1980's to a record high of $110.1 in 1987. The average for the 10-year period was $98 million per year. The State's high-tonnage mineral commodities, sand and gravel, stone, and clay, are low-unit value items whose market areas are limited by transportation costs. These commodities have traditional markets and, with current economic conditions, it is doubtful that demand will increase significantly above the current level.

During 1989, two of the common clay producers in eastern Mississippi planned to open new mines, and a Columbus sodium chlorate producer announced expansion plans that would make the company the world's largest.

LEGISLATION AND GOVERNMENT PROGRAMS

No bills were passed by the 1989 session of the Mississippi legislature that directly impacted the State's mineral industry. A member of the State Commission on Environmental Quality, however, called for changes in the mining law to help protect the environment.

The Mississippi Bureau of Geology, an agency within the Department of Environmental Quality, consisted of four sections: (1) Surface Geology, (2) Subsurface Geology, (3) Environmental Geology, and (4) Mining and Reclamation. The Bureau was also the parent organization for the Mineral Lease Division.

The Surface Section published a bulletin on the geology of Tishomingo County, including mineral resources. Field work began on mapping the Naheola Formation and Lower Wilcox units, which contain kaolinitic clays and lignite. Bentonite radiometric dating was ongoing.

TABLE 1

NONFUEL MINERAL PRODUCTION IN MISSISSIPPI[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	short tons	838,826	$13,044	1,093,316	$24,564	899,373	$23,573
Gem stones		NA	1	NA	1	NA	5
Sand and gravel (construction)	thousand short tons	e14,700	e47,000	13,314	38,806	e15,600	e51,500
Stone (crushed)	do.	1,492	9,621	e1,500	e9,000	1,069	3,994
Combined value of cement (masonry, portland), clays (ball clay, fuller's earth, 1987), and sand and gravel (industrial)		XX	40,413	XX	31,029	XX	28,539
Total		XX	110,079	XX	103,400	XX	107,611

e Estimated. 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.

The Environmental Geology Section provided technical expertise and ground water data to industry, the public, and other government agencies. The Subsurface Section continued to collect and provide subsurface data to academia, the oil and gas industry, and the public. Mineral potential study support was provided to the Mineral Lease Division for State-owned land evaluation. The section also published a report on coalbed methane resources in Clay County.

The Mining and Reclamation Section inspected approximately 600 mine sites. Twenty-six mining permits were issued covering 737 acres; bond release was granted for the initial reclamation of 420 acres and final reclamation of 754 acres. Section personnel were revising the State coal mining regulations for compliance with the U.S. Office of Surface Mining.

The Mineral Lease Division oversaw the drilling of four wells on State-owned land and the initiation of the first deep offshore well on State lands in the Mississippi Sound area. Division personnel worked with the U.S. Minerals Management Service on several geologic studies on offshore lands.

The Mississippi Mineral Resources Institute (MMRI) at the University of Mississippi was funded $564,000 by the Bureau of Mines. During the fiscal year, several mineral-related studies by Mississippi Universities were funded by MMRI. Included were the composition of Mississippi commercial clay deposits, the mineral resource potential of the Jackson dome, crude oil production data base and decline curve analysis, boron minerals associated with subsurface evaporites, and authigentic clay mineral distribution in the lower Tuscaloosa Formation.

Other MMRI funded projects during 1989 included a heavy mineral sampling program in Senegal, placer drilling tests near Cape Prince of Wales, Alaska, and exploration for gravel in the Mississippi and Yazoo Rivers.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Mississippi's mineral industry mined or manufactured seven industrial minerals. Historically, the construction industry has been the largest user of the State's mineral output.

Cement.—United Cement Co. operated a portland cement plant at Artesia in Lowndes County. The plant was designed to use the wet process in clinker manufacture. Cretaceous chalk mined in-county was blended with a local sand and mill scale obtained from Alabama. The blend was slurried into a 14- by 500-foot, coal-fired kiln. The resulting clinker was ground, after adding gypsum imported from Spain, to produce grey portland cement that was marketed throughout a nine-State area.

Output and value declined about 65,000 short tons and $2.5 million. Cement sales were reported in the following categories: ready-mix companies (59%), highway and miscellaneous contractors (20%), concrete products manufactures (9%), building materials dealers (6%), miscellaneous customers (5%), and government agencies (1%). United Cement also purchased and resold a small tonnage of masonry cement.

In August, the company received its first shipment of coal, 8,700 tons, through the Lowndes County Port on the Tennessee-Tombigbee Waterway. A few weeks later the plant received five barges of gypsum through the port.[3]

Clays.—Mississippi's clay industry produced 899,000 metric tons of ball clay, bentonite, common clay, and fuller's earth valued at $23.6 million. This was a decrease of 92,000 metric tons and $1 million below the 1988 level.

Ball Clay.—The Kentucky-Tennessee Clay Co. mined and processed ball clay near the community of Sledge in northwestern Mississippi. A second firm, Cyprus Industrial Minerals Co., mined ball clay in the Sledge area intermittently. The crude clay was shipped to Tennessee for processing. The ball clay, a fine-grained, highly plastic kaolinitic sediment, was mined by surface methods and trucked to the processing facility where it was dried, ground, bagged, and sold primarily to the tile and asphalt-filler markets. Production and value decreased.

Bentonite.—Three companies mined and processed bentonite, a clay with superior absorbent and green strength properties. The three, Applied Industrial Minerals Corp. (AIMCOR), American Colloid Co., and Engelhard Corp., operated three surface mines in east-central Mississippi. American Colloid and Engelhard also shipped bentonite from Arizona for processing.

AIMCOR operated a mine and processing plant for calcium bentonite in Tippah County near Aberdeen. Scraper and draglines removed 60 to 80 feet of overburden to expose 6 to 10 feet of clay. The crude bentonite was trucked to a processing plant where it was air dried, shredded, sized, and bagged. It was then sold to the foundry industry for a binder in mold making and to the animal feed industries for a pelletizing medium.

American Colloid Co., Aberdeen, mined beds of bentonite that averaged 6 feet in thickness after removing 40 to 120 feet of overburden. Clay was trucked to the Aberdeen plant where it was processed by conventional methods and by acid treatment. With the conventional method, the bentonite was air dried, crushed, screened, and bagged for the foundry industry. A significant tonnage of conventionally processed clay was shipped to Malaysia via the Tennessee-Tombigbee Waterway. Both Mississippi and Arizona bentonite was treated with sulfuric acid to produce a clay for specialty sales. Following the acidulation process, the clays were washed, dried, sized, and bagged. The Arizona clays were sold to the desiccant industry, and the Mississippi bentonite was sold to the vegetable oil industry as a filter to remove impurities. American Colloid's plant capacity was 12,000 metric tons per year.[4]

Englehard Corp. purchased the chemical catalyst business of Harshaw/Filtrol Partnership in 1988; included was a plant in Jackson and surface mines in Monroe and Smith Counties. The Jackson plant processed Mississippi and Arizona bentonite by conventional and sulfuric acid activation methods during 1989. The Arizona clays underwent conventional processing to produce a product sold for desiccant applications. The acid-activated clays were sold to the vegetable oil and petrochemical industry.

Two of the four acid-activated bentonite plants in North and Central America are in Mississippi. Production, which included fuller's earth, decreased 106,000 metric tons, and value fell about $700,000.

Common Clay.—Common clay was mined by 8 companies from 14 mines in the eastern part of the State. Production, 498,000 metric tons valued at $2.6 million, accounted for about 50% of the State's clay output. The 1989 tonnage was 44,000 metric tons lower than in 1988; value decreased $300,000.

One company, Boydston Lumber Co., Louisville, mined clay for sale to brick and tile companies in Mississippi, Alabama, and Louisiana. Jackson Ready Mix Concrete Co., Jackson, mined clay for the manufacture of lightweight aggregate. The mine and kiln were located in the Jackson metropolitan area.

Six of the seven brick companies in Mississippi operated 12 mines to obtain clay for brick manufacture. One brick company purchased its raw material from Boydston. Two of the brick companies applied for the necessary permits to open mines in eastern Alabama near Gordo and Fayette.

Fuller's Earth.—Two firms, Oil Dri Production Co. Inc. and AIMCOR, mined and processed fuller's earth, a high absorbency clay, in the Ripley-Blue Mountain area of north-central Mississippi. Production and value were included with bentonite.

Oil Dry operated a mine and a processing plant north of Ripley to produce industrial waste absorbents and agricultural products carriers. Mining was by scrapers, backhoes, and front-end loaders. Mined land was reclaimed for catfish farming. The raw clay was trucked to the Ripley plant where it was shredded, air dried, calcined, sized, and bagged. The company's second mine and plant, south of the community of Blue Mountain, produced a pet waste absorbent. Run-of-mine fuller's earth was shredded, ground, calcined, screened, and bagged.

The AIMCOR plant, north of Blue Mountain, produced pet and industrial waste absorbents and agricultural carriers. Run-of-mine fuller's earth was shredded, ground, calcined, and a 10% moisture fraction removed from the product stream for animal waste absorbent sales; the remainder, after further drying, was sold for industrial waste absorbents and agricultural applications.

Both firms sold a small amount of dust collected by the plant environmental control systems for binder applications. Most of the dust, however, was slurried to settling ponds.

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

The estimated production and value data for 1989 exceeded the 1988 figures by 2.3 million short tons and $12.7 million. The 1989 figures reflect an increase in average unit value from $2.91 per ton in 1988 to $3.30 in 1989. In 1988, the last year that individual company data were available for the full 12-month period, 73 companies reported sand and/or gravel production from 125 mines. The three leading companies in 1988, Blain Sand and Gravel Inc., J. J. Ferguson Sand and Gravel Co., and American Sand and Gravel Co., accounted for 24% of the State's total tonnage. Ten companies produced between 25,000 and 50,000 short tons, six produced between 50,000 and 75,000 short tons, and two produced over 75,000 short tons. These 18 companies accounted for approximately 72% of Mississippi's total sand and gravel output.

Over one million short tons was produced in each of the three leading counties, Copiah in the southwest, De Soto in the northwest, and Monroe in the northeast. The three accounted for about 36% of the State's total production.

Sand and gravel producers provided transportation data for approximately 40% of the sand and gravel shipped. Over 99% was moved by truck; less than 25,000 short tons were shipped by water.

End-use data were provided for about 47% of the sand and gravel output. Sales for concrete aggregate accounted for approximately 60%, asphaltic concrete 19%, and road base and cover 13%. The remaining uses included plaster-gunite, concrete products, and fill.

The sand and gravel industry faced stiff opposition from local residents throughout most of the year. Two mine owners in Hinds county were sued for $4 million for allegedly operating "in violation of county zoning ordinances."[5] American Sand and Gravel Co.'s attempt to mine 25 acres in the Bowie River met with citizens' protests. Following a hearing by the Mississippi Commission on Environmental Quality, the Commissioners voted to issue the mining permit. A few days later, a Chancery judge placed a moratorium on mining pending a ruling on the validity of the permit.[6]

Industrial.—One firm, Tri-Sands Inc., reported industrial sand production from a mine in Tishomingo County. Sales were to the foundry industry for mold and core forming. Two firms reported production in 1988.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Mississippi's stone industry consisted of a single company producing "hard" limestone and several operations that produced "soft" limestone (predominantly chalk).

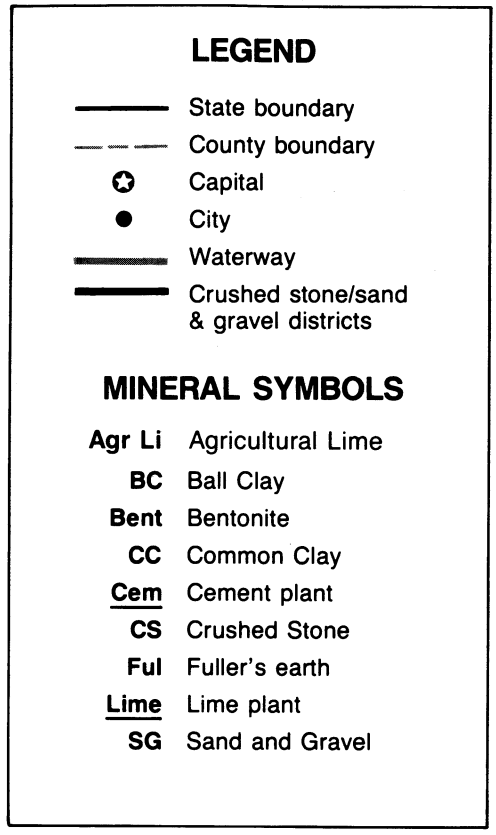
Stone production fell approximately 400,000 short tons and value dropped $6 million from the 1987 level. The decline was due to the closing of a few small soft limestone operations; data on stone used in cement production were not included in the total.

Vulcan Materials Co. quarried a "hard" Mississippian-age limestone near Iuka. Sales were for concrete and bituminous aggregate, road base surface stone, railroad ballast, stone sand, and agricultural lime.

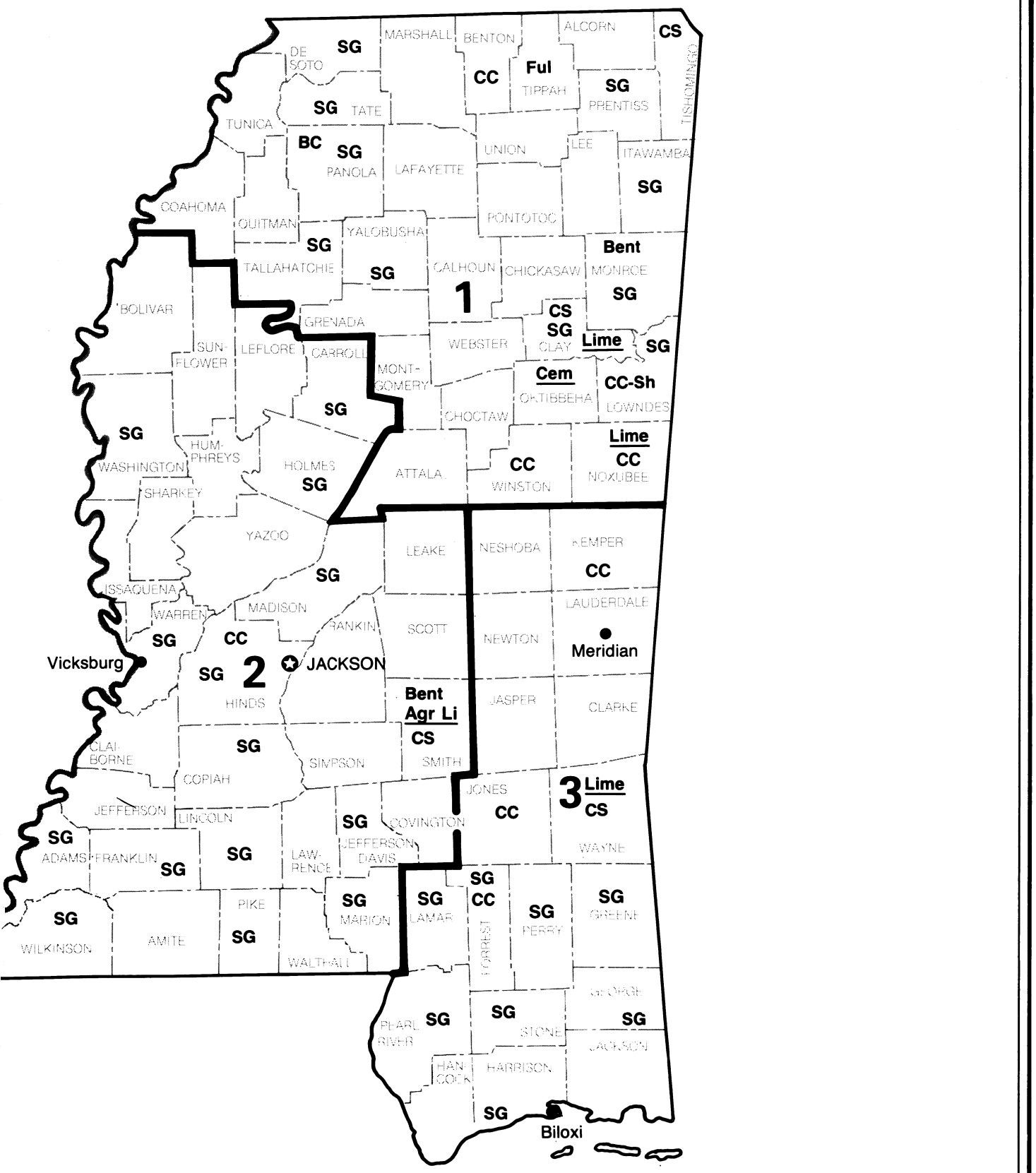
Chalk was mined by six firms and crushed for agricultural lime sales.

Sulfur (Recovered).—The State maintained its third-place ranking in sulfur recovery from petroleum and natural gas refining. Five companies reported sulfur recovery from five refineries in Clarke, Jackson, Lamar, and Rankin Counties. Chevron USA Inc. was the leading producer, followed by Shell Western Inc. and Pursue Gas Processing and Petrochemical Corp. Output totaled 703,000 metric tons valued at $65 million. This was a decrease from the 773,000 metric tons and $67 million reported in 1988. The drop reflected the decline in Mississippi's hydrocarbon production.

MISSISSIPPI



Principal Mineral-Producing Localities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GEORGE
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JACKSON
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TABLE 2

MISSISSIPPI: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate: Other construction materials[2]	911	3,156
Agricultural: Agricultural limestone	92	454
Unspecified:[3]		
Estimated	66	384
Total	1,069	3,994

[1] Includes limestone.
[2] Includes stone used in concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, railroad ballast, stone sand (concrete and bitum · · ·ix or seal), graded road base or subbase, and crusher run or fill or waste.
[3] Data represents estimates for nonrespoi.dents.

Other Industrial Minerals.—In addition to the commodities listed in table 1, several mineral commodities were shipped into Mississippi from other States or foreign countries and processed into higher value products. Two firms imported ilmenite, a titanium mineral, to manufacture a titanium dioxide pigment.

E.I. du Pont de Nemours & Co. Inc. began a $10 million expansion of its titanium dioxide pigment plant at De Lisle. The expansion, scheduled for completion in 1990, will bring plant capacity to 270,000 short tons. The plant imported ilmenite from Australia.

Kerr-McGee Chemical Corp. completed a $45 million expansion to its titanium dioxide pigment plant at Hamilton. Plant capacity was increased to 106,000 short tons per year. Kerr-McGee's synthetic rutile plant at Mobile, AL, manufactured feedstocks for the Hamilton facility.

Anhydrous ammonia was manufactured by Mississippi Chemical Corp. at a plant at Yazoo City. Natural gas feedstock was used in the manufacturing process.

Mississippi continued to rank first among the 33 States with perlite expanding facilities. Perlite is a volcanic rock that expands significantly when heated. Two companies, Manville Products Corp., Natchez, and USG Interiors, Inc., Greenville, expanded perlite for use by the formed products, roof, and insulation board industries. Production was essentially the same as in 1988; however, value increased slightly.

Lime was shipped into Falco Lime Inc.'s plant at Vicksburg; the lime was purchased from Mississippi Lime Co. in Missouri. Falco marketed quick and hydrated lime, calcium carbonate, and kiln dust. Customers included soil stabilization contractors, pulp and paper mills, and water treatment plants. Kiln dust was used in hazardous waste disposal to solidify and neutralize toxic chemicals.[7]

Cobalt and manganese oxide and iron oxide pigments were shipped in-state from Texas and Georgia for use as coloring agents by several of the State's brick companies. Barite from Georgia was also used in the brick making process. Phosphate rock from Florida was shipped to Nu-South Industries Inc. (formerly Mississippi Chemical Corp.) in Pascagoula. The rock, barged from Hillsborough Bay, FL, was used in fertilizer manufacture.

Rock salt from Louisiana was shipped to KemaNord Inc.'s plant in Columbus for use in sodium chlorate manufacture. A plant expansion was completed late in the year and a second expansion announced. The second expansion, which will raise plant capacity to 150,000 short tons per year, will rank the Columbus facility as the largest sodium chlorate plant in the world. Sodium chlorate is used by paper mills in bleaching pulp.

Metals

Mississippi's processed metal value, not included on table 1 in this chapter, added significantly to the economy of the communities in which the metal-producing facilities were located.

Iron and Steel.—Birmingham Steel Corp. operated a 210,000-short-ton melting capacity minimill in Jackson. The facility had a rolling capacity of 300,000 tons. Birmingham Steel completed a feasibility study of the economics of expanding the mill's melting capacity. Study completion was followed by preliminary planning to boost steel output to 500,000 short tons per year.

Manganese.—Manganese ore was imported from West Africa by Kerr-McGee for its electrolytic manganese metal plant in Hamilton. The Hamilton facility was one of two in the United States producing electrolytic manganese metal. Plant output was sold primarily to the aluminum industry.

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[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL. He has 29 years of industry and government experience and has covered the mineral activities in Alabama since 1989. Assistance in the preparation of the chapter was given by Maylene E. Hubbard, editorial assistant.

[2] Director, Mississippi Bureau of Geology, Jackson, MS.

[3] Columbus Commercial Dispatch. A Day of 1sts at Port. Aug. 10, 1989.

[4] Industrial Minerals (London). Acid Activating Bleaching Clays. No. 276, Sept. 1990, p. 56.

[5] Jackson Clarion-Ledger. 8 Residents Near Sandpits Sue Owners. Nov. 4, 1989.

[6] Jackson Clarion-Ledger. Judge Questions Bowie River Gravel Mining Permit. Sept. 2, 1989.

[7] Vicksburg Evening Post. Falco Lime Sells Highest Quality Products. Mar. 24, 1990.

TABLE 3

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 Division, 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 Bureau of Mines, U.S. Department of the Interior, and the Missouri Department of Natural Resources, Division of Geology and Land Survey, for collecting information on all nonfuel minerals.

By Leon E. Esparza,[1] Laurence M. Nuelle,[2] and Ardel W. Rueff[2]

The value of nonfuel minerals produced in Missouri rose more than 8% to about $1.1 billion in 1989. As in 1988, this year's increase was mostly owing to greater lead and zinc production. Metal markets continued their strong showing as has been evident for the past 3 years. Nationally, Missouri ranked 11th in nonfuel mineral production, up from 12th place in 1988, and accounted for 3% of the Nation's total. Missouri was the Nation's leading producer of fire clay, lead, and lime; was second in crude iron oxide pigments and zinc production; and third in barite and iron ore. Leading commodities produced in the State, in decreasing order of contribution to the total nonfuel mineral value, were lead, cement, crushed stone, lime, and zinc. Industrial minerals accounted for more than $536.2 million or 51% of the total nonfuel mineral value.

TRENDS AND DEVELOPMENTS

Mining employment totaled 5,200 jobs according to the Missouri Department of Labor. This was a decrease of nearly 2% from that of 1988 and the fourth consecutive year of decline. This 2% decrease was partially attributed to cutbacks in demand for some industrial minerals used in the construction industry. Since 1985, mining employment has declined nearly 18% owing in part to reductions in staff requirements in the State's lead industry. Continued softness in worldwide petroleum exploration also has reduced jobs previously provided by the barite mining sector.

Most of the State's industrial minerals production is used in construction. According to the U.S. Department of Commerce, the number of private and

TABLE 1

NONFUEL MINERAL PRODUCTION IN MISSOURI[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Barite	thousand metric tons	24	$2,030	24	$1,930	W	W
Cement:							
Masonry	thousand short tons	167	10,027	153	6,310	W	W
Portland	do.	5,110	185,317	4,679	184,755	4,922	$182,005
Clays[2]	metric tons	1,338,858	10,414	1,435,045	12,171	1,479,898	14,665
Iron ore	thousand metric tons	756	W	816	W	1,060	W
Lead[3]	metric tons	W	W	353,194	289,194	366,931	318,320
Sand and gravel:							
Construction	thousand short tons	e10,900	e30,400	11,217	32,941	e10,000	e32,500
Industrial	do.	622	7,786	744	9,876	750	9,972
Silver[3]	metric tons	37	8,276	45	9,550	53	9,456
Stone:							
Crushed	thousand short tons	54,910	184,824	e52,100	e183,000	51,754	171,848
Dimension	short tons	3,212	454	e3,644	e547	W	W
Zinc[3]	metric tons	34,956	32,306	41,322	54,842	50,790	91,885
Combined value of clays (fuller's earth), copper, gem stones, iron oxide pigments (crude), lime, and values indicated by symbol W		XX	391,206	XX	182,833	XX	219,405
Total		XX	863,040	XX	967,949	XX	1,050,056

e Estimated. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

public residential units authorized in Missouri during 1989 fell more than 23% to 17,970. This was in addition to a 19% decrease in 1988. Value of nonresidential construction decreased nearly 4% to about $1.4 billion. Uncertainty over long-term interest rates and softness in demand for new units owing to previous years' over-expansion are partial explanations for this development. This trend seemed likely to continue in 1990. State road contract awards continued a strong upward trend that began in 1987 and increased nearly 8% to $509 million during 1989.[3] Since 1987, road contract awards have increased about 29%, reflecting enactment of 1987 State legislation that called for a 15-year highway construction and maintenance program.

The nationwide trend by the mining industry to increase public awareness of mining's benefits to society was especially evident in actions of the Mining Industry Council of Missouri. In August, the Council sponsored an exhibition booth at the Missouri State Fair in Sedalia. The goal of the booth was to show the importance of mining to the State and to the individual.

REGULATORY ISSUES

The U.S. Environmental Protection Agency (EPA) continued studying a proposal, initiated in 1988, to place the Oronogo-Duenweg Mining Belt in Jasper County on the Superfund priority list for toxic waste cleanup. If the proposal is approved, the area could qualify for long-term cleanup action under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Public Law 96-510); also known as the Superfund law. The 20-square-mile belt has an estimated 10 million short tons [9 million metric tons (MMmt)] of tailings containing cadmium, lead, and zinc resulting from lead mining that began in 1848 and ended in 1968.

At yearend, The Doe Run Co. awaited a decision by the Bureau of Land Management (BLM) concerning its preference right lease applications to explore for lead deposits in the Mark Twain National Forest near Winona. In December 1988, the U.S. Forest Service (USFS) filed a Record of Decision allowing the company to explore the area with the stipulation that exploration could be conducted, but that there would be no guarantee that a mine plan would be approved. Under these conditions, Doe Run had planned to drill 20 exploration holes, but an appeal by environmental groups led to a reversal of the lease issuance. The group claimed, among other points, that concern about potential pollution to water resources had not been adequately addressed. The USFS suggested that Doe Run could possibly drill under a General Use Permit but that no right to lease would be guaranteed. Conceivably, under that arrangement, Doe Run could encounter additional ore intercepts, and other companies could then lease the ground. Doe Run acquired the lease area in question from USX Corp. in 1984 but has never been able to drill the property. Two ore-grade holes were drilled by USX. The history of this issue has been reported in four previous editions of the Missouri chapter of the Minerals Yearbook. Two Federal agencies were involved in the decision process because of different responsibilities. The USFS must ensure that mineral leases conform with the purpose for which the lands were acquired and are being administered, and the BLM is responsible for leasing minerals on acquired Federal lands.

The USFS and BLM anticipated the eventual submission of a mine plan by Doe Run for the Winona lease area. A technical team was formed to decide the type of data needed for an environmentally sound decision concerning mining in the lease area. Team members included personnel from the USFS, the BLM, the U.S. Geological Survey (USGS), the EPA, the National Park Service, the Missouri Department of Natural Resources, the University of Missouri, and Doe Run.

Phase 1 of "A Comprehensive Assessment of the Potential Hydrologic and Geological Impact of Lead and Zinc Mining in the Mark Twain National Forest of Southern Missouri" report was completed in November; it listed sources of information concerning environmental and hydrologic data in the lease area. In addition, continuous water level recorders were installed on two exploratory holes supplied by Doe Run. A continuous recording rain gauge was installed on property near the lease area. Plans were made for the inventory of shallow and deep wells in the study area. Detailed information was to be obtained about well location, construction, and specific conductance of the water.

EXPLORATION ACTIVITIES

Even with continued strong metal prices, lead and zinc exploration in Missouri remained minimal. Companies were leery of exploring on national forest lands in light of the problems associated with Doe Run's Winona area leases. In 1989, no new exploration lease applications were submitted, and no known exploration took place on private lands; lead and zinc exploration was restricted to existing leases with active mines.

Missouri's Precambrian iron ore deposits continued to be viewed by some explorationists as possible petrotectonic analogs of the Olympic Dam deposit on the Stuart Shelf in South Australia. Olympic Dam is an extremely large polymetallic deposit (containing an estimated 2 billion metric tons of ore) with copper, gold, silver, uranium, and rare-earth elements (REE). Five companies are known to be interested in the exploration for this type of deposit in the Middle Proterozoic St. Francois terrane of southeast Missouri. Doe Run and Cominco American Inc. hold leases on privately owned ground near Salem. Cominco drilled two holes on its leases, but Doe Run has not yet drilled on its leases. Cominco also drilled holes on its undeveloped Boss-Bixby copper-iron deposit. This deposit has been shown to have attributes similar to the Olympic Dam-type deposits.[4] Additional exploration drilling is planned from underground workings in the nearby Magmont lead mine.

LEGISLATION AND GOVERNMENT PROGRAMS

The Metallic Minerals Waste Management Act (House Bill 321) was signed into law in May. The law, supported throughout the legislative process by the mining industry, provided for management of waste material from the mining and beneficiation of metal-

lic minerals. Permitting requirements, guidelines, and fees were addressed, and penalties for noncompliance or permit violations were defined.

In July, The Natural Streams Campaign filed a petition with the Missouri Secretary of State and Attorney General that sought to place the Natural Streams Act on the November 1990 general election ballot. The campaign had until early July 1990 to collect at least 70,000 signatures. The act would designate 52 streams as "natural streams" with uses controlled by a citizens commission in cooperation with local governments, landowners, and conservation and recreation groups. Concern that limits on some recreational uses would be created and new restrictions imposed on land uses such as logging, mining, and real estate development had grown within the business community and various recreation groups.

In preparation for the 1990 legislative session, the Missouri Department of Natural Resources began circulating for public comment its proposed revisions to the Land Reclamation Act. In general, the revisions would increase the oversight authority of the Land Reclamation Commission, require higher reclamation standards, and increase user fees to support the actual cost of administering and enforcing the regulations.

The Bureau of Mines Rolla Research Center developed an energy efficient and pollution-free leach electrowinning method for use in recovering pure lead metal and byproducts from lead sulfide concentrates. The method would replace the current high-temperature pyrometallurgical primary lead smelting process and supply pure lead metal within proposed EPA and Occupational Safety and Health Administration lead emission standards. Rolla Center researchers also developed and successfully tested a continuous flotation process that recovers about one-half of the cobalt previously lost to mill tailings in processing copper, lead, and zinc. The study concluded that the procedure would be economic with cobalt prices of at least $44 per kilogram (kg).

The Bureau continued its study on using froth flotation and gravity to recover REE from phosphate minerals occurring in breccia pipes at the Pea Ridge iron ore mine in Washington County. Additionally, barium, copper, gold, silver, and tin had been identified in the ore and were possible byproducts. The major REE minerals, occurring as oxides, were monazite and xenotime, with minor amounts of allanite and traces of bastanite. Other sources of REE occurred in mine tailings and excess mine water.

The REE are categorized into two subgroups: the cerium or light subgroup and the yttrium or heavy subgroup. Many of the new metallurgical, magnetic, and electrical uses of the REE require those from the heavy subgroup. Domestically, there are no real sources of the heavy subgroup, which is usually a byproduct of the treatment of beach sands for titanium. The REE found in California's Mountain Pass deposit contain only 0.5% of the heavy subgroup. REE from the Pea Ridge deposit contain as much as 25% of the heavy subgroup, making this potential resource even more attractive.[5] Research had shown that the ore could be upgraded to a commercial grade of 62% rare-earth oxide using flotation of the phosphate followed by gravity separation.

Environmental technology research by the Bureau included several continuing studies focused on treating mining and metallurgical wastes. One sought to develop a high-technology, low-voltage system for electrolytic removal of trace elements from waste solutions contained in runoff waters from abandoned mines, agricultural activities, and industrial sources. A second study investigated pyrometallurgical treatment as a method to recover metal values from metallurgical wastes while producing a nonhazardous slag for safe disposal. A third study looked at treating lead-bearing wastes such as soils, fumes, residues, and sludges to also render them nonhazardous. Somewhat related to this study was a fourth project that sought treatments for hazardous residues. Specifically sought were methods to recover and recycle minerals and metals of economic value and environmentally acceptable methods to dispose of the metallurgical wastes.

The Missouri Department of Natural Resources, Division of Geology and Land Survey (DGLS) dedicated its new drill-core library at Rolla in October. The facility was purchased through donations from industry and private individuals and government funding. The Survey also celebrated its centennial anniversary. The first Geological Survey of Missouri was established in 1853, but in the intervening years there were two interruptions during which the Survey was not funded by the legislature. Since 1889, the Geological Survey has been continuously funded.

In April, the DGLS and the USGS cohosted a Symposium on Midcontinent Mineral Resource Potential. The symposium was held in St. Louis, and fifteen other midcontinent State geological surveys also participated. The purpose of the meeting was to report results of cooperative research by the geological surveys on the Conterminous U.S. Mineral Appraisal Program (CUSMAP) and on the Strategic and Critical Minerals (SCM) Program; both are cooperative programs sponsored by the USGS in conjunction with State geological surveys. Discussion topics included geologic mapping and geochemical studies at the Pea Ridge iron mine for purposes of comparison with Olympic Dam-type deposits. Study of the deposit is a task of the SCM program. Preliminary results showed that REE-bearing breccia pipes cut the ore body. DGLS also presented its results of CUSMAP studies relating to the Joplin and Harrison 2 degree quadrangles. Another CUSMAP activity calls for the completion of most of the Paducah quadrangle projects during late 1990 or early 1991. Also, the DGLS and the USGS cooperatively studied Mississippi Valley-type mineralizing systems in the Ozarks.

The University of Missouri at Rolla developed, and began offering, training to prepare students for a career in the crushed stone industry. Students will be allowed to major in mining, geological, and metallurgical engineering programs with an emphasis on quarry engineering. Courses offered included processing, environmental issues, material handling, and planning. The quarry engineering specialized curriculum was the only such program in the Nation.

The University of Missouri at Rolla, Mining and Mineral Resources Research Institute (MMRRI) received an allotment grant of $138,000 for fiscal year 1989 from the Bureau of Mines under provisions of Public Laws 98-409 and 100-483. The MMRRI coordinated and administered training and research in mining, mineral resources, mineral development, and mineral processing. MMRRI programs emphasized

graduate research in ceramic engineering, geological and petroleum engineering, geology and geophysics, metallurgical engineering, mining engineering, and nuclear engineering. Research funded partially by the MMRRI included an evaluation of capital and operating costs associated with subsurface, limestone aggregate resources in northern Missouri. The two-part study produced maps showing the location of previously unexploited subsurface limestone deposits. Depths considered were up to about 1,200 feet and limestone thicknesses up to about 150 feet. A second part of the study developed computer programs to evaluate costs for both open pit and underground room-and-pillar mining methods. Aggregate supplies for northern Missouri have been imported from distances of about 100 miles at unit costs up to triple those of other areas with nearby sources.

A second study undertaken by MMRRI-supported researchers was part of a large, multifaceted investigation about potential midcontinent analogs to the Olympic Dam Australia deposit. The MMRRI study focused on gaining an understanding of the ore genesis of the yet unmined, but much drilled, Boss-Bixby, MO, deposit.

A third study focused on the formation of heavy-metal-humic acid complexes near a lead smelter. Results of the completed study indicated that a high percentage of cobalt, copper, lead, and nickel were removed from a polluted smelter area in the form of metal-humic acid complexes. Also shown was that although total metal concentration diminished with distance from the smelter, through dilution or removal, the fraction of complexed metals increased. This observation supported the conclusion that complexed metals are geochemically more mobile than metals in an ionic form. Results of this study were beneficial because few specific reports have been available on the formation of metallo-organic complexes in nature. Formation of such complexes have been, however, well documented from pollution studies. A reason given for this was that concentrations of the metals and the complexing humic acids were generally too low to permit the observation of complex formation.

A fourth study concerned the direct smelting of Missouri lead concentrates. This type of research has been ongoing by various institutions for about 35 years. Recent years have seen stricter environmental regulations and a need to increase sulfide processing efficiency in terms of energy consumption and metal loss. The objective of this ongoing MMRRI-sponsored work was to explore the possibility of producing a low-sulfur lead bullion and a low-lead oxide slag from a typical Missouri lead concentrate in a single reactor.

The university also hosted the Generic Mineral Technology Center (GMTC) for pyrometallurgy, of which seven universities were participating members. Funding for the center for fiscal year 1989 was $1 million. A study done by the GMTC sought to determine the solubility of zinc in iron and iron-carbon alloys at temperatures well above the boiling point of zinc (11,500° to 15,500° C). Developed data would support laboratory and industrial research activities concerning pyrometallurgical treatment of zinc-bearing iron or steel alloys.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Abrasive Materials.—American Tripoli Co. produced finished tripoli at its Seneca plant in Newton County from raw materials shipped from Oklahoma. Tripoli is a porous, siliceous, microcrystalline material that, because it lacks distinct edges, is useful as a mild abrasive. Tripoli is used as a filler, in tooth polishing compounds, for buffing and polishing, automobile paint, and as filter media.

Barite.—Missouri, one of six barite-producing States, was the Nation's third largest producer in 1989, following Nevada and Georgia, the first and second largest producers, respectively. Production and value of Missouri barite fell about 21% and 26%, respectively, in 1989, continuing a trend that began in 1985 with the slowdown in oil well drilling activity. Barite is used as a drilling mud additive to prevent blowouts in wells and as a pigment and filler in the manufacture of paint and rubber. In 1989, three producers operated surface mines north of Potosi in Washington County.

Cement.—Missouri was the Nation's fifth leading producer of portland cement, accounting for about 7% of the total domestic production. Portland cement production increased more than 5% in 1989 and again was the second most valuable nonfuel mineral commodity produced in Missouri. Sales to ready-mixed concrete companies accounted for 81% of the total quantity sold, followed by 7% to highway contractors, 5% to concrete product manufacturers, and the remaining 7% to various other customers. Five companies produced Types I and II portland cement; three of these also produced Type III. Three of these companies also produced masonry cement. Masonry cement production and value decreased in 1989. Decreases posted the past 2 years reflected steep declines in authorized public and private residential units. In 1989, authorized units dropped 23%, adding to the 19% drop reported by the U.S. Department of Commerce in 1988.

Clays.—Production and value of clays, excluding fuller's earth, increased 3% and 20%, respectively, in 1989. Missouri was the Nation's leading producer of fire clay, accounting for 52% of total domestic production. Production and value of fuller's earth increased moderately in 1989. Clay, of all types, was mined by 16 companies from 43 pits. Fire clay was mined at 32 pits, common clay and shale at 9, and fuller's earth at 2. Typical clay uses included portland cement and brick manufacturing and pet waste absorbents.

In October, A. P. Green Industries Inc. became the target of a hostile takeover by East Rock Partners L. P. The partners indicated they owned 8.7% of Green's stock and proposed a $97.2 million buyout of the company based in Mexico, MO. Green subsequently rejected the offer and initiated legal action against East Rock and its principals, contending that the partners had misrepresented themselves in U.S. Securities and Exchange Commission documents. In December, East Rock reported its acquisition plan would use $10 million of Green's cash and about $9 million from Green's pension funds. The partners indicated the $9 million

was an excess of the amount needed to pay benefits. At yearend, the takeover battle continued.

Lime.—Lime production increased 1% in quantity and 4% in value over 1989 figures, establishing a record-high output for the State. The increase also moved the State from a second place ranking in 1988 to the number one position of 32 lime-producing States. Ash Grove Cement Co. and Mississippi Lime Co. produced both quicklime and hydrated lime at plants in Springfield, Greene County, and Ste. Genevieve, Ste. Genevieve County, respectively. Resco Products of Missouri Inc. produced dolomitic lime and refractory, dead-burned dolomite at Bonne Terre, St. Francois County. Of the 72 companies producing lime in the United States in 1989, Mississippi Lime was the second largest, and its Ste. Genevieve plant was the largest of 115 active plants.

Perlite (Expanded).—Perlite from out-of-State sources was expanded by the Georgia-Pacific Corp. at Cuba, Crawford County, and by Brouk Co. at St. Louis, St. Louis County. In 1989, quantity and value of the expanded material sold and used decreased. Expanded products were used in manufacturing acoustical tile and absorbents.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988. Construction sand and gravel production was estimated to have decreased about 11%, whereas value remained essentially unchanged.

Industrial.—Quantity and value of industrial sand and gravel posted slight increases in 1989, a departure from the marked increases of the 2 previous years when production and value increased significantly. Four companies in two counties produced industrial sand and gravel for use as ground filler, foundry molding and core sand, and chemicals manufacturing.

Slag (Steel).—International Mill Service Co. processed steel slag from electric furnaces at Kansas City and was the State's sole producer of the material. Quantity and value of sales decreased 21% and 32%, respectively, in 1989.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Crushed stone was produced in 87 counties by 130 operators. Production in 1989 remained nearly unchanged from that of the previous year, and value decreased 6%. Counties leading in production were St. Louis, Ste. Genevieve, and Jefferson. Crushed stone accounted for nearly 16% of Missouri's total nonfuel mineral value. Missouri crushed stone statistics were compiled by geographical districts as depicted in the State map. Table 3 presents end-use statistics for Missouri's eight districts.

Riverside Quarry of Villa Ridge, for the second consecutive year, received the Missouri Limestone Producers Association's prestigious Hillenkamp-Rush Memorial Safety Award. Safety achievement awards for no-lost-time accidents also were presented to 36 other producers.

TABLE 2

MISSOURI: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	1,309	4,219
Riprap and jetty stone	3,823	11,861
Filter stone	377	1,159
Other coarse aggregate	38	156
Coarse aggregate, graded:		
Concrete aggregate, coarse	5,495	20,811
Bituminous aggregate, coarse	3,990	14,979
Bituminous surface-treatment aggregate	1,251	4,168
Railroad ballast	1,668	5,602
Fine aggregate (−3/8 inch):		
Stone sand, concrete	405	1,614
Stone sand, bituminous mix or seal	157	532
Screening, undesignated	676	2,172
Coarse and fine aggregates:		
Graded road base or subbase	8,235	27,282
Unpaved road surfacing	1,798	6,647
Crusher run or fill or waste	862	2,737
Other construction materials[2]	499	1,280
Agricultural: Agricultural limestone	1,643	5,153
Chemical and metallurgical: Cement manufacture	6,308	13,454
Other miscellaneous uses[3]	881	3,055
Other uses not listed	165	709
Unspecified:[4]		
Actual	7,987	30,253
Estimated	4,187	14,002
Total	51,754	[5]171,848

[1]Includes limestone, granite, dolomite, sandstone, traprock, and other miscellaneous stone.
[2]Includes stone used in other coarse and fine aggregates and terrazzo and exposed aggregate.
[3]Includes stone used in poultry grit and mineral food, lime manufacture, dead-burned dolomite, flux stone, chemical stone, sulfur oxide removal, asphalt fillers or extenders, and roofing granules.
[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.

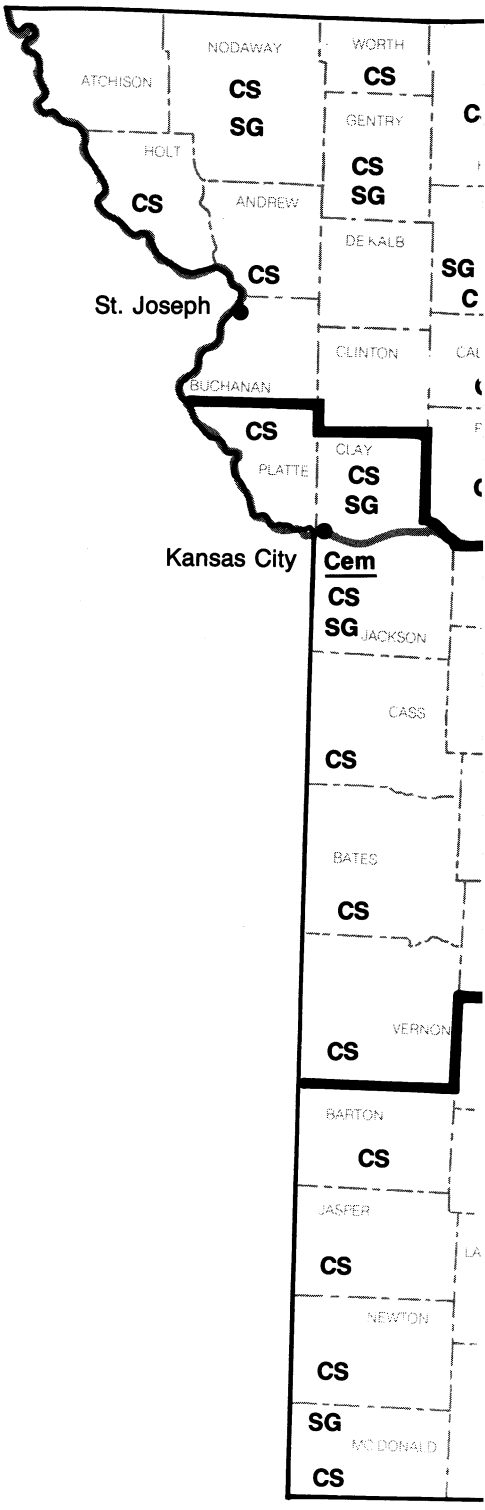
MISSOURI

LEGEND

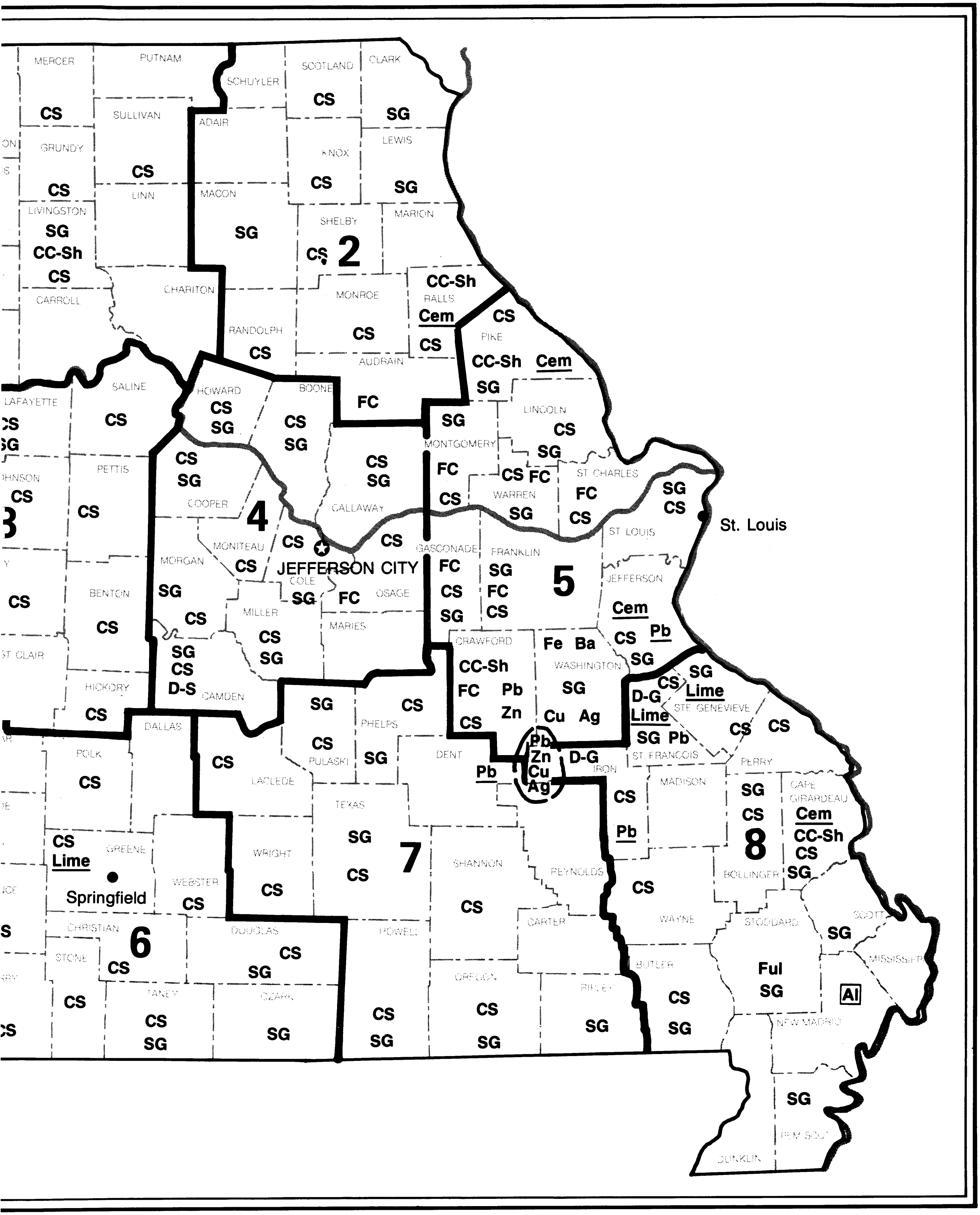
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

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


MERCER
PUTNAM
SCHUYLER
SCOTLAND
CLARK
CS
SULLIVAN
ADAIR
CS
SG
GRUNDY
LEWIS
KNOX
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CS
CS
SG
LINN
MACON
LIVINGSTON
SHELBY
MARION
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CC-Sh
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2
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CC-Sh
CHARITON
CARROLL
MONROE
RALLS
Cem
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RANDOLPH
CS
PIKE
CS
CS
AUDRAIN
CC-Sh
Cem
SALINE
HOWARD
BOONE
SG
LAFAYETTE
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SG
FC
CS
CS
SG
SG
LINCOLN
MONTGOMERY
CS
CS
SG
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PETTIS
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ST CHARLES
JOHNSON
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COOPER
CALLAWAY
WARREN
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4
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ST LOUIS
St. Louis
MONITEAU
CS
CS
GASCONADE
FRANKLIN
MORGAN
CS
JEFFERSON CITY
FC
SG
5
CS
BENTON
SG
COLE
SG
FC
OSAGE
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FC
JEFFERSON
CS
MILLER
SG
CS
Cem
CS
MARIES
CS
Pb
CS
CRAWFORD
Fe
Ba
ST CLAIR
SG
SG
CC-Sh
WASHINGTON
SG
CS
SG
HICKORY
D-S
CAMDEN
FC
Pb
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Lime
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Cu
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Lime
STE GENEVIEVE
DALLAS
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MADISON
CAPE GIRARDEAU
TEXAS
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GREENE
WRIGHT
7
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SHANNON
REYNOLDS
BOLLINGER
SG
CS
Springfield
WEBSTER
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WAYNE
CHRISTIAN
6
DOUGLAS
HOWELL
CARTER
STODDARD
SCOTT
STONE
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MISSISSIPPI
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BUTLER
Ful
OREGON
RIPLEY
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TANEY
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NEW MADRID
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TABLE 3

MISSOURI: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(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 aggregate (+1 1/2 inch)[1]	331	1,111	41	177	180	690	89	280
Coarse aggregate, graded[2]	W	W	67	278	2,725	10,737	657	1,886
Fine aggregate (−3/8 inch)[3]	W	W	W	W	293	997	—	—
Coarse and fine aggregates[4]	W	W	296	1,069	1,811	6,386	738	2,305
Other construction aggregates	216	1,918	59	184	2	14	151	151
Agricultural[5]	64	244	75	160	198	447	126	308
Chemical and metallurgical[6]	—	—	(7)	(7)	771	2,190	—	—
Special[8]	—	—	—	—	(7)	(7)	—	—
Other miscellaneous	—	—	890	1,812	9	109	—	—
Unspecified:								
Actual[9]	2,150	10,195	1,021	3,393	993	4,198	86	328
Estimated[10]	345	1,193	269	972	944	3,373	481	1,748
Total[11]	3,107	14,662	2,720	8,045	7,925	29,141	2,327	7,007

	District 5		District 6		District 7		District 8	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregate (+1 1/2 inch)[1]	1,070	3,471	W	W	W	W	3,675	11,121
Coarse aggregate, graded[2]	4,396	15,662	2,387	9,777	W	W	1,919	5,343
Fine aggregate (−3/8 inch)[3]	293	963	389	1,563	—	—	231	702
Coarse and fine aggregates[4]	4,825	16,170	W	W	229	751	1,488	4,457
Other construction aggregates	—	—	1,703	5,936	324	1,121	—	—
Agricultural[5]	203	605	367	1,369	180	650	430	1,374
Chemical and metallurgical[6]	(7)	(7)	(7)	(7)	—	—	1,798	4,223
Special[8]	—	—	—	—	—	—	(7)	(7)
Other miscellaneous	3,100	6,237	256	941	121	479	408	1,225
Unspecified:								
Actual[9]	1,562	5,202	383	1,352	257	769	1,534	4,815
Estimated[10]	785	2,577	720	2,142	84	286	559	1,711
Total[11]	16,233	50,886	6,206	23,079	1,194	4,057	12,043	34,970

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[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), and fine aggregate (screening-undesignated).
[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, crusher run or fill or waste, and other coarse and fine aggregates.
[5] Includes agricultural limestone and poultry grit and mineral food.
[6] Includes crushed stone for cement manufacture, lime manufacture, dead-burned dolomite, flux stone, chemical stone for alkali works, and sulfur oxide removal.
[7] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[8] Includes crushed stone for asphalt fillers or extenders and roofing granules.
[9] Includes production reported without a breakdown by end use.
[10] Includes estimates for nonrespondents.
[11] Data may not add to totals shown because of independent rounding.

Dimension.—Dimension stone was produced by Beavers Stone Co. and Missouri Red Quarry Inc. Beavers extracted sandstone from three quarries near Camdenton. Material was sold by Beaver for use as dressed flagging, blocks, and veneer stone. Missouri Red quarried granite from its operation near Graniteville for use in making monuments. Dimension stone production and value increased in 1989.

Vermiculite (Exfoliated).—Vermiculite from out-of-State sources was exfoliated by Brouk Co. and W.R. Grace & Co. at their plants in St. Louis. Production and value fell 9% and 11%, respectively. Vermiculite was used in manufacturing aggregate, insulation, and agricultural products, such as soil conditioners and fertilizer carriers.

Metals

Aluminum.—Aluminum output increased about 1% in spite of a 3-month strike at the Noranda Aluminum Inc.'s

New Madrid reduction plant, the State's only producer. Members of United Steel Workers Local 7686 walked off their jobs at the Noranda facility in early September. Workers returned on December 5; however, without formal acceptance of a company offer for a 5-year contract that called for a 4-year wage freeze after a 4% wage hike the first year. During the strike, salaried employees continued operations but at reduced levels. The operator, a subsidiary of Noranda Mines Ltd. of Toronto, Canada, received its alumina raw material from foreign sources via barge up the Mississippi River.

Toyota Motor Corp. announced in December its intent to purchase Bodine Aluminum Inc. of Vinita Park, St. Louis County, for about $30 million. The auto manufacturer indicated that its acquisition would help boost production of domestically manufactured aluminum cast automotive parts. The 77-year-old, family-run, Bodine facility would use new Japanese technology to produce cylinder heads and other aluminum cast parts for a Toyota power train plant in Georgetown, KY. Previously, these parts were brought in from plants in Japan. The Bodine plant employs about 300 people.

Copper, Lead, Silver, and Zinc.—Copper, silver, and zinc were produced as coproducts of lead mining and milling operations by three southeast Missouri operators. In 1989, continued strength in base metals markets for the third consecutive year supported increased production, resulting in significant double digit increases for copper, lead, and zinc values. Although silver production increased, attendant value was essentially stagnant because of lower market prices.

Lead production and value increased about 4% and 10%, respectively. Missouri ranked first of 11 lead-producing States and accounted for 89% of the total domestic production. Lead accounted for 30% of the State's total nonfuel mineral production value.

Zinc production and value increased about 23% and 68%, respectively. Value of zinc output contributed nearly 9% to the value of the State's total nonfuel mineral production and accounted for 18% of the total domestic production, up from 13% in 1988. Missouri ranked second of nine producing States.

Missouri copper production and value increased about 25% and 35%, respectively. The State ranked sixth of 12 producing States.

Silver production increased nearly 18%, but value slipped by about 1% because of lower silver prices. Silver's average unit price in 1989 was $5.50 per troy ounce, down from $6.54 per troy ounce in 1988. Missouri accounted for nearly 3% of domestic production and ranked eighth of 18 silver-producing States. Silver contributed about 1% to Missouri's total nonfuel mineral production value.

Mississippi Valley-type lead and zinc deposits, in the Southeast Missouri Lead District, occur in Cambrian-age sedimentary rocks along the flanks of the St. Francois Mountains. The largest deposits are hosted by the Bonneterre Formation. Ore bodies are associated with open-space filling of stratabound pore space, network of vugs that transect strata, and solution collapse breccias. Ore minerals include galena, sphalerite, and chalcopyrite. Silver occurs as trace amounts in sphalerite and is recovered from zinc concentrate. Mining of the deposits is by underground, vertical shaft access, large room-and-pillar mining methods. Mining depths typically are about 1,000 feet.

North America's largest integrated lead producer, The Doe Run Co., owned six mines, four mills, and two smelters in southeast Missouri. Doe Run was a joint-venture partnership between Homestake Mining Co. and St. Joe Minerals Co., a wholly owned subsidiary of Fluor Corp. The partnership was formed in November 1986 with St. Joe contributing five mines, three mills, and a smelter for a 57.5% interest; Homestake contributed its Buick Mine, mill, and smelter complex for a 42.5% equity. During 1989, however, there was talk in the industry about a possible breakup of the partnership. Fluor Corp. announced in March that it was not actively pursuing a sale of its share of the partnership but was responding to inquiries regarding the future of lead in the company's portfolio. The corporation retained two investment banking firms to screen calls and disseminate information about the lead operations.[6] There were no further developments by yearend.

Doe Run ore reserves at yearend were reported by Homestake to be 73.1 million short tons (66.3 MMmt), with grades of 4.98% lead, 0.88% zinc, and 0.29% copper.[7] Total ore milled during 1989 increased by 6% to 4.3 million short tons (3.9 MMmt). This resulted in production of about 251,000 short tons [228,000 metric tons (mt)] of refined lead products, 55,000 short tons (50,000 mt) of zinc concentrates, and 76,700 short tons (70,000 mt) of copper concentrates. Milled ore grades were about 5.6% lead, 0.9% zinc, and 0.6% copper.[8]

Nearly all of the concentrates produced at Doe Run's mills, which had an aggregate daily ore capacity of about 29,000 short tons (26,000 mt), were transported to the company's Herculaneum lead smelter at Herculaneum, Jefferson County. This smelter, the largest in the United States, had an annual capacity of about 225,000 short tons (204,000 mt) of refined lead. The Buick lead smelter, near Boss in Dent County, operated as a backup to Herculaneum in 1989. Buick had an annual capacity of 140,000 short tons (127,000 mt).

In October, Doe Run received all the necessary State and Federal permits for construction and operation of its proposed $34 million lead battery recycling facility. The Buick Resource Recovery Facility, which would be built adjacent to the Buick smelter, would recycle spent lead-acid batteries from automobiles, industrial batteries, and lead scrap. At yearend, plant construction startup awaited final corporate approval by Doe Run's parent companies. Plant startup was anticipated by spring 1992. The state-of-the-art plant would use technology developed by Engitec Impianti of Milan, Italy.

The Missouri Department of Natural Resources announced a preliminary decision to issue a hazardous waste storage permit for the recycling plant in July and held public hearings in September. There were few opponents to the projects. The permit would authorize processes used to separate, store, and reclaim battery components, which included lead, sodium sulfate, and polypropylene. Hazardous wastes generated during processing would be reclaimed or shipped offsite to approved hazardous waste disposal sites. The plant would produce about 59,500 short tons per year (54,000 mt per year) of refined lead metal, or about 10% of

domestic secondary lead production, from about 110,000 short tons (100,000 mt) of spent batteries or other lead scrap. Sulfuric acid would be converted into salable sodium sulfate for use in laundry detergents. Sodium sulfate production is expected to be about 9,500 short tons per year (8,600 mt per year). Plastic battery casings would be recycled into pellets for manufacturing various plastic products. Annual plastic output was expected to be about 5,000 short tons. About 125 new jobs would be created.

At yearend, Doe Run's Herculaneum smelter completed a record 14 consecutive months, in excess of one million worked hours, without a lost-time accident. Homestake also reported refined lead production at the smelter was a record high of 238,935 short tons (216,762 mt), and productivity improved to a record high of 1.82 short tons (1.65 mt) per shift.[9]

In June, Doe Run was issued a Notice of Violation of Missouri's ambient air quality standard for lead at the Herculaneum smelter. At yearend, Doe Run anticipated entering a Consent Order with the State. The order would obligate the company to install additional emission controls as part of the Missouri State Implementation Plan to comply with the standards. The company expected costs to meet the standards could be as high as $10 million over 4 years.

ASARCO Incorporated operated the Sweetwater and West Fork Mines and mills throughout 1989. According to Asarco's annual report to stockholders, contained metal production from the mines totaled 91,000 short tons (83,000 mt) of lead, 19,100 short tons (17,300 mt) of zinc, and 513,000 troy ounces (16,000 kg) of silver.

Operations at the Sweetwater Mine were at 66% of capacity. About 840,000 short tons (762,000 mt) of ore were milled at the Sweetwater mill for an average mill recovery rate of 98%. Sweetwater contained metal production was 129,000 troy ounces (4,000 kg) of silver, 37,000 short tons (33,600 mt) of lead, and 4,700 short tons (4,300 mt) of zinc. Ore reserves at Sweetwater were reported by Asarco to be 24.1 million short tons (21.9 MMmt), grading 4.84% lead and 0.58% zinc.[10] The Sweetwater Unit was awarded the prestigious Sentinels of Safety Award in the underground metal category for 1988. The annual mine safety award was sponsored by the U.S. Mine Safety and Health Administration and the American Mining Congress. Eligibility for the award required at least 30,000 injury-free hours and no lost-time injuries.

Asarco reported that its West Fork Unit milled 933,000 short tons (846,000 mt) of ore for an average mill recovery of 98.4%. Contained metal production was 384,000 troy ounces (11,900 kg) of silver, 54,000 short tons (49,000 mt) of lead, and 14,400 short tons (13,000 mt) of zinc. Ore reserves at yearend were about 9.2 million short tons (8.3 MMmt), grading 0.30 ounce per short ton (10 grams per metric ton) of silver, 0.04% copper, 5.87% lead, and 1.53% zinc.

The company's Glover smelter and refinery at Glover had a defined capacity of 125,000 short tons (113,400 mt) of lead. In 1989, Asarco reported it produced 118,800 short tons (107,800 mt), a reduction of about 4% from that of 1988. The company had the mine capacity to provide all the lead concentrates required for its Glover smelter.

Cominco American and Dresser Industries Inc., in an equal share joint venture, operated the Magmont Mine south of Bixby. Cominco, the operating partner, is a wholly owned subsidiary of Cominco Ltd., Vancouver, British Columbia. Copper, lead, and zinc were produced at the Magmont. The Cominco 1989 annual report to stockholders indicated about 960,000 metric tons of ore was milled yielding about 81,000 metric tons of lead concentrate, 13,400 metric tons of zinc concentrate, and 1,300 metric tons of copper concentrate. Average ore grades were 6.8% lead, 1.0% zinc, and 0.3% copper. Silver also was recovered.

Surface drilling at the Magmont did not yield new lead mineralization. The mine's ore reserves continued to be rapidly depleting. Cominco reported that the ore was expected to be exhausted, and the Magmont operation shut down sometime in 1991 or 1992. The company hoped to forestall the eventuality of laying off its nearly 200 employees by continued exploration drilling in the Viburnum Trend and elsewhere in Missouri. Layoffs seemed inevitable, however, given the 8- to 10-year lead time necessary to identify a deposit, develop a mine and reclamation plan, secure the appropriate State and Federal permits, complete the mine construction phase, and begin ore production.

During 1989, there were no further developments on the zinc deposits in the Joplin area. Mattes Brothers Construction Co. had completed the permitting procedures for the Hyde Park Mine near Duenweg in 1988. Startup, however, was idled while adequate project financing was sought.

In February, Cyprus Minerals Co. announced that it had reached an agreement in principle to acquire the assets of Warrenton Refining Co., a subsidiary of Anshutz Corp. of Denver, CO. The cost of the acquisition was not disclosed. Warrenton, with a refinery in Truesdale, MO, and headquarters in New Canaan, CT, has been a major domestic producer of copper ingots and wire bars. The modern, 300,000-square-foot secondary refinery employed 70 people. Assets sold in the transaction included plant and equipment, two reverberatory furnaces, casting facilities, laboratory, and 25 acres of land. Monthly output, according to Cyprus, had been 6 million pounds (2,700 mt) of copper scrap. Refined products were sold to brass mills, foundries, and hot-rolling mills.

Iron Ore and Iron Oxide Pigments.—In 1989, iron ore shipments and value from Missouri's only active iron ore mine increased 30% and 32%, respectively. Nearly 1.1 million metric tons (1.1 million long tons) were shipped from the Pea Ridge Mine, the Nation's only underground iron ore operation. Pea Ridge Iron Ore Co. operated the mine and pelletizing plant throughout the year. Operations commenced at Pea Ridge in 1964. Pea Ridge sold most of its production to the Granite City Steel Div. of National Steel Corp. at East St. Louis, IL. Most of the production was olivine-enriched pellets made from magnetite concentrate. Other production was largely magnetite concentrate used as heavy media in coal cleaning.

Fluor Corp., the San Francisco-based parent company of Pea Ridge, continued to host inquiries from parties interested in buying the iron ore operation. In 1987, Fluor announced intentions to sell Pea Ridge as it had many of its other natural resource investments, including gold and zinc operations. At yearend 1989, several prospective buyers were rumored, but a

solid purchase commitment was not apparent.

Interest in the Pea Ridge deposit's REE and gold mineral potential continued to grow. Industry, academia, and government continued various studies, ranging from identifying similar new targets elsewhere in Missouri to the DGLS's detailed underground mapping and sampling and the Bureau of Mines' rare-earth-oxide beneficiation.

Pea Ridge also produced crude iron oxide pigments. Production and value increased significantly—nearly 138% and 95%, respectively. Pea Ridge pigments and ferrite are sold for use in manufacturing ceramic magnets. Heavy-medium magnetite was produced for coal cleaning uses.

Manufactured iron oxide pigments were produced in St. Louis and Washington Counties. Production increased 4%, but value decreased 7%.

[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN. Assistance in the preparation of the chapter was given by Wanda J. West, editorial assistant.

[2] Geologist, Missouri Dept. of Nat. Resour., Div. of Geol. and Land Survey, Rolla, MO.

[3] Highway and Heavy Construction Magazine. Market Update: Battle Lines Form Over Gridlock, Gas Tax. V. 132, No. 3, Mar. 1989, p. 34.

[4] Hagni, R. D., and R. T. Brandom. Comparison of the Boss-Bixby, Missouri, and Olympic Dam, South Australia, Ore Deposits and the Potential for These Deposits in the Mid-Continent Region. Paper in Proceedings Volume, North American Conference on Tectonic Control of Ore Deposits and the Vertical and Horizontal Extent of Ore Systems, ed. by G. Kisvarsanyi and S.K. Grant. (Proc. Conf. Univ. of Missouri, Rolla, MO, Oct. 6–8, 1987). Univ. of Missouri at Rolla, 1988, pp. 333–345.

[5] Paulson, D. L. (BuMines). Private communications, 1989; available upon request from L. E. Esparza, BuMines, Minneapolis, MN.

[6] St. Louis Post-Dispatch. Fluor to Evaluate Stake in Doe Run. Mar. 30, 1989.

[7] Homestake Mining Co. (San Francisco, CA). 1989 Form 10K Annual Report. 38 pp.

[8] ——. 1989 Annual Report to Stockholders. 40 pp.

[9] Work cited in footnote 6.

[10] ASARCO Incorporated (New York, NY). 1989 Annual Report to Stockholders. 40 pp.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Noranda Aluminum Inc.	New Madrid, MO 63869	Plant (smelter)	New Madrid.
Barite:			
Baroid Drilling Fluids Inc.	Box 1675 Houston, TX 77251	Mine and plant	Washington.
DeSoto Mining Co.	Box 35 Richwoods, MO 63071	do.	Do.
General Barite Co.	119 West Clement St. De Soto, MO 63111	Mines and plant	Do.
Cement:			
Continental Cement Co. Inc.	120 South Central Ave. Suite 1040 St. Louis, MO 63105	Quarry, clay pit, plant	Ralls.
Dundee Cement Co., a division of Holderbank Financiere Glaris SA.	Box 67 Clarksville, MO 63336	do.	Pike.
Lone Star Industries Inc.	Box 120014 Stamford, CT 06912-0014	Quarry and plant	Cape Girardeau.
Missouri Portland Cement Co., a subsidiary of Cementia Holdings, A.G.	7711 Carondelet Ave. Clayton, MO 63105	Plant	Jackson.
River Cement Co., a subsidiary of IFI International of Italy (Instituto Finanziario Industriale S.p.A.)	12700 Southfork Rd. St. Louis, MO 63128	Quarry and plant	Jefferson.
Clays:			
Buildex Inc.	Box 15 Ottawa, KS 66067	Pit and plant	Platte.
Dillon Clay Mining Co.	Box 115 St. James, MO 66559	Pits	Crawford.
A. P. Green Industries Inc.	1018 East Breckenridge St. Mexico, MO 65265	Pits and plants	Audrain, Callaway, Crawford, Franklin, Gasconade.
Southern Clay Inc. (Lowe's Inc.)	Box 1086 Cape Girardeau, MO 63701	do.	Stoddard.
Iron ore:			
Pea Ridge Iron Ore Co., a subsidiary of Fluor Corp.[1]	Route 4 Sullivan, MO 63080	Underground mine and plant	Washington.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Iron oxide pigments (finished):			
Columbian Chemicals Co.	1600 Parkwood Circle Suite 400 Atlanta, GA 30339	Plant	St. Louis.
Lead:			
ASARCO Incorporated:[2]	Route 1, Box 202C Bunker, MO 63629		
Glover smelter	do.	Smelter	Iron.
Sweetwater Unit	do.	Underground mine and plant	Reynolds.
West Fork Unit	do.	do.	Do.
Cominco American Incorporated Magmont Mine[2]	Bixby, MO 65439	do.	Iron.
The Doe Run Co.:[2]	11885 Lackland Rd. Suite 500 St. Louis, MO 63146		
Buick	do.	Underground mine, plant, smelter	Do.
Casteel	do.	Underground mine and plant	Do.
Fletcher	do.	do.	Reynolds.
Herculaneum smelter	do.	Smelter	Jefferson.
Viburnum No. 28	do.	Underground mine and plant	Iron.
Viburnum No. 29		do.	Washington.
Lime:			
Ash Grove Cement Co.	3820 South Lone Pine St. Springfield, MO 65804	Plant	Greene.
Do.	do.	Quarries	Various.
Mississippi Lime Co.	7 Alby St. Alton, IL 62002	Plant	Ste. Genevieve.
Resco Products of Missouri Inc.	Box 1110 Clearfield, PA 16830	Quarry and plant	St. Francois.
Perlite (expanded):			
Brouk Co.	1367 South Kingshighway Blvd. St. Louis, MO 63110	Plant	St. Louis.
Georgia-Pacific Corp.	133 Peachtree St., NE. Atlanta, GA 30303	do.	Crawford.
Sand and gravel:			
Construction (1988):			
Holliday Sand & Gravel Co., a subsidiary of List & Clark Construction Co.	6811 West 63d St. Overland Park, KS 66204	Dredges and plants	Clay.
Limited Leasing Co., a subsidiary of St. Charles Sand Co.	Route 1, Box 158 Hazelwood, MO 63042	do.	St. Louis.
Winters 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.[3]	Route 1, Box 158 Hazelwood, MO 63042	Pit and plant	Do.
Masters Bros Silica Sand Co., a subsidiary of Bussen Quarries Inc.	Route 1, Box 204 Pevely, MO 63070	Dredge and plant	Jefferson.
Unimin Corp.	258 Elm St. New Canaan, CT 06840	Mine and plant	Do.
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	Dredge and plant	St. Louis.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Slag (Iron and steel):			
International Mill Service Co.	1818 Market St. Philadelphia, PA 19103	Plant	Jackson.
Stone:			
Crushed:			
Granite:			
GAF Chemicals Corp.	Box 186 Annapolis, MD 20104	Quarry and plant	Iron.
Quality Aggregate Co.	Box 307 Piedmont, MO 63957	do.	Wayne.
Limestone-dolomite:			
Bussen Quarries[4]	5000 Bussen Rd. St. Louis, MO 63129	Quarries and plants	Jefferson and St. Louis.
Martin Marietta Aggregates	Box 30013 Raleigh, NC 27622	do.	Andrews, Daviess, Gentry, Harrison, Holt, Jackson, Mercer, Nodaway, Worth.
Tower Rock Stone Co.	Box 69 Columbia, IL 62236	Quarry and plant	Ste. Genevieve.
Fred Weber Inc.	7929 Alabama Ave. St. Louis, MO 63111	Quarries and plants	Jefferson, St. Charles, St. Louis.
West Lake Quarry & Material Co.	13570 St. Charles Rock Rd. Bridgeton, MO 63044	do.	Cape Girardeau, Henry, Jefferson, St. Louis, Scott.
Dimension:			
Granite:			
Missouri Red Quarry Inc.	Box 516 Elberton, GA 30635	Quarry and plant	Iron.
Sandstone:			
Beavers Stone Co.	Box 322 Camdenton, MO 65020	do.	Camden.
Vermiculite (exfoliated):			
Brouk Co.	1367 South Kingshighway Blvd. St. Louis, MO 63110	Plant	St. Louis.
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	do.	Do.

[1] Also crude iron oxide pigments.
[2] Also copper, silver, and zinc.
[3] Also construction sand and gravel.
[4] Also crushed sandstone.

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 1989 nonfuel mineral production value rose to $599.2 million, an increase of nearly 4% from that of 1988 and almost 63% more than in 1987. Gains in the production value for gold, molybdenum, platinum-group metals, and crushed stone more than offset the decline in values for copper, construction sand and gravel, and silver.

Copper was the leading commodity in terms of value, followed by gold, platinum-group metals, molybdenum, and silver. Metallic minerals—copper, gold, iron ore, lead, molybdenum, platinum-group metals, silver, and zinc—accounted for 84% of the State's nonfuel mineral production value, which nationally ranked 18th, the same as in 1988.

TRENDS AND DEVELOPMENTS

Metallic mineral production continued strong in Montana's mineral economy. Total production values for metals increased more than 4%. The year saw the opening of two new gold mines—the Mineral Hill Mine near Jardine and the Beal Mountain Mine near Anaconda. Metals exploration remained extremely active. The prime exploration target was gold; however, several companies showed interest in base metals. A diversity of industrial minerals continued to be produced in the State. Total production value of industrial minerals increased slightly over that of 1988.

EMPLOYMENT

According to the Montana Department of Labor and Industry, overall mining employment, including petroleum and coal industry workers, was 6,200, the same as that reported in 1988. Metal mining employment increased to 2,600 from the 2,200 employee total for 1988. Average weekly earnings for Montana's mineral industry workers increased to $581 from the $564 figure recorded in 1988. Mineral industry workers were the second highest paid group in the private nonfarm industries wage sector.

REGULATORY ISSUES

State and Federal environmental officials announced a $62.5 million proposal to clean up the Warm Springs Ponds Superfund site that resulted from decades of mining, milling, and smelting waste being dumped into Silver Bow Creek, Deer Lodge County. The ponds were the result of a series of three tailings dams built by The Anaconda Co. to prevent mining 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 was no longer being allowed. The U.S. Environmental Protection Agency (EPA) proposed building a fourth pond. Another option, proposed by the Atlantic Richfield Co. (ARCO), was to raise the height of the existing ponds and to build a new water-treatment facility. The tailings pond sites (a high-priority for cleanup) are administered by ARCO, which, as a responsible party, would have to pay for the cleanup. Officials were soliciting public comment on the feasibility study. The Warm Springs ponds are part of the greater Butte-Silver Bow-Clark Fork Superfund site, one of the country's largest.

In May, The Montana State Board of Health granted Rhone-Poulenc Chemical Co.'s phosphate plant, west of Butte, a 1-year exemption from State air pollution regulations. In March, the EPA had filed a civil complaint that the former Stauffer Chemical Co. plant had violated local opacity standards under the Federal Clean Air Act. Rhone-Poulenc said that, by the summer of 1990, it would install new pollution control equipment that would eliminate the EPA-alleged air pollution violations. During the exemption period, the company must monitor plant emissions and evaluate possible danger to residents living near the plant.

EXPLORATION ACTIVITIES

Mineral exploration in Montana remained strong. The Department of State Lands reported a total of 210 active exploration permits in 1989, up from 192 in 1988. Of the 210 permits, 19 were new and the remainder renewals. As of August, the department issued a cumulative total of 1,500 Small Miner's Exclusion Statements, or 234 more than in 1988. The exclusion applies to operations under 100 metric tons per day (mt/d) or 36,500 tons per year. Of the 1,500 total, all but 23 could be defined as extremely small-scale and/or recreational projects.

The number of new operating plans filed with the U.S. Forest Service rose to 391, up from 246 in 1988. As of October 1, the U.S. Bureau of Land Management (BLM) reported that 13,084 new mining claims had been filed, contributing to a total of 59,659 active unpatented mining claims in the State. During 1989, BLM granted 5 patents for 118 claims covering 2,646 acres in Montana. As of October 1, 12 applications had been filed for patents covering 9 lode claims, 1 mill site, and 4 placers.

Highlighting exploration in Montana was a joint venture by Noranda Exploration Inc. and Crown Butte Resources Ltd. near Cooke City, Park County. As a result of a drilling program, the companies announced discovery of additional copper, gold, and silver reserves in the New World mining district. The district contains two deposits that could be mined by open pit and an underground reserve.

Chrome Corp. of America, a subsidiary of Boulder Gold N.L., conducted a sizable predevelopment and ore definition program at its Mountain View chromite property in the Stillwater Complex, Stillwater County. Early results indicated a high potential for development.

TABLE 1

NONFUEL MINERAL PRODUCTION IN MONTANA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	metric tons	26,199	$98	91,802	$1,416	95,743	$1,835
Gem stones		NA	1,302	NA	1,602	NA	2,500
Gold[3]	kilograms	7,290	104,984	9,175	129,291	11,623	142,965
Gypsum	thousand short tons	24	W	27	W	W	W
Lead[3]	metric tons	W	W	8,266	6,768	W	W
Platinum-group metals	kilograms	W	W	W	W	6,280	85,318
Sand and gravel (construction)	thousand short tons	e6,800	e18,800	7,984	20,225	e5,800	e13,900
Silver[3]	metric tons	185	41,619	192	40,457	194	34,367
Stone (crushed)	thousand short tons	1,463	3,585	e1,800	e4,500	2,846	9,718
Talc and pyrophyllite	do.	356,231	11,334	r458,166	r14,524	500,424	12,718
Zinc[3]	metric tons	W	W	18,935	25,130	W	W
Combined value of barite (1987, 1989), cement, clay (fire clay), copper, graphite (natural 1988–89), iron ore, lime, molybdenum, peat, phosphate rock, sand and gravel (industrial), stone (dimension), vermiculite, and values indicated by symbol W		XX	186,456	XX	r332,630	XX	295,918
Total		XX	368,178	XX	576,543	XX	599,239

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data, value included with "Combined value" figure. 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.

Reportedly, the company was looking for a partner to help finance the estimated $150 million cost for the mine, refinery, and necessary infrastructure. Also in the Stillwater Complex, International Platinum drilled its Picket Pin property.

Orvana Resources Corp. continued exploration on its Libby gold project, and Cominco American Resources drilled in the Sylvanite District along the Yaak River, Lincoln County. ASARCO Incorporated drilled its J. F., Trout Creek, and Minton Pass properties, as well as the Ross Point claims. Others that drilled in the northwestern part of the State included Santa Fe Pacific Mining Co., Western Gold Exploration & Mining Co. (WestGold), and United States Borax & Chemical Corp.

In the Helena region, the joint venture of Inland Gold and Silver Corp. and N. A. Degerstrom Inc. continued exploration at the Big Blackfoot property, a newly acquired gold property. The project, near Lincoln in Lewis and Clark County, is amenable to open pit mining and heap-leach technology. Phelps Dodge Corp. and Addwest Gold Inc. drilled the 7-Up Pete project and in the McDonald Meadows area. The joint venture of Sindor Resources Inc. and Westmont Gold Inc. drilled on its Big Indian property. Cominco American Resources continued to drill and define ore body limits at the Sheep Creek massive sulfide deposit, north of White Sulfur Springs, Meagher County. Gold Fields Mining Corp. entered the predevelopment stage on its gold deposits near Elkhorn and planned to drive a decline to further investigate the geology and metallurgy.

Mascot Silver-Lead Mines announced signing a lease agreement with Pegasus Gold Inc. in which Pegasus will explore Mascot's Argentine and Silver Chief mining claims near Pegasus' Montana Tunnels Mine.

In the Butte-Anaconda area, Chevron Resources Co. drilled on the Southern Cross property. In the Highlands area, BHP-Utah International explored in Camp Creek and adjacent drainages. On the west side of the Tobacco Root Mountains, Newmont drilled on its Antimony Creek property; Noranda and Gold Fields had projects in Bevins Creek; WestGold drilled Goodrich Gulch; and Goldstream Corp. trenched and drilled California Gulch.

LEGISLATION AND GOVERNMENT PROGRAMS

Effective October 1, new legislation requires any small miner to obtain an operating permit from the Montana Department of State Lands prior to using cyanide or a cyanide compound to recover metallic minerals from ore. Applications for the permit must include an operating plan and a reclamation plan tailored to the size of the operation and site-specific conditions. Also, a new law requires that small placer operations post reclamation bonds of $5,000 per site and do reclamation work.

The State's Abandoned Mine Reclamation Bureau began a program to reclaim an estimated 3,000 defunct hardrock sites in Montana abandoned before 1977. The program would be administered by the Department of State Lands and funded by a Federal tax on Montana coal producers. Reclamation of those sites

already identified was expected to take more than one decade to complete.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Aluminum.—The quantity of aluminum produced in Montana remained virtually the same as in 1988, but the value dropped almost 20%. Columbia Falls Aluminum Co. reportedly operated its aluminum reduction plant in Flathead County near the annual rated capacity.

Antimony.—United States Antimony Corp. produced antimony oxide and sodium antimonate at its refinery near Thompson Falls, Sanders County; antimony metal and sulfide concentrates were purchased on contract from China.

Copper.—Copper production dropped more than 18% in quantity and 11% in value from that of 1988. Production was reported from seven mines in six counties; Montana ranked forth in the Nation in copper output in 1989.

The State's leading producer was Montana Resources Inc.'s Continental Pit at Butte, Silver Bow County. During 1989, Asarco purchased 49% of Montana Resources' copper-molybdenum operation for $100 million. Employees at Asarco's Troy Unit, the State's second largest copper producer, voted to remain nonunion. The 8,500 mt/d Lincoln County copper-silver mine operated at capacity.

Gold.—Gold production in Montana increased by almost 27% in quantity and by nearly 11% in value over that of 1988; the State again ranked fifth in the Nation for gold production. Production was reported from 12 lode mines in 8 counties.

Two new gold mines began production. One was the Mineral Hill gold mine, a joint venture of Homestake Mining Co. and American Copper & Nickel Co., a subsidiary of Inco Ltd. The 600 mt/d underground mine at Jardine, Park County, was the only mine in the State depositing dry tailings. Processing included vat leaching, followed by Merrill-Crowe zinc precipitation. Pegasus Gold began production at its Beal Mountain open pit, heap-leach gold operation at German Gulch near Anaconda, Silver Bow County. The company began exploring another ore body adjacent to the operation.

Placer Dome Inc.'s Golden Sunlight Mine near Whitehall, Jefferson County, ranked 1st in the State and 18th in the Nation in gold production in 1989. The company submitted expansion plans to the Montana Department of State Lands that would result in increased mine life and employment.

Pegasus continued to produce gold and silver from its Zortman-Landusky Mine in the Little Rockies, Phillips County. The seasonal operation was the State's 2d largest gold producer and ranked 20th in the Nation for production in 1989. Ore production dropped owning to increasing haulage distances. The company was researching the feasibility of operating a leach pad throughout the winter. The company drilled and identified additional reserves in the Queen Rose (Landusky) area.

Pegasus announced that results of a drilling program at the Montana Tunnels gold mine indicated that the periphery of the ore body was not as uniform as previously thought. This resulted in a decrease in estimated ore grade and tonnage and an increase in operating costs. Based on the new data, the company completed a revised mine plan for the Jefferson County mine, Montana's third largest gold producer in 1989.

Pegasus purchased Pangea Resources Ltd.'s Paupers Dream (Basin Creek) gold mine and adjacent claims for a reported $26 million. Company plans for the Jefferson County open pit mine included a possible new heap-leach pad and development of additional reserves for the State's fourth largest gold producer.

In Fergus County, the joint venture of Addwest Gold Inc. and Canyon Resources Corp. continued gold production at the open pit, heap-leach Kendall Mine near Lewiston, the State's fifth largest gold producer. The Department of State Lands issued an amended permit that allowed for expansion, including construction of a new heap-leach pad to accommodate gold and silver ores from several open pits within the expanded permit boundary. Canyon Resources announced its intentions to purchase Addwest Gold, a subsidiary of Addwest Resources Inc., a Kentucky-based coal mining company. The purchase would give Canyon Resources 100% ownership of the Kendall Mine.

Blue Range Mining Co. was in the process of expanding its Gies gold mine, near Giltedge, in the Judith Mountains, Fergus County. The company completed a decline and considered building a shaft to develop the lower extensions of the ore body. Ore was crushed on-site and shipped to a flotation mill at the former U.S. Gypsum plant near Heath. Blue Range also started a 500-foot decline to further delineate the ore body at its developing Turtle Winza Mine in the Giltedge mining district.

The joint venture of Cusac Industries and Gulf Titanium Ltd. continued to produce at the Cruse-Belmont gold mine in the Marysville area, Lewis and Clark County. The small underground mine began full production after the companies contracted a 100 mt/d mill to process the ore. Other mines reporting gold production included New Butte Mining's Butte Hill Mine, Silver Bow County; Asarco's Troy Unit, Lincoln County; and Black Pine Mining Co.'s Black Pine Mine, Granite County.

Chelsea Resources Ltd. suspended production at its Spotted Horse underground gold mine, northeast of Lewistown in Fergus County. The 2900 Development Corp., an affiliate of Chicago Mining Co., continued development work on the Atlantic-Pacific mining operation in the Tobacco Root Mountains near Pony. The company was building a custom mill and planned to develop other properties in the area.

According to the Montana Bureau of Mines and Geology, placer gold production occurred at several localities. Some of the larger known placer operations were on Quartz Creek and Cedar Creek in the Superior area, Mineral County; on Marion Creek and McCormick Creek in Ninemile drainage, Missoula County; various gulches in the Big Belt Mountains, Broadwater and Meagher Counties; Sauerkraut Creek and Lincoln Creek, Lewis and Clark County; and the Fish Creek drainage, Silver Bow County.

Iron Ore.—Iron ore was produced by Hallet Minerals Co. at its Black Butte Mine near White Sulfur Springs, Meagher County. Production dropped 20% from that of 1988. The product was used in-State in the manufacture of cement.

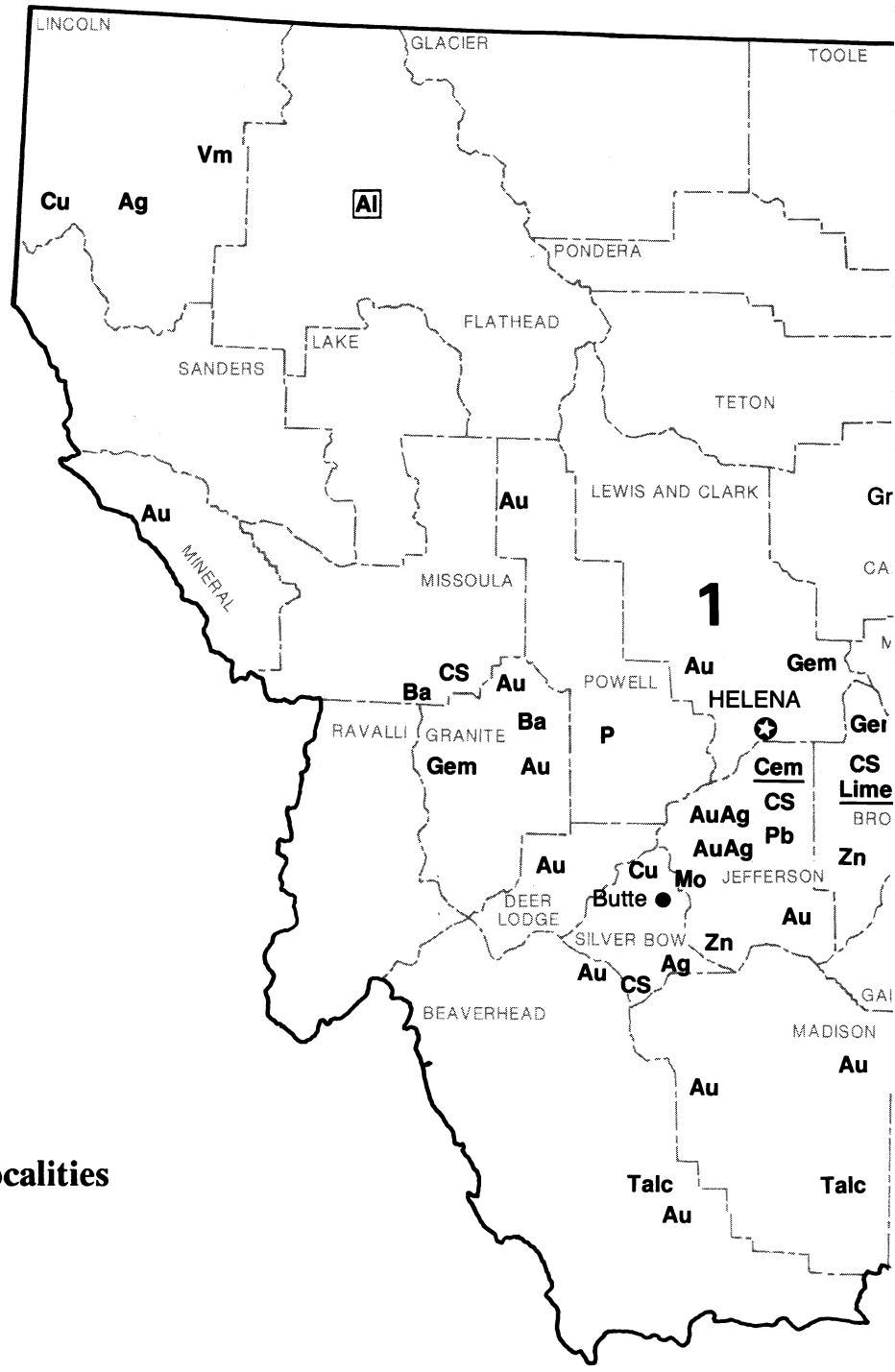
Lead.—Lead production dropped in both quantity and value from that of 1988. Montana ranked fourth nationally in 1989. Lead was recovered as a byproduct from six base and precious-metal mines in six counties; the bulk of

LEGEND

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

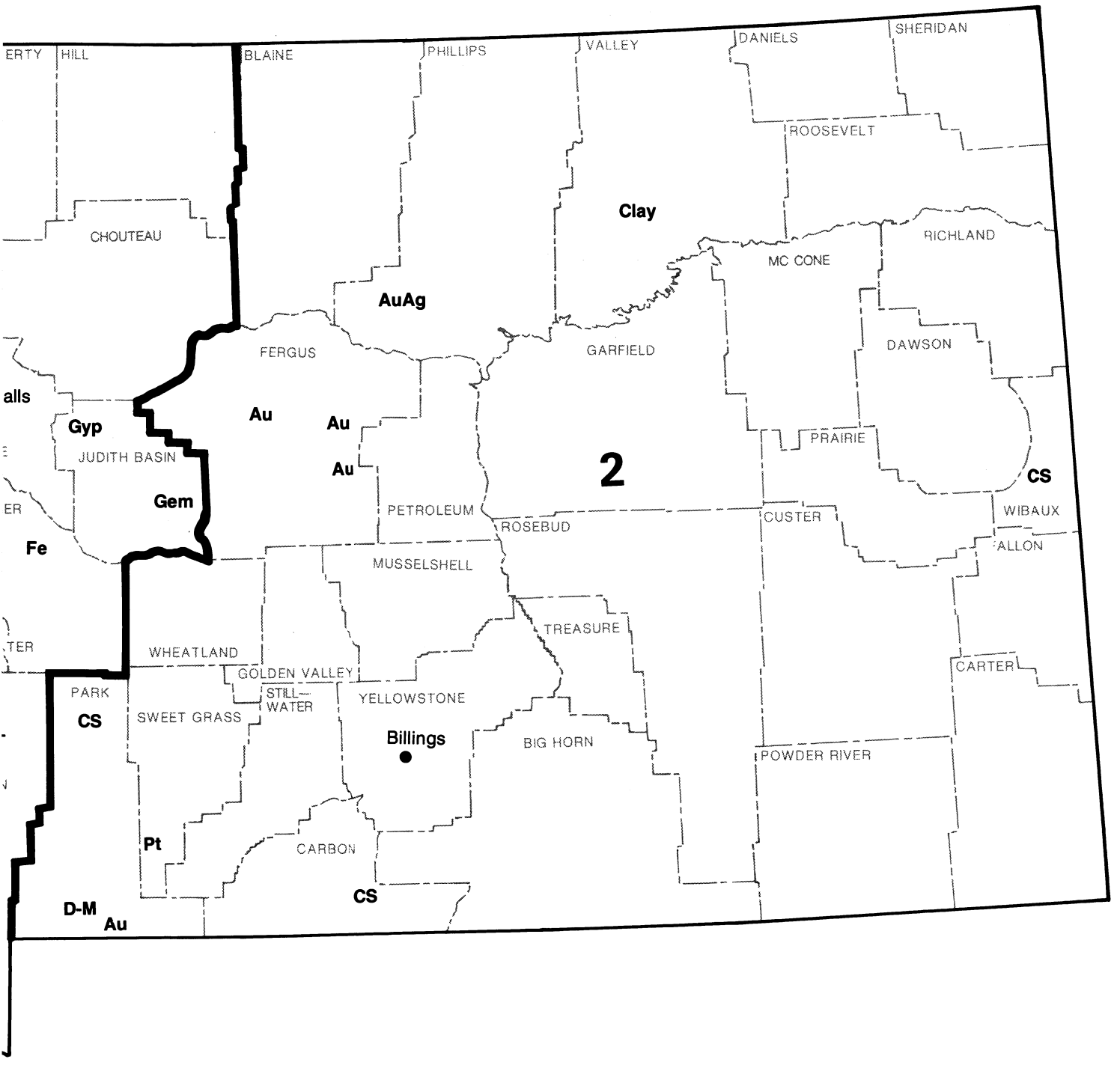
MINERAL SYMBOLS

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

ANA


ERTY
HILL
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PHILLIPS
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DANIELS
SHERIDAN
ROOSEVELT
Clay
CHOUTEAU
RICHLAND
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FERGUS
GARFIELD
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PRAIRIE
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CUSTER
WIBAUX
Fe
MUSSELSHELL
ALLON
TREASURE
TER
WHEATLAND
CARTER
GOLDEN VALLEY
PARK
STILL-
WATER
YELLOWSTONE
CS
SWEET GRASS
Billings
BIG HORN
POWDER RIVER
Pt
CARBON
CS
D-M
Au

the production came from Pegasus' Montana Tunnels Mine, Jefferson County.

Molybdenum.—The quantity of molybdenum produced increased by nearly 9% and the value rose by almost 38% from that of 1988. 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 rose in both quantity and value from that of 1988. Stillwater Mining Co. increased production at its Stillwater platinum-palladium mine, the Nation's only producer of platinum-group metals, to 1,220 mt/d. Concentrates were shipped to Belgium for processing. The underground mine near Nye, Stillwater County, utilized a 13.5-foot-diameter tunnel-boring machine to drive footwall laterals that developed the ore zone at 200-feet intervals. With it, development progressed rapidly. The ore also contained traces of gold and rhodium. Chevron Resources and Manville Corp., partners in the endeavor, bought out the third partner, LAC Minerals Ltd., in late 1988 for a reported $40 million. Stillwater Mining wanted to build a smelter near the mine near Nye but encountered some opposition. The Department of State Lands was reviewing the proposal. Stillwater Mining obtained necessary permits to explore for additional platinum-group metals at its East Boulder project, about 15 miles from the present mine.

Silver.—Although the quantity of silver produced in 1989 remained relatively the same, value dropped about 15% from that of 1988. The State produced nearly 10% of the Nation's silver and retained its ranking as the Nation's third largest silver producer. Output was reported from 11 mines in 7 counties.

Asarco's Troy copper-silver mine in Lincoln County was the State's largest silver producer and the seventh ranked silver-producing mine in the Nation. According to Asarco's 1989 annual report, the Troy Unit produced 3.6 million troy ounces of silver and 16,500 tons of copper from 2.7 million tons of ore.

Pegasus produced silver as a byproduct at its Montana Tunnels zinc-gold mine, Jefferson County. The mine was the State's 2d largest producer and ranked 17th in the Nation for silver production. The State's 3d largest and the Nation's 19th ranked silver producer was Montana Resources' Continental Pit at Butte, Silver Bow County. Other major silver-producing mines included New Butte Mining's Butte Hill zinc-silver mine in Silver Bow County and Pegasus' Zortman-Landusky gold mine, Phillips County.

Black Pine Mining's Black Pine silver mine, Granite County, operated at a very reduced production rate until midsummer, when it ceased operation. At yearend, the company had not announced a decision regarding the future of the property. Asarco's Rock Creek silver-copper project in the Cabinet Mountain Wilderness, near Noxon, Sanders County, continued in the permitting stage. An environmental impact statement was being drafted, and an agreement had been reached on design parameters of the proposed tailings facility. The Department of State Lands and the U.S. Forest Service questioned the ability of the mine's tailings dam structure to withstand the effects of an earthquake.

Noranda Inc. and Montana Reserves Co. began driving an 18,000-foot exploration decline at their Montanore (Rock Lake Deposit) joint venture near Libby in Sanders County. Production from the silver-copper deposit, purchased from U.S. Borax & Chemical in 1988, was anticipated in 1992. Montana Reserves announced intentions to transfer its 45%interest to Sunshine Mining Co. CoCa Mines Inc. delayed plans for opening the Hog Heaven silver-gold property, Flathead County, pending development of the Golden Sunbeam Mine in Idaho.

Zinc.—Although the quantity of zinc produced fell from that of 1988, production value increased modestly. The State ranked sixth nationally in zinc production in 1989. Pegasus' Montana Tunnels zinc-gold mine in Jefferson County was the State's leading zinc producer.

New Butte Mining operated its underground zinc-silver Butte Hill Mine in Butte, Silver Bow County. The company continued development of the noncopper leads in the upper zones of the mine. Construction of a decline was completed. This allowed the use of rubber-tired vehicles and improved ventilation. The ore was trucked to the Contact Mill in Philipsburg for processing.

Industrial Minerals

Barite.—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. Concentrate was shipped for further processing to the company's mill at Lethbridge, Ontario, Canada.

Cement.—Although the quantity of cement production dropped slightly, the value of Montana's cement increased by 4% from that of 1988. Portland cement was produced by Ideal Basic Industries 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. Portland cement produced in the State was used by ready-mixed concrete companies (65%), other contractors (14%), concrete product manufacturers (13%), and miscellaneous customers, building material dealers, highway contractors, and government agencies (8%). Raw materials consumed in cement manufacture were locally mined clay, gypsum, iron ore, limestone, sandstone, and silica. 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 Mine near Silver Star, Madison County. The chlorite was sold for many of the same industrial applications for which talc was used.

Clays.—Clay production increased 5% in quantity and almost 30% in value over that of 1988. 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. Common clay, produced by three companies in Gallatin and Jefferson Counties, was used in cement and pottery. Fire clay was produced by one company in Deer Lodge County. Shale was mined in Jefferson and Gallatin Counties; an expanded shale and construction products plant was operated at Three Forks.

Gem Stones.—The value of gem stone production in 1989 jumped 56% from that of 1988. The State ranked fifth in the Nation in natural gem stone production. Several sapphire mines continued both commercial and hobbyist production, with some production targeted for international sales.

The Gem Mountain Sapphire Mine operated on the West Fork of Rock Creek, near Skalkaho Pass, Granite County. Also in Granite County, the Skalkaho Grazing Association sapphire mine, a new operation, began production. Sapphires were produced at Eldorado Bar and French Bar Placer in Lewis and Clark County. Eldorado Bar was the only mine to allow fee digging. In Judith Basin County, at the famous Yogo Dike, Roncor Inc. and Vortex Mining Co. operated sapphire mines. Roncor processed sapphire-bearing material from Yogo Creek and ran old tailings from the American Mine through its washing plant. Vortex mined material from recently discovered sapphire-bearing breccia south of the American Mine.

Gypsum.—Gypsum production in Montana dropped both in value and quantity from that of 1988. Maronick Construction Co. Inc. closed its surface gypsum mine at Raynesford, Judith Basin County. The mine, the last gypsum producer in Montana, shipped its product to the Ash Grove cement plant at Montana City and to the Ideal Basic cement plant in Trident.

Lime.—Although lime production dropped slightly from that of 1988, production value increased 9%. Continental Lime Ltd. of Canada, parent company of Continental Lime Inc., was purchased by Graymont Inc. of Canada. The Indian Creek quicklime plant near Townsend, Broadwater County, continued to operate as Continental Lime Inc. The Great Western Sugar Co. operated a plant in Yellowstone County, and Holly Sugar Corp. produced quicklime at its plant in Richland County.

Peat.—The quantity and value of Montana peat production in 1989 remained essentially the same as in 1988. Bulk peat was produced by Martins Peat Inc. at Swan Lake, Flathead County. Packaged peat was produced by Farmer's Plant Aid Corp. near Hamilton, Beaverhead County.

Phosphate Rock.—Phosphate rock production increased nearly 43% in quantity and 41% in value from that of 1988. Following construction of new loading facilities and a washing and dry-grinding plant, Cominco American Resources Inc. expanded production at its Warm Springs underground phosphate mine in Powell County. The phosphate was shipped by rail to Cominco's fertilizer plant at Warfield, British Columbia, Canada, where sulfuric acid from the company's Trail zinc smelter was used to make fertilizer.

Rhone-Poulenc Chemical Co.'s Silver Bow elemental phosphorous plant, west of Butte, operated at capacity. The former Stauffer Chemical Co. plant processed phosphate rock from the company's Wooley Valley Mine in southeastern Idaho.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the 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 estimates for 1987 and 1989. Estimated sand and gravel production for 1989 dropped more than 27% in quantity and more than 31% in value from that reported in 1988.

Industrial.—Production of industrial sand and gravel dropped both in quantity and value from that of 1988. Output was reported by Rhone-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 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 1987 and 1989 and estimates for 1988.

Crushed.—Crushed stone production in 1989 increased 58% in quantity and more than doubled the value estimated for 1988. Production was reported by 11 companies and governmental agencies in 9 counties. Carbon, Gallatin, Jefferson, and Yellowstone Counties accounted for 96% of the State's total production. Five companies accounted for 95% of the quantity produced and 94% of the value. The bulk of the crushed stone produced was limestone, which accounted for more than 94% of the total in 1989, followed by sandstone, quartzite, and traprock. Limestone for manufacturing cement was the largest use of crushed stone in Montana in 1989.

Dimension.—The Livingston Marble & Granite Works mined travertine building stone from a quarry north of Gardiner, Park County, and marketed the product from the company plant at Livingston.

Sulfur.—Montana Sulphur & Chemical Co. and the Farmers Union Central Exchange recovered sulfur as a byproduct from petroleum refining at Laurel, Yellowstone County. The quantity of sulfur produced remained nearly the same, but the value rose 4% from that of 1988.

Montana Sulphur & Chemical applied to the State for a permit to build a fertilizer plant, a small hydrogen plant, and other changes in its operation in Lockwood, outside Billings.

TABLE 2

MONTANA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse and fine aggregates: Other construction materials[2]	505	1,517
Other miscellaneous uses[3]	2,084	7,278
Unspecified:[4]		
Actual	257	923
Total	2,846	9,718

[1]Includes limestone, sandstone, quartzite, traprock, volcanic cinder and scoria, and miscellaneous stone.
[2]Includes stone used in riprap and jetty stone, concrete and bituminous aggregate (coarse), stone sand (concrete and bituminous mix or seal), graded road base or subbase, and unpaved road surfacing.
[3]Includes stone used in other agricultural uses, cement manufacture, and flux stone.
[4]Includes production reported without a breakdown by end use.

Talc.—Talc production continued to expand in the southwestern part of the State. The quantity of talc produced increased more than 9%, but the value dropped more than 12% from that of 1988. Pfizer Inc. announced plans to build a totally automated beneficiation plant at its Treasure Chest Mine, south of Dillon, Madison County. The company reported it had some good drill indications at its Stone Creek deposit. Montana Talc's Johnny Gulch Mine saw a slight increase in production. The company reported promising results from its exploration program 10 miles south of Dillon. Cyprus Industrial Minerals produced talc at its Yellowstone and Beaverhead Mines. The Beaverhead underground mine produced cosmetic talc. At the Yellowstone Mine, the company completed an improvement program at its beneficiation plant that resulted in increased productivity and decreased production costs.

Vermiculite.—Although production dropped 7% in quantity and value from that of 1988, Montana retained its position as the Nation's second largest producer of vermiculite. W. R. Grace & Co. mined and processed vermiculite at the Rainy Creek Mine near Libby, Lincoln County. Stansbury Mining Corp. secured initial financing for an environmental impact statement on its proposed vermiculite mine near Hamilton, Ravalli County.

[1]State Mineral Officer, Bureau of Mines, Spokane, WA. He has covered the mineral activities in Montana for 2 years. Assistance in the preparation of the chapter was given by W. A. Lyons, editorial assistant.

[2]Staff field agent, Montana Bureau of Mines and Geology, Butte, MT.

TABLE 3

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.	5550 SW. Macadam Ave. Suite 300 Portland, OR 97201	Plant and quarry	Jefferson.
Ideal Basic Industries, Cement Div.	Box 8789 Denver, CO 80201	do.	Gallatin.
Copper:			
ASARCO Incorporated	Box 868 Troy, MT 59935	Underground mine and plant	Lincoln.
Montana Resources Inc.	600 Shields Ave. Butte, MT 59701	Surface mine and plant	Silver Bow.
Gem stones:			
Roncor Inc.	2056 South Barrington Ave. Los Angeles, CA 90025	do.	Judith Basin.
Vortex Mining Co.	Utica, MT 59452	do.	Do.
Gold:			
American Copper & Nickel Co. & Homestake Mining Co.	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	Phillips, Jefferson, Silver Bow.
Placer Dome Inc.	Box 678 Whitehall, MT 59759	Surface mine and plant	Jefferson.
Gypsum:			
Maronick Construction Co. Inc.	East Helena, MT 59635	Surface mine	Judith Basin.
Lead:			
Pegasus Gold Inc.	North 9 Post Suite 400 Spokane, WA 99201	Surface mine and plant	Jefferson.
Lime:			
Continental Lime Co., a subsidiary of Graymont Inc.	Box 550 Townsend, MT 59644	Surface mine	Broadwater.

TABLE 3—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Lime—Continued			
Great Western Sugar Co.	3020 State Ave. Box 30878 Billings, MT 59107	Surface mine and plant	Yellowstone.
Holly Sugar Corp.	Box 1052 Colorado Springs, CO 80901	do.	Richland.
Phosphate rock:			
Cominco American Inc.	Box 638 Garrison, MT 59731	Underground mine and plant	Powell.
Platinum-group metals:			
Stillwater Mining Co.	Star Rt. 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.
Stone:			
Crushed:			
Ash Grove Cement West Inc.	5550 SW. Macadam Ave. Suite 300 Portland, OR 97201	Quarry	Do.
Empire Sand & Gravel Inc.	Box 1215 Billings, MT 59103	do.	Yellowstone.
Ideal Basic Industries Inc., Cement Div.	Box 8789 Denver, CO 80201	Quarries	Gallatin.
Kaiser Cement Corp., a subsidiary of Hanson Trust PLC	Montana City, MT 59602	do.	Jefferson.
Weaver Stone Products Co.	Box 22745 Billings, MT 59104	do.	Carbon.
Dimension:			
Livingston Marble and Granite Works	Box 851 Livingston, MT 59047	Quarries 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, 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, Madison.
Vermiculite:			
W. R. Grace & Co., Zonolite Div.	1114 Avenue of the Americas New York, NY 10036	do.	Lincoln.
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 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 Karl Starch[1] and Raymond R. Burchett[2]

The value of nonfuel mineral production in Nebraska rose to $103.8 million in 1989, nearly a 14% increase over that of the preceding year, a record high. Sand and gravel, portland cement, and crushed stone accounted for all but a small portion of this output. No metals were mined in Nebraska. Nebraska ranked 43d among States, with one-third of 1% of the Nation's total nonfuel mineral production.

TRENDS AND DEVELOPMENTS

Nearly all of the increase in value of nonfuel mineral output in Nebraska was in sand and gravel, which also benefited from an increase in average unit price. Portland cement output and value increased only minimally, while output and value of crushed stone decreased moderately. A 3-year bridge rebuilding program in the State continued to benefit the construction industry, the principle user of Nebraska's mineral products. The number of residential units authorized for construction during the year rose more than 5% to about 6,000 units while the value of nonresidential construction fell about 4% to about $289 million. The value of State road contract awards rose nearly 6% to $284 million. The Construction Labor Research Council indicated Nebraska had the fifth lowest construction unemployment rate in the Nation in 1988.

The first commercial mining of uranium in Nebraska was stalled indefinitely by a Nebraska attorney general's ruling in September that Ferret Exploration Co. of Nebraska was a foreign corporation and not eligible to do business in Nebraska. Denver-based Ferret is 25% owned by Uraenertz, a West German corporation; 18.7% by Imperial Metals of Canada; and 10% by Korea Electric Power Corp. Ferret has spent about 10 years and $10 million developing its Crow Butte Project near Crawford in northwest Nebraska, where it believes it has an ore reserve of about 30 million pounds of U_3O_8, or enough for 20 years of operation at the proposed production rate of 500,000 pounds to 1 million pounds of unrefined yellowcake per year. Ferret proposed solution mining the 650-foot-deep deposit and has successfully operated an in situ leach pilot plant on the site for 3 years. The attorney general acted upon a complaint by a citizen's group, The Western Nebraska Resources Council, that was concerned about uranium mining's long-term impact on underground water in Nebraska. His opinion was based on Nebraska statues prohibiting foreigners from owning or leasing real estate 3 miles outside of a city's limits; limiting foreign ownership of capitol stock of a company operating in Nebraska to less than 50%; and the number of foreigners serving on a company's board of directors to less than two-thirds of the entire board. It was unclear whether the 210,000 acres in northwestern Nebraska leased by Ferret for further exploration would be affected by the ruling.

The Nebraska Department of Environmental Control immediately stopped work on a permit that would have allowed Ferret to begin commercial mining. The Nebraska Secretary of State was instructed to start action to dissolve Ferret and its subsidiary, Crow Butte Land Co., and the Dawes County attorney to effect forfeiture of mineral leases the company holds. Ferret officials indicated the company would contest the ruling and particularly any forfeiture or dissolution proceedings.

Petroleum production in Nebraska has been in decline since 1985 and, in 1989, was at the lowest level of the 1980's; natural gas production in Nebraska ended in 1986. With the exception of some production in Richardson County, the

TABLE 1

NONFUEL MINERAL PRODUCTION IN NEBRASKA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	202,963	$721	215,419	$786	224,624	$880
Gem stones		NA	10	NA	10	NA	2
Sand and gravel (construction)	thousand short tons	e10,300	e26,300	11,229	28,928	e15,200	e41,800
Stone (crushed)	do.	4,316	19,461	e4,900	e22,000	3,978	20,050
Combined value of cement, lime, and sand and gravel (industrial)		XX	43,256	XX	39,468	XX	41,085
Total		XX	89,748	XX	91,192	XX	103,817

eEstimated. NA Not available. XX Not applicable.

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

southeastern most county in Nebraska, all petroleum production in Nebraska has been in southwestern and panhandle counties. Nebraska ranked 20th among the 31 petroleum-producing States with proven reserves of about 50 million barrels of oil.

EMPLOYMENT

Mining employment remained essentially unchanged from that of 1988 at about 1,500 workers. Of these, about two-thirds worked in nonmetal mining and quarrying and about one-third in oil and gas extraction. The $419 average weekly wage in mining was substantially above the $338 average for all industries, and the $542 average weekly wage paid workers in primary metals manufacture (Omaha refinery) was among the highest paid any industrial workers in the State.

Although nonfuel mining employment was only about one-quarter of 1% of total nonagricultural employment in the State, it was the sine qua non of the construction industry and several manufacturing sectors in Nebraska.

REGULATORY ISSUES

Following a year-long study of three potential sites, a 320-acre site in Boyd County was chosen for Nebraska's proposed low-level radioactive waste disposal facility. The State had been designated to host such a facility by the Central Interstate Low-Level Radioactive Waste Compact of which Nebraska was a member along with Arkansas, Kansas, Louisiana, and Oklahoma. U.S. Ecology Inc. and its affiliate, Bechtel National Inc., selected to build and manage the site, had performed extensive geological testing of proposed sites in three counties in Nebraska before settling on the Boyd County location. The facility with a planned January 1, 1993, opening would provide for aboveground storage and would cost about $40 million. More than 95% of the volume of waste to be stored at the site was expected to be category A waste, which is waste that must be contained for 100 years. It is the least dangerous of the three low-level classes of waste. U.S. Ecology and its contractors did extensive drilling and geological research in determining the suitability of alternative sites to ensure containment of possible migration of contaminants into the ground. The proposed establishment of a low-level waste facility in Nebraska spawned a rush of public controversy and legislative proposals (see Legislation and Government Programs section).

With the proposed establishment of a low-level radioactive waste disposal facility and the possibility of uranium mining, environmental concern has run strong in Nebraska in the past several years. However, the Federal Environmental Protection Agency's first National Toxic Release Inventory Report ranked Nebraska near the bottom of a State toxic emissions list. Nebraska was one of only about a dozen States that did not practice deep ground injection of toxic materials. The largest toxic chemical release was into the air, the largest single source of which was ammonia released by three fertilizer manufacturing plants in southeastern Nebraska. Nebraska's air quality remained one of the best in the Nation.

Twenty-five landfills in Nebraska were licensed to accept asbestos. Some accepted asbestos only on a limited basis, while others were accepting it from surrounding States. Demand for such disposal was high, and three new asbestos-only landfills were on the drawing board, according to the State Department of Environmental Waste Recovery Section. Most asbestos that will go into landfills was expected to come from school districts ordered by the Federal Government to remove asbestos from pipes, walls, ceilings, etc. The State Department of Health estimated that about $1/2 billion of asbestos will be removed from Nebraska schools alone. Asbestos disposal in Nebraska was currently much less expensive than in some neighboring States such as Colorado.

Aside from the uranium mining and low-level radioactive waste disposal, the major environmental concerns in the State appeared to be the potential ground water impacts posed by solid waste disposal and nitrate contamination from agricultural fertilizer practices. Controversy remained on the question of who should bear responsibility for ground water contamination that might result from use of agricultural chemicals—the farmer, the agricultural chemical manufacturer, or the agricultural chemical dealer.

EXPLORATION ACTIVITIES

Ferret Exploration of Nebraska, during a several-year time period, leased 210,000 acres in several northwest Nebraska counties to explore for uranium. Further exploration will be related to successful development of the company's Crow Butte uranium project near Crawford.

LEGISLATION AND GOVERNMENT PROGRAMS

In January, the Nebraska Congressional Delegation introduced legislation in both Houses of Congress to designate a 76-mile stretch of the Niobrara River east of Valentine, in north-central Nebraska, a wild and scenic river. If accepted into protected status, Federal assistance could become available to maintain the river and its environment. At yearend, Congressional approval was pending.

Research continued on the manufacture of synthetic diamonds at the Walter Scott Engineering Center at the University of Nebraska—Lincoln. Industrial-grade diamond films were created by using radiowaves instead of the more traditional microwaves. Lower frequency radiowaves resulted in lower production cost and less expensive manufacturing equipment. Thin films of high-temperature superconductive material could speed electrical transmission, thereby improving communication and reducing electrical power losses.

Nebraska received $115,000 as its share of mineral revenue obtained from Federal mineral leases, ranking it 22d among the 26 States that received Federal mineral revenue shares. In Nebraska, this mineral royalty revenue was entirely from oil production.

Of several legislative proposals dealing with the handling of low-level radioactive waste considered by the Nebraska Legislature, only LB 761 was signed by the Governor. This act provided for local site-monitoring committees, required all waste storage to be above ground with zero waste release to the environment, and limited operational life of the site

to 30 years or 5 million cubic feet of waste.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Nonfuel mineral production in Nebraska consisted entirely of industrial minerals. The Nebraska Geological Survey, Conservation and Survey Division, identified 712 active mining operations in Nebraska in 1989, about one-fifth of all the quarries, pits, and mines that have ever been active in the State during the past 90 years. Of these, 658 were sand and gravel or silt pits, 28 were limestone quarries, 18 sandstone pits, and 8 clay or shale pits. Active operations disturbed about 330 acres and restored about 90 acres. During the years, mining was estimated to have disturbed nearly 43,000 acres with more than 50% of these having been reclaimed.

Cement.—A single plant produced cement in Nebraska in 1989, the Ash Grove Cement Co. plant near Louisville in Cass County. Production and value of portland cement increased just more than 3% in 1989. Output and value of masonry cement increased about 11%, but total output was small. Ideal Basic Industries Inc. closed its Nuckolls County plant in 1986. Nebraska ranked 25th among the 38 States in which portland cement was produced. Numerous plants across the State produced ready-mix concrete or cured concrete products for the construction industry.

Clays.—Output of clay increased moderately in 1989, just more than 4%, and an increase in unit price raised the value of output by nearly 12%. Most of the clay produced was for manufacture of common and face brick. Three plants manufactured brick in Nebraska, all in the southeastern corner of the State—Endicott Clay Products Co. in Jefferson County, Yankee Hill Brick Manufacturing Co. in Lancaster County, and Omaha Brick Works in Douglas County.

Lime.—Lime was produced in western Nebraska by Western Sugar Co. at two limekilns in Scotts Bluff County and one in Morrill County from limestone imported from Wyoming. The lime was used primarily for sugar refining. The reported amount of lime produced increased 60% and more than 44% in value.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Construction sand and gravel was produced in 85 of Nebraska's 93 counties. The Bureau of Mines estimated production of construction sand and gravel increased more than 35% in 1989 and the value of that production by more than 44%. This value comprised 40% of the total value of nonfuel mineral production in the State in 1989. Production served primarily the State's population centers, most notably in the southeast part of the State. Nebraska was 19th of the 50 States producing construction sand and gravel in 1989 and 37th of 38 industrial sand producers.

Industrial.—In contrast to the estimates for construction sand and gravel, industrial sand and gravel output declined by more than one-half during the year. Output by the State's sole producer of industrial sand, in Saunders County, was used in sandblasting and traction enhancement.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed stone was one of the three stalwarts of industrial mineral production in Nebraska. Reported production for 1989 indicated a nearly 19% decline in quantity produced from the previous year and a nearly 9% decline in value. Limestone was the major type of stone quarried. Limestone production was centered in the southeastern corner of the State, with Cass County to the south of Omaha and Washington County on the north of Omaha being the leading producers. There were approximately 17 limestone plants in the eastern third of the State. A limestone deposit near the small town of Weeping Water, Cass County, was the major stone resource utilized in the State. Ash Grove Cement Co.; Texasgulf Inc., a subsidiary of Elf Aquitaine; Kerford Limestone Co.; and Martin Marietta Aggregates were the principal operators at Weeping Water. The crushed limestone was used for aggregates in concrete, cement manufacture, road base, riprap, agricultural lime, wall stone, and mineral fillers. In addition, finely ground limestone was used in the manufacture of feed supplements, paint, and rubber. Although no dimension stone was reportedly quarried in Nebraska, about one dozen plants around the State cut stone brought in from other States.

Talc.—Ground talc was produced by Cyprus Industrial Minerals Inc. at a facility in Grand Island from ores supplied

TABLE 2

NEBRASKA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1½ inch):		
Riprap and jetty stone	42	279
Other construction materials[2]	2,549	14,267
Agricultural: Agricultural limestone	242	2,131
Other miscellaneous uses[3]	903	2,085
Unspecified:[4]		
Actual	242	1,288
Total	3,978	20,050

[1]Limestone.
[2]Includes stone used in macadam, concrete aggregate, bituminous aggregate, railroad ballast, stone sand (bituminous mix or seal), fine screenings, unpaved road surfacing, and crusher run or fill or waste.
[3]Includes stone used in poultry grit and mineral food and cement manufacture.
[4]Data represents production reported without a breakdown by end use.

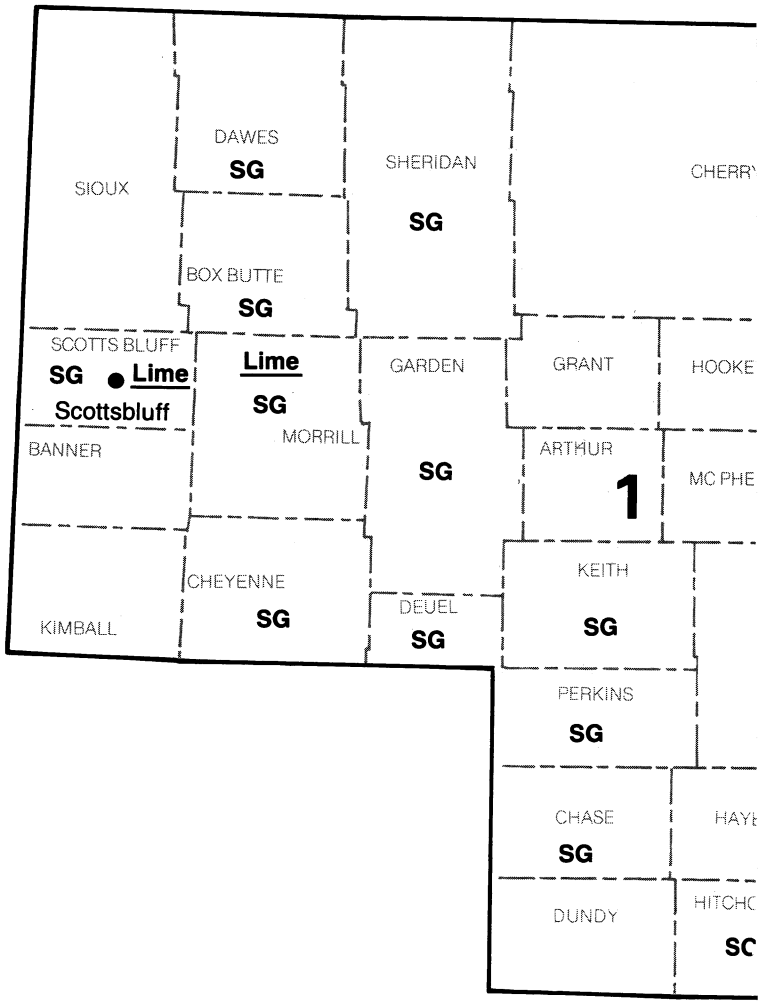
NEBR

LEGEND

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

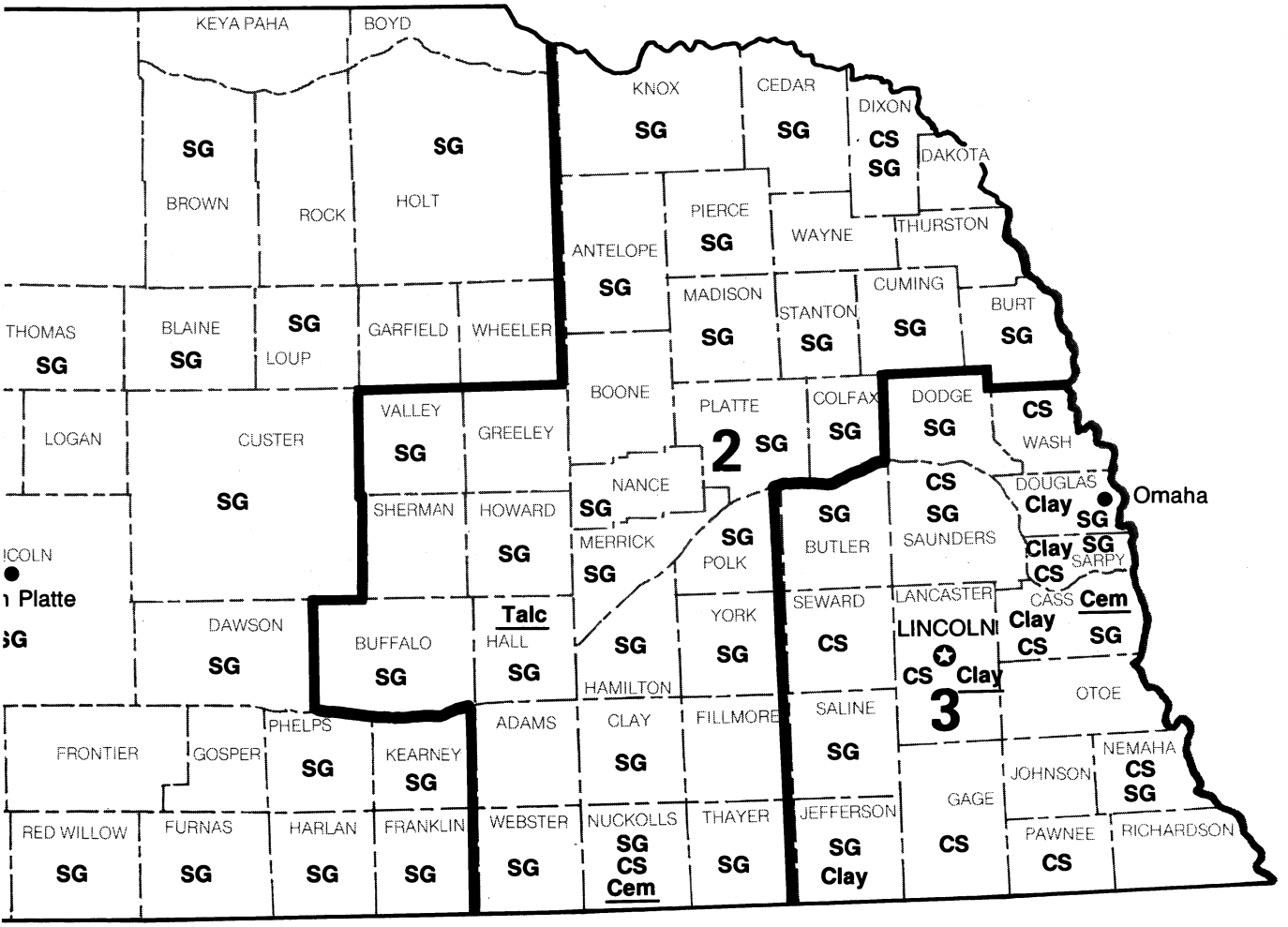
MINERAL SYMBOLS

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

SKA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JEFFERSON
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Clay
PAWNEE
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RICHARDSON

by Death Valley (California) and Montana mines.

Vermiculite.—The W. R. Grace & Co. vermiculite exfoliation plant in Douglas County was inactive during the year.

Metals

No metals were mined in Nebraska. ASARCO Incorporated, however, has operated a lead refinery in Omaha since about 1870. A $6.7 million upgrading of this facility was scheduled to be completed in April 1990. When completed, the new state-of-the-art facility was expected to make possible the increased recovery of gold, silver, and zinc from the lead bullion processed at the plant. The gold and silver removed would be further refined at ASARCO's precious-metals refinery in Amarillo, TX, and sold to commercial users. About three-fourths of the purified lead produced was used in the manufacture of storage batteries by various companies. The Omaha plant also refined bismuth, which was used in pharmaceuticals, and antimony oxide, which is used in paint pigments and as a fire retardant. The new facility was planned to reduce handling and energy requirements and provide improved environmental controls.

Nucor Corp., Cold Finish Div., operated a plant at Norfolk that produced cold-finished carbon and alloy steel products used extensively for shafts and machined precision parts. The Norfolk facility was the largest of three such Nucor plants in the United States. Nucor reported cold-finish steel sales growing steadily through the 1980's.

[1]Chief, Branch of State Activities, Bureau of Mines, Denver, CO. He covered the mineral activities in Nebraska in 1989. Assistance in the preparation of the chapter was provided by Pat La Tour and Wanda West, editorial assistants.

[2]Research geologist, Conservation and Survey Division of the University of Nebraska (Nebraska Geological Survey), Lincoln, NE.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Ash Grove Cement Co.	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.	Rt. 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, 1988):			
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.[1]	Box 28 Ashland, NE 68003	Dredges and pits	Cass, Dodge, Saunders.
Weverka Sand & Gravel Co.	Box 567 Arapahoe, NE 68922	Pit and plant	Furnas.
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 industrial sand in Saunders County.

THE MINERAL INDUSTRY OF NEVADA

This chapter has been prepared under a Memorandum of Understanding between the 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] and Jonathan G. Price[2]

Nevada's nonfuel mineral production in 1989 was valued at $2.3 billion, approximately 18% higher than that of 1988. Nevada ranked third nationally in the value of its nonfuel mineral production.

Nevada continued as the largest producer of barite, gold, mercury, and silver among the States. It was the sole producer of mined magnesite. Gold production accounted for over 80% of the total nonfuel mineral value produced in the State in 1989. Silver, mostly as by-product from gold production, accounted for an additional 4.8%. Principal nonfuel minerals produced in the State, in order of value, were gold, silver, construction sand and gravel, molybdenum, portland cement, diatomite, lithium, and lime.

TRENDS AND DEVELOPMENTS

Precious metals production continued to rise, although at a somewhat lesser rate, with five additional mine openings during the year. Gold-mining operations continued to expand, particularly in the northern half of the State. Newmont Gold Co. and American Barrick Resources Corp. reported new, deep gold resources in the Carlin Trend of Eureka and Elko Counties. Newmont was the largest gold producer in Nevada, as well as in the Nation and North America. Exploration by the company increased its reserves by 27% during 1989, to a total of 640,000 kilograms (20.7 million ounces) of gold.

EMPLOYMENT

According to the Nevada Employment Security Department, employment in the Nevada mining industry reached 14,400 persons by December 1989, with an annual average of 13,500 jobs. Mining added more than 2,400 jobs statewide during the year, a 20% increase. Metal mining employment averaged 12,300 workers during the year. Precious metals operations employed the largest number of workers, followed by the sand and gravel industry.

REGULATORY ISSUES

Congressional hearings were held during 1989 on Federal legislation to create wilderness areas on 733,400 acres of Nevada forest lands managed by the U.S. Forest Service.

The Nevada Division of Environmental Protection held hearings in March on pollution problems brought on by the State's fast growth rate and a lack of environmental regulations. Problems of toxic pollution were studied; these ranged from problems resulting from farm runoff into the Stillwater Wildlife Refuge to problems resulting from the large amounts of cyanide in mining operation ponds that threaten ground water purity.

The U.S. Bureau of Land Management halted operations at 25 sand and gravel pits in southern Nevada in November until arrangements were made to protect the desert tortoise habitat nearby.

EXPLORATION ACTIVITIES

The search for precious metals continued to dominate Nevada mineral exploration. Drilling and exploration projects were reported throughout the State, particularly in Eureka, Elko, Esmeralda, Humboldt, Mineral, Nye, and White Pine Counties. Important new gold discoveries were reported in the Roberts Mountain area of Eureka County by Atlas Corp. and U.S. Gold Corp. Exploration was also continued in Eureka County by NERCO Minerals Co., ASARCO Incorporated, Hycroft Resources and Development Corp., and at least eight other mining companies.

LEGISLATION AND GOVERNMENT PROGRAMS

The Nevada legislature concluded its historically longest biennial session with changes in Nevada's tax laws on mining profits and the first mine land reclamation legislation in the State's history. Senate Joint Resolution 22, passed by both the legislature and a vote of the people, changed the net proceeds of mines tax from 2% to 5%. Additional proposed mining severance taxes were defeated. Assembly bill 958, which placed responsibility for administrating a new reclamation program in the Nevada State Department of Environmental Protection, was passed in the closing days of the session.

Also passed were Senate bill 7, authorizing the Department of General Services to contract for the minting of precious metal medallions and bars; Senate bill 61, which set up an indexing schedule for payment of the net proceeds tax; and Assembly bill 65, which required a person with experience in mine taxation to be appointed to the Nevada Tax Commission.

The Nevada Bureau of Mines and Geology published a 55-page special publication (MI-1989), "The Nevada Mineral Industry, 1989," which included production statistics; exploration activities for and development of minerals, petroleum, and geothermal resources; discoveries of ore bodies; new mine openings; expansions of existing mines; statistics on known bulk minable gold and silver deposits, including grades and reserves; and directories of mines and plants.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Copper.—Silver King Mines Corp. and Pacific Silver Corp. (Alta Gold Co.) began mining and stockpiling ore at their

TABLE 1

NONFUEL MINERAL PRODUCTION IN NEVADA[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Barite	thousand metric tons	279	$4,778	289	$5,053	209	$3,473
Clays[2]	metric tons	10,704	810	26,186	2,143	57,264	5,457
Gem stones		NA	280	NA	280	NA	1,402
Gold[3]	kilograms	83,341	1,200,269	114,322	1,611,020	154,573	1,901,280
Perlite	thousand short tons	W	W	5	142	5	136
Sand and gravel:							
Construction	do.	e10,600	e30,700	15,729	50,928	e20,000	e70,000
Industrial	do.	578	W	602	W	718	W
Silver[3]	metric tons	379	85,429	608	127,760	625	110,442
Stone (crushed)	thousand short tons	[4]1,264	[4]5,700	e[4]1,300	e[4]5,700	1,560	4,638
Combined value of cement (portland), clays (fuller's earth, 1987; kaolin), copper (1988), diatomite, fluorspar, gypsum, lead (1988), lime, lithium minerals, magnesite, mercury, molybdenum (1989), salt, stone (crushed dolomite), and values indicated by symbol W		XX	128,063	XX	151,356	XX	222,240
Total		XX	1,456,029	XX	1,954,382	XX	2,319,068

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.
[4]Excludes certain stones; kind and value included with "Combined value" figure.

Ward Mountain copper-zinc mine in White Pine County during the second quarter of 1989. Alta leased the mill at the nearby Taylor Mine from NERCO Minerals to process the ore. Conversion of the mill to process 1,000 tons per day was undertaken, with conversion expected to be completed in the spring of 1990. Mining and stockpiling of ore from the Ward Mine began in mid-1989.

Arimetco Inc. purchased ARCO's old Anaconda copper property in Yerington from a local businessman who had bought the property from ARCO. Mining began in July 1989, and cathode copper was produced in October using the solvent extraction-electrowinning (SX-EW) method. According to the Nevada Department of Minerals, total 1989 production from the mine, now called Copper Tek, was 375,000 pounds of copper.

Gold.—Nevada continued to lead all States in the amount and value of gold produced in 1989, accounting for 58% of the total amount produced in the United States. Nevada mines reported 154,573 kilograms (4,969,523 troy ounces) of gold production to the Bureau of Mines, a 35% increase from the previous year, but approximately 85,000 troy ounces less than the 5,055,000 troy ounces reported by the Nevada Department of Minerals in 1989. The record production increased for the 10th consecutive year.

Six additional mine openings were reported in the State during 1989, and the extensive development of the 3 previous years eased somewhat. A drop in the average annual price from 1988's $448 per ounce to $383 per ounce prompted a dropoff in exploration activity. New discoveries continued to be reported, however, particularly in the deeper deposits of the Carlin Trend. Gold-mining operations continued to expand, particularly in the northern half of the State.

Mine openings were reported in Humboldt, Nye, Washoe, and White Pine Counties. A joint venture between Santa Fe Pacific Minerals Corp. (30%) and Cordex VI Syndicate (70%) began production in September at the Marigold Mine in Humboldt County. Construction was completed on a 1,250-ton-per-day mill and a 730,000-ton-per-year heap-leach facility. When in full operation, the mine was expected to produce 60,000 ounces of gold per year.

The Getchell Mine, owned by First-Miss Gold Inc., began operations of its new mill in February, processing oxide ore. The first of three autoclaves began operating in March, with the remaining two starting up in September at the Humboldt County open pit gold mine.

In Nye County, Bond International Gold Inc. began operation of the Bullfrog Mine in September. According to the Nevada Department of Minerals, 50,000 ounces of gold and 41,000 ounces of silver were produced from the open pit operation near Beatty by the end of the year. Yearly production is expected to be about 239,000 ounces of gold.

AMAX Gold Inc.'s Wind Mountain Mine in Washoe County began commercial production in the second quarter of 1989. According to its 1989 annual report, AMAX Gold produced about a ton of gold and more than 10 tons of silver from the open pit, heap-leach operation from May through December, using the Merrill-Crowe process to produce precious metal precipitates; the precipitates were subsequently processed to

produce doré at AMAX Gold's Sleeper Mine in Humboldt County.

Alta Bay Joint Venture (Alta Gold, 60%; Echo Bay Mining Co., 40%) began production in June at its Golden Butte Mine, north of Ely in White Pine County. The mine, an open pit, heap-leach operation, recovered gold and a small quantity of silver.

Newmont Gold, the largest U.S. gold producer, also controlled the Nation's largest block of gold ore reserves, in the Carlin Trend of Eureka and Elko Counties. Exploration increased reserves by 27% in 1989, to a total of 20.7 million troy ounces (640,000 kilograms) of gold contained in more than 10 deposits. Newmont operated five separate mills and four leaching facilities to produce a record 1.47 million troy ounces (45,648 kilograms) of gold, worth $560 million. Newmont completed its Mill No. 4 in the north area of its Carlin Trend properties during the later part of 1989, culminating the expansion program begun in 1987 that increased its total milling capacity from 13,000 short tons per day in 1987 to 40,000 short tons per day in 1989.

Construction began in 1989 at American Barrick Resource's Goldstrike property in Eureka County with the installation of the first of six planned autoclaves, designed to process refractory ores. Each unit was expected to process 1,500 tons per day when operating at full capacity. American Barrick announced plans to develop both its Betze deposit sulfide reserve and its Post deposit oxide reserves. Goldstrike, adjacent to Newmont Gold's operations on the Carlin Trend, was one of Nevada's leading gold-producing mines in 1989, yielding more than 207,264 ounces (6,446 kilograms) of gold.

The Round Mountain Mine in Nye County, completed a 2-year, $134 million expansion program in September that effectively doubled its tonnage capacity. Published company data reported 318,616 troy ounces of gold production during the year. The mine's owners, Homestake Mining Co., Echo Bay Mining Co., and Case Pomeroy & Co., merged Echo Bay's nearby properties, including the Manhattan mill, into the Round Mountain operations, thereby enabling the mine to achieve better recovery rates on its high-grade ore than could be otherwise achieved by heap leaching. A new zone of free gold in unoxidized host rock was discovered along the proposed boundary of the open pit. The new mineralization, which was dubbed the Masada Zone, was not fully delineated.

Freeport McMoRan Gold Co. was the largest gold producer in Elko County during 1989, with production coming from the Jerritt Canyon/Big Springs complex. The company announced the pouring of its 2 millionth ounce during the year at the Jerritt Canyon complex. Major expansion at the Jerritt Canyon operation was completed in September with the installation of two fluid-bed roasters, which were expected to increase production by several tens of thousands of ounces of gold. Total ore throughput at Jerritt Canyon following installation of the roasters was estimated to be about 6,400 tons per day. A new roaster was also installed in June at the company's Big Springs Mine, also in Elko County. The Nevada Department of Minerals reported 1989 production of 297,000 ounces of gold from the Jerritt Canyon complex and 60,000 ounces of gold from Big Springs.

AMAX Gold's Sleeper Mine in Humboldt County produced 256,000 ounces of gold and 340,000 ounces of silver in 1989, according to the Nevada Department of Minerals. Production was from both leach pads and the mill, which operated at a rate in excess of 1,500 tons per day with an average mill-head grade of 0.378 ounce of gold per ton and a recovery rate of almost 95%. According to the company, exploration drilling managed to replace almost all of the mined reserves.

Echo Bay's McCoy-Cove gold and silver mine in Lander County completed its new mill in July and the driving of two access ramps, one to 600 feet below the surface at the Cove deposit and the other 900 feet below the surface of the McCoy deposit. Underground mining began in December at Cove. Gold production from both surface and underground works at McCoy-Cove more than doubled during 1989, to 214,566 troy ounces (6,673 kilograms), despite underground problems related to poor ground conditions and substantial waterflows at Cove.

Battle Mountain Gold Co.'s Lander County operations at the Canyon placer mine and two open pit gold mines, the Fortitude and the Surprise, recovered 251,000 troy ounces of gold (7,800 kilograms) during the year. Drilling south of the Fortitude Mine discovered the new Reona deposit. At the end of 1989, Battle Mountain Gold announced combined reserves at its Fortitude, Surprise, and Satellite deposits to be nearly 6.7 million tons of ore reserves grading 0.13 troy ounce per ton of gold and containing 3.15 million troy ounces of silver. The Canyon placer deposit was said to have gold reserves containing 245,000 ounces of gold.

Atlas Corp.'s Gold Bar Mine in Eureka County completed a $5 million expansion program that doubled the daily processing capacity to 3,000 tons per day. According to the Nevada Department of Minerals, the mine reported production of 66,000 troy ounces in 1989, a 28% increase over the previous year. Exploration continued on the 50,000 acres surrounding the Gold Bar deposit.

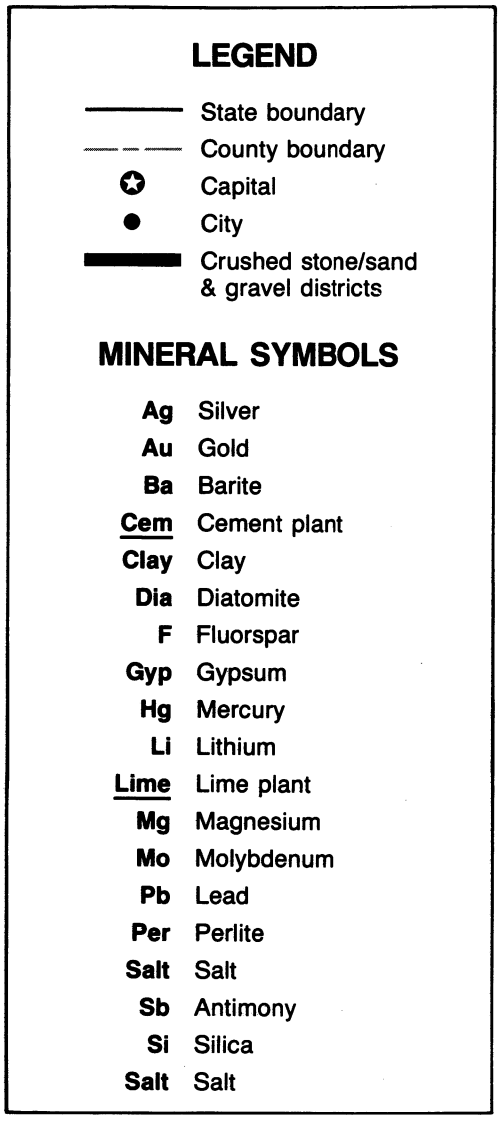
The Tonkin Springs gold mine of U.S. Gold Corp. reported lower production in 1989 due to shutdowns of the mill and heap-leach operations while expansion of processing facilities was undertaken. Because of delays and startup problems, the new carbon-in-leach mill and bioleach process did not begin operations in 1989 as planned.

Hycroft Resources and Development's Crofoot/Lewis Mine in Humboldt County produced 82,000 ounces of gold and 123,000 ounces of silver during 1989, according to the Nevada Department of Minerals.

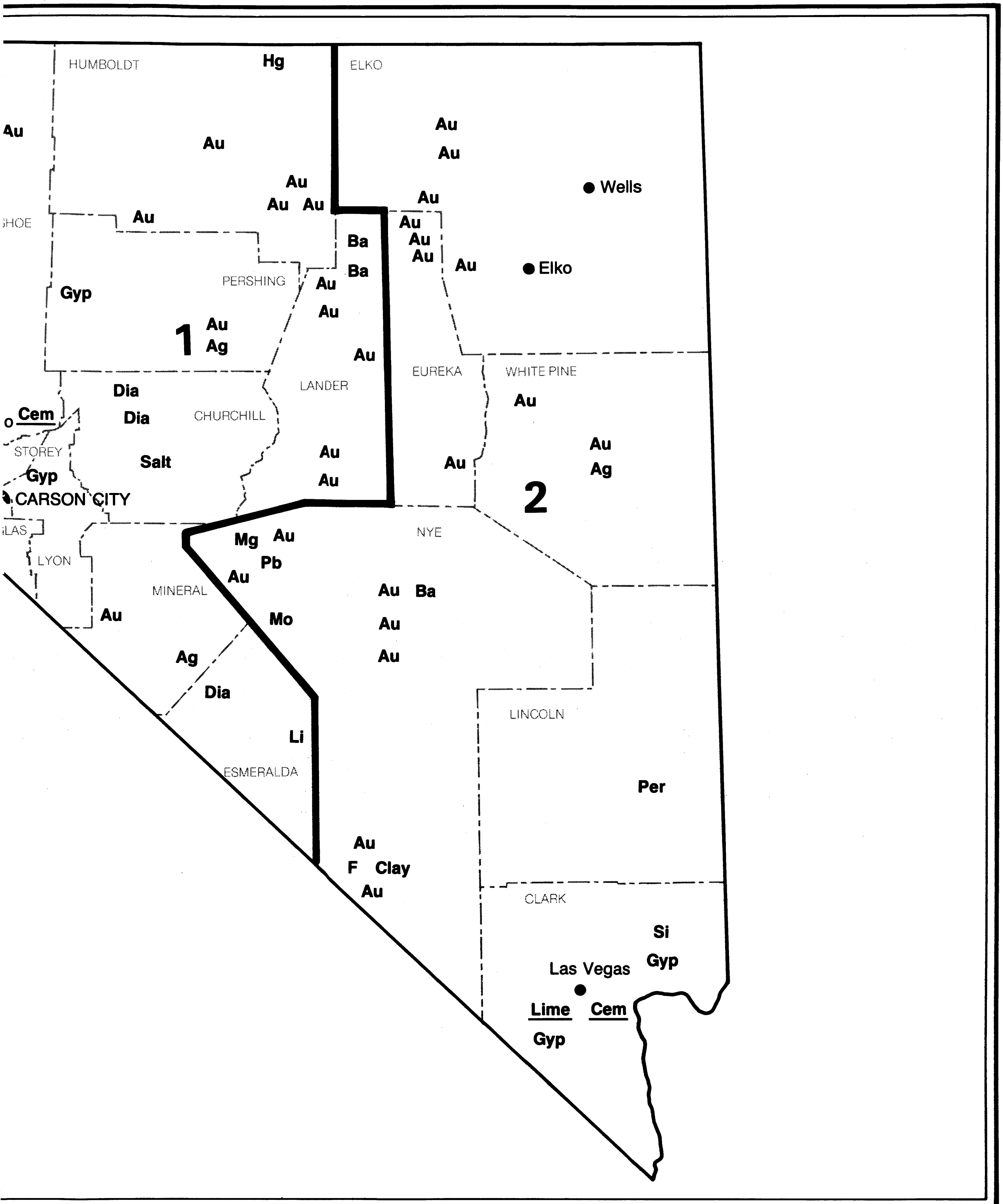
Santa Fe Pacific Minerals' Rabbit Creek gold mine continued development drilling of its Humboldt County prospect in 1989. According to the company, more than 600 drill holes had been completed by yearend, resulting in an estimated 3.6 million ounces of gold reserves. New gold discoveries were also announced in Humboldt County at the Stonehouse deposit (T. 34 N., R. 42 E., sec. 11), by Rayrock Yellowknife Resources Inc., and at the Lone Tree Hill deposit immediately adjacent to the Stonehouse discovery, by Santa Fe Pacific Minerals.

Echo Bay Minerals Co.'s Borealis Mine in Mineral County, where several small pits had been mined since 1981, was mined out by midyear. Mining operations were suspended at NERCO Minerals Alligator Ridge Mine in White Pine County in December due to exhaustion of identified ore reserves, although ore treatment

NEVADA



Principal Mineral-Producing Localities



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and metal production from both heap-leach and carbon-in-leach facilities were expected to continue into 1990. Mining was halted and reclamation of the site was begun at the Austin Mine in Lander County in November. The mine was operated by Westgold Inc., in partnership with FMC Gold Co. Ore at the Humboldt County Preble Mine was exhausted during the third quarter, but heap leaching was expected to continue until the second quarter of 1990. The facilities were expected to be used in the future to process ore from the Kramer Hill deposit, about 20 kilometers southwest of Preble. Mining operations were completed, and the loading of ore on the heap-leach pads at Pegasus Gold Inc.'s Relief Canyon Mine in Pershing County ended in late 1989. Leaching operations and gold-silver recovery were expected to end in 1990.

Exploration drilling for gold continued in most areas. In Humboldt County, FirstMiss Gold conducted additional exploration at its Getchell property, and several companies explored the area surrounding the Marigold Mine. Zephyr Resources explored near Silver Peak in Esmeralda County. Nye County exploration included drilling at the Mother Lode project near Beatty by Gexa Gold Corp., Freeport-McMoRan Gold Co.'s exploration of the west side of the Monitor Range, Placer Dome Inc.'s exploration in the Toiyabe National Forest in northern Nye County, and Mountain West Minerals explored drilling in the Toiyabe Mountains of Nye County. AMAX Gold continued exploration to define additional reserves at its Wind River Mine in Washoe County.

St. George Minerals Inc. explored the Dean Mine 15 miles south of Battle Mountain in Lander County. Multinational Resources Inc. drilled its Emigrant Springs property in Elko County.

Mercury.—Nearly all of the primary mercury production in the United States during 1989 was from Nevada, except for very small amounts from California and Utah. The major portion came from the McDermitt Mine, near the Oregon border in Humboldt County, and FMC Gold Co.'s Paradise Peak gold-silver mine near Gabbs, in Nye County. Additional byproduct mercury from gold production was reported from the Carlin Mine in Eureka County, the Pinson Mine in Humboldt County, the Borealis Mine in Mineral County, the Hog Ranch Mine in Washoe County, and the Alligator Ridge Mine in White Pine County.

Molybdenum.—Cyprus Minerals Co. shut down its Nye County primary molybdenum operation near Tonopah on December 20, 1989, in an announced decision to firm the market by trimming production. Despite the closure, molybdenum was Nevada's fourth most important mineral produced in 1989 in terms of value.

Silver.—Nevada silver production increased just over 1% from that of 1988 to 625 metric tons (20,094,000 troy ounces). Because of lower silver prices during the year, value declined nearly 14%, to $110,442,000. Nevada ranked first among the States in the amount of silver produced. Four of the Nation's top 10 silver producers, Paradise Peak in Nye County, Coeur-Rochester in Pershing County, Candelaria in Mineral County, and McCoy-Cove in Lander County, were in Nevada.

Nevada's leading silver producer in 1989, and second in the Nation, was FMC Gold's Paradise Peak Mine. Byproduct production from gold ore of 5.2 million troy ounces of silver was obtained from the open pit, disseminated-lode gold mine.

Coeur d'Alene Mines Corp.'s Rochester silver-gold mine was the State's second largest silver producer. Primarily a silver mine, in 1989, 4.6 million ounces of silver production was reported, down from the 5 million ounces produced in 1988.

The Candelaria Mine in Mineral County, Nevada's third largest silver producer, which came on-stream in 1979, set a mine record in 1989 of 4.36 million ounces of silver, according to the Nevada Department of Minerals. This was a 40% increase in silver output over 1988.

A new 6,800-ton-per-day mill at the McCoy-Cove Mine in Lander County began commercial production in July, processing high-grade oxide ore from both the McCoy and Cove open pit mines.

Industrial Minerals

Barite.—Despite a 28% drop in production of barite to 209,170 short tons and a 31% reduction in value to $3,473,000, Nevada remained the top 1989 barite producer among the States. Continued competition from foreign imports forced most mining and grinding operations in the State to operate on minimal production schedules.

Nevada had five primary barite operations and four crushing plants in Churchill, Lander, and Nye Counties. Milpark Drilling Fluids' Argenta Jig plant and NL Baroid Inc.'s Battle Mountain Mine were the major operations, with production also reported from Circle A, Standard Slag Co., and M-I Drilling Fluids' Greystone Mine.

Cement.—Portland cement production from the Centex Corp. plant at Fernley, Nevada's only producer in 1989, was slightly lower than that of 1988. According to the Nevada Bureau of Mines and Geology, annual production at this plant is about 400,000 tons. Construction continued at the Las Vegas Cement Co. Inc. plant at Logandale in Clark County.

Diatomite.—Nevada ranked second among the five States producing diatomite in 1989. Reported sales were slightly higher than those of 1988.

Production was reported from five operations in Churchill, Esmeralda, Lyon, Pershing, and Storey Counties. Eagle-Picher Industries Inc. was the largest Nevada producer, mining from three separate areas in northern Nevada for beneficiation at plants near Lovelock and Reno. Principal uses were in filtration, insulation, fillers, and absorbents.

Fluorspar.—J. Irving Crowell, Jr., & Son produced and shipped a small amount of metallurgical-grade fluorspar from its Crowell-Daisy Mine in Nye County. Closure of the Daisy Mine in April resulted in a considerable drop in fluorite production in the State. The Nye County operation had been mining fluorite at the underground mine near Beatty more or less continuously since the 1920's.

Gypsum.—Gypsum mining and calcined gypsum production in Nevada during 1989 continued the steady growth recorded throughout the 1980's. The Nevada Department of Minerals reported that gypsum production in Nevada increased from about 1.5 million tons in 1988 to over 1.6 million tons in 1989 owing to vigorous regional construction activity. Production of wallboard from gypsum was an important basic industry in the Las Vegas area.

In the Las Vegas area, in 1989, the two largest gypsum producers were Pacific Coast Building Products Inc. and James Hardie Gypsum Inc. These were followed

by the Georgia Pacific Corp. and Nevada Gypsum and Mining Co. In the State as a whole, the largest gypsum producer was U.S. Gypsum Co., which mined gypsum in northern Pershing County and processed it at the company's Washoe County wallboard plant.

Nevada ranked sixth among the 21 gypsum-producing States and was the fifth largest calcined gypsum producer, with four active plants reporting 1,186,000 short tons of calcined gypsum valued at $19,075,000.

Lime.—Three plants reported lime production in Nevada during 1989. Chemstar Inc. was the major producer of quicklime and hydrated lime from two plants in Clark County. Continental Lime Inc. produced quicklime from its Pilot Peak plant in Elko County.

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Nevada's construction sand and gravel was estimated to have increased about 21% to 20,000,000 short tons in 1989 as the Clark County construction boom continued.

Industrial.—The State's only producer of industrial sand and gravel was Simplot Industries Inc.-Silica Products Division in Clark County. Major uses were in containers, flat glass, molding and cores, chemicals, and roofing granules. Production of 718,000 short tons was nearly 20% more than the 602,000 short tons reported in 1988.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Nevada stone 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 crushed stone production of nearly 1,560,000 short tons was 23% higher than that reported in 1987. However, lower prices reduced the value to $4,638,000, about 19% lower than 1987's reported value. Crushed stone from eight counties was reported from 18 quarries in 1989, compared with 11 quarries in 1987. Principal producers included Centex Corp.'s Nevada Cement Co. and Dayton Sand and Gravel Inc., both in Lyon County, and Clark County's Chemstar Inc. and Southern Nevada Liteweight Co.

Other Industrial Minerals.—Cyprus Foote Mineral Co. was Nevada's sole producer of lithium carbonate from its Silver Peak plant in Esmeralda County. The Basic Inc. operation in Nye County was the sole producer of mined magnesite in the United States. U.S. Gypsum manufactured plaster aggregate from expanded perlite at its Empire plant in Washoe County. Huck Salt Co. increased salt production about 30% over that of 1988 at its plant near Fallon in Churchill County. Borates from the Billie Mine in San Bernardino County, CA, were processed in Clark County at the American Borate Co. plant.

TABLE 2

NEVADA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse and fine aggregates: Other construction materials[2]	726	2,016
Other miscellaneous uses[3]	833	2,622
Total	[4]1,560	4,638

[1]Includes limestone, dolomite, traprock, volcanic cinder and scoria, granite, marble, and miscellaneous stone.
[2]Includes stone used in stone sand (concrete), graded road base or subbase, unpaved road surfacing, concrete aggregate (coarse), terrazzo and exposed aggregate, and combined aggregates.
[3]Includes stone used in cement and lime manufacture, other agricultural uses, and poultry grit and mineral food.
[4]Data do not add to total shown because of independent rounding.

TABLE 3

NEVADA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2	
	Quantity	Value	Quantity	Value
Construction aggregates:				
Coarse aggregate, graded[1]	—	—	W	W
Fine aggregate (-3/8 inch)[2]	—	—	W	W
Coarse and fine aggregates[3]	324	740	25	32
Other construction aggregates	—	—	377	1,244
Agricultural[4]	([5])	([5])	—	—
Chemical and metallurgical[6]	([5])	([5])	([5])	([5])
Other miscellaneous	667	1,947	166	675
Total	991	2,687	[7]569	1,951

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[1]Includes concrete aggregate (coarse).
[2]Includes stone sand (concrete).
[3]Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and other coarse and fine aggregates.
[4]Includes poultry grit and mineral food, and other agricultural uses.
[5]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[6]Includes crushed stone for cement manufacture and lime manufacture.
[7]Data do not add to total shown because of independent rounding.

[1]State Mineral Officer, Bureau of Mines, Reno, NV. He has covered the mineral activities in Nevada for 8 years. Assistance in the preparation of the chapter was given by Mary Carico and Pat La Tour, editorial assistants.
[2]State geologist, Nevada Bureau of Mines and Geology, Reno, NV.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Barite:			
Milpark Drilling Fluids Co.	Box 370 Battle Mountain, NV 89820	Surface mine and mill	Lander.
NL Baroid Inc.	Box 141 Battle Mountain, NV 89820	do.	Nye.
Cement:			
Centex Corp., Nevada Cement Co.	Box 895 Fernley, NV 89408	Plant	Lyon.
Clays:			
Industrial Mineral Ventures Inc.	1800 East Sahara Ave. Suite 107 Las Vegas, NV 89104	Surface mine and mill	Nye.
Copper:			
Battle Mountain Gold Co.	Box 1627 Battle Mountain, NV 89820	do.	Lander.
Diatomite:			
Eagle-Picher Industries Inc., Minerals Div.	Box 12130 Reno, NV 89510	Surface mine and plants	Lyon, Pershing, Storey.
Grefco Inc., Dicolite Div.	Box 288 Mina, NV 89422	Surface mine and plant	Esmeralda.
Fluorspar:			
J. Irving Crowell, Jr., & Son	Box 96 Beatty, NV 89003	Underground mine	Nye.
Gold:			
Battle Mountain Gold Co.	Box 1627 Battle Mountain, NV 89820	Surface mine and mill	Lander.
FMC Corp.	Box 1237 Hawthorne, NV 89415	Surface mine and plant	Nye
Freeport-McMoRan Gold Co.	Mountain City Star Route Elko, NV 89801	do.	Elko.
Nevada Gold Mining Inc. (AMAX)	Box 1820 Winnemucca, NV 89445	Surface mine and mill	Humboldt.
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.
Gypsum:			
Genstar Building Products Co.	Box 2580 Irving, TX 75061	Surface mine and plant	Clark.
Pacific Coast Building Products Inc.	Box 405 Newark, CA 94560	do.	Do.
USG Corp.	101 South Wacker Dr. Chicago, IL 60606	do.	Pershing.
Lime:			
Chemstar Inc.	901 Mariner's Island Blvd. Suite 425 San Mateo, CA 94404	do.	Clark.
Lithium compounds:			
Cyprus Foote Mineral Co.	301 Lindenwood Dr. Suite 301 Malvern, PA 19335-1740	Dry lake brines and plant	Esmeralda.
Magnesite:			
Basic Inc.	845 Hanna Bldg. Cleveland, OH 44115	Surface mine and mill	Nye.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Mercury:			
FMC Corp.	Box 1237 Hawthorne, NV 89415	Surface mine and plant	Nye.
Placer Dome U.S. Inc., Joint Venture	Box 497 McDermitt, NV 89421	do.	Humboldt.
Perlite (expanded):			
USG Corp.	Empire, NV 89405	Plant	Washoe.
Salt:			
Leslie Salt Co., Huck Salt Co.	895 Harrigan Rd. Fallon, NV 89406	Solar evaporation plant	Churchill.
Sand and gravel: Construction:			
ARC Materials Corp., WMK Transit	Box 14697 Las Vegas, NV 89114	Pits and mills	Clark.
Eagle Valley Construction Co.	5894 Sheep Dr. Carson City, NV 89701	Pits and mill	Carson City, Douglas, Lyon, Storey.
Granite Construction Co.	Box 2087 Sparks, NV 89432	Pits and mills	Washoe.
Robert L. Helms Construction Co.	Drawer 608 Sparks, NV 89432-0608	do.	Lander and Washoe.
Las Vegas Building Materials Inc.	Box 530 Las Vegas, NV 89125	Pit	Clark.
Las Vegas Paving Corp.	1770 South Industrial Rd. Las Vegas, NV 89102	Pit	Do.
Paiute Pit Aggregates Inc.	P.O. Box 159 Wadsworth, NV 89442	Pit and mill	Washoe.
Silver:			
Coeur-Rochester Inc.	Box 1057 Lovelock, NV 89419	Surface mine and plant	Pershing.
FMC Corp.	Box 1237 Hawthorne, NV 89415	do.	Nye.
NERCO Minerals Co.	Box 1246 Hawthorne, NV 89415	do.	Mineral.
Stone:			
Centex Corp., Nevada Cement Co.	Box 895 Fernley, NV 89408	Quarry	Lyon.
Chemstar Inc.	901 Mariner's Island Blvd. Suite 425 San Mateo, CA 94404	Quarries	Clark.

THE MINERAL INDUSTRY OF NEW HAMPSHIRE

This chapter has been prepared under a Memorandum of Understanding between the 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 1989 was $33 million, a decrease of $20 million from that of 1988. Construction sand and gravel and crushed and dimension stone accounted for most of the State's mineral production; common clay and gem stones accounted for the remainder. Gypsum was shipped into the State and made into wallboard at one plant.

TRENDS AND DEVELOPMENTS

The 38% drop in the State's mineral production value in 1989 was primarily caused by large decreases in construction sand and gravel and crushed and dimension stone output. In 1989, construction sand and gravel output fell 34%. Crushed stone production declined 68%, and dimension stone output dropped 25%.

Because most of New Hampshire's mineral production is consumed by the construction industry, mineral output is usually influenced by demand from this industry. Total housing starts declined in the State for the third consecutive year. In 1989, housing starts fell 17% after declining 25% in 1988 and 19% in 1987. As a result of these declines, demand for construction mineral aggregates has declined steadily in the last few years.

In September, Coastal Cement Corp., a subsidiary of Cementos del Norte (CDN), Boston, and Sprague Energy, one of New England's largest marketers and handlers of liquid and solid energy products and bulk commodities, began constructing a state-of-the-art, 25,000-short-ton-capacity cement storage and handling facility at Sprague's Newington terminal. The new cement storage and handling facility would be operated by Sprague. Newington was chosen by Coastal because in 1988 CDN purchased the only cement plant in New England, at Thomaston, ME. The new facility, which is between Thomaston and Boston, allows CDN to expand its New England cement distribution network.

EXPLORATION ACTIVITIES

Noranda Exploration Inc. of Rhinelander, WI, announced that the company was no longer interested in mineral prospecting in the White Mountain National Forest (WMNF) because of continuing opposition from environmental groups and the U.S. Environmental Protection Agency. The company, one of several dozen exploration applicants, was seeking a mining permit to prospect for copper, lead, zinc, silver, and gold in the WMNF. The proposed prospecting locations were confined to about 44,000 acres in the 780,000-acre WMNF, primarily in the areas of Bartlett, west of Mount Chocorua; the Waterville Valley area, along the Kancamaugus Highway; and in the Benton-Warren area.

LEGISLATION AND GOVERNMENT PROGRAMS

Senate bill 67-FN (Chapter Law 363), rewrote a State law regulating the mining of sand and gravel and construction aggregate. The bill replaced existing regulations that allowed local communities to set conditions for mining of these commodities. The new legislation required that all mining facilities operate under new State standards and gave local communities the authority to enforce those regulations. The bill also defined an abandoned pit, outlined reclamation requirements, and required aggregate deposits to

TABLE 1

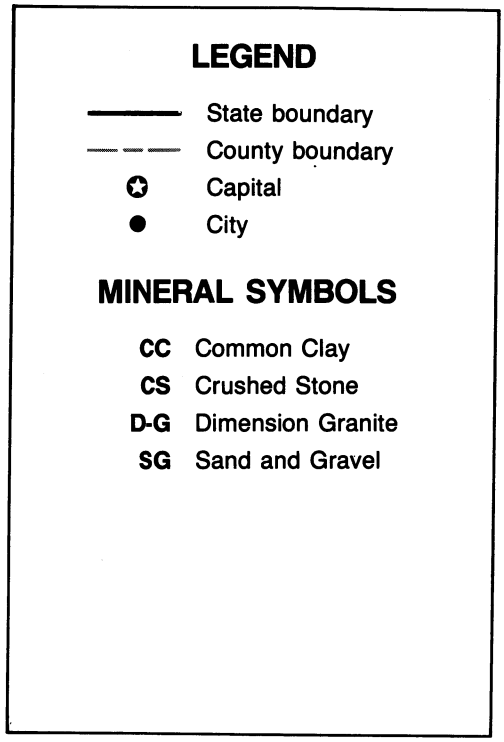
NONFUEL MINERAL PRODUCTION IN NEW HAMPSHIRE[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	$310	NA	$100	NA	$51
Sand and gravel (construction)	thousand short tons	e9,100	e33,300	9,089	32,614	e6,000	e20,400
Stone:							
Crushed	do.	2,479	10,386	e2,400	e9,800	771	4,020
Dimension	short tons	67,479	10,684	e73,393	e10,546	55,305	8,769
Total[2]		XX	54,680	XX	53,060	XX	33,240

eEstimated. NA Not available. XX Not applicable.

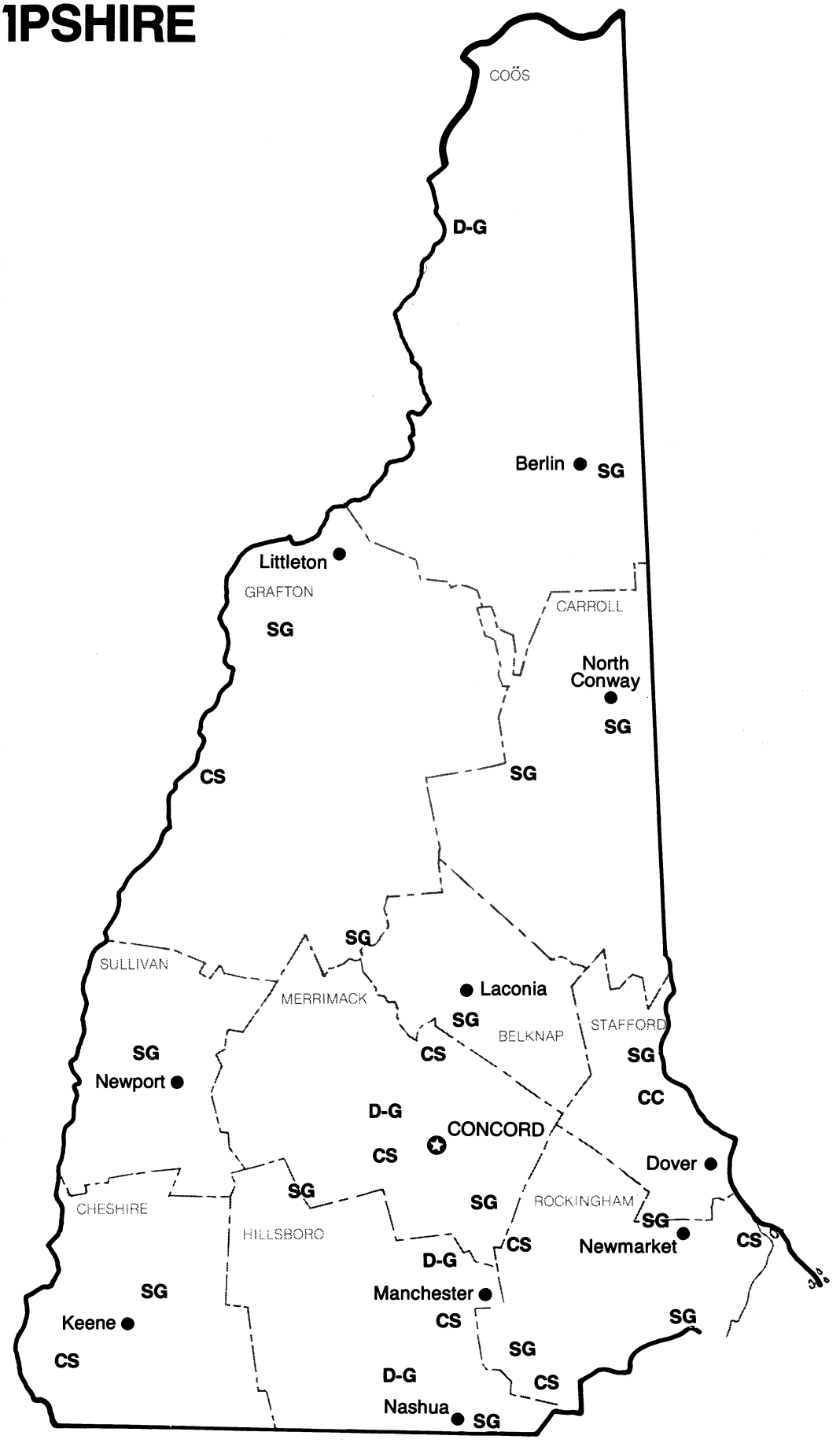
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2]Partial total, excludes values which must be concealed to avoid disclosing company proprietary data.



Principal Mineral-Producing Localities

1PSHIRE


COÖS
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CARROLL
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Conway
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Laconia
SG
BELKNAP
STAFFORD
SG
CS
SG
Newport
CC
D-G
CONCORD
CS
Dover
SG
SG
ROCKINGHAM
CHESHIRE
HILLSBORO
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Newmarket
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D-G
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Manchester
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Nashua
SG

be identified in a town's master plan. Chapter Law 363 also had a grandfather provision for existing operations. This bill is expected to make it easier for construction aggregate operators to get excavation permits. It is also expected to ease local restrictions on aggregate producers and expand the supply of aggregate in the State.

House bill 382-FN-A, "Construction Aggregate Severance Tax," was rejected by the New Hampshire House and Ways Committee in October. The proposed legislation would have imposed a severance tax of 10 cents per ton on sand and gravel, loam, rock, soil, or construction aggregate. The proceeds of the tax were to be returned to the cities and towns where the mineral was severed. The bill was referred to the 1990 legislature.

New Hampshire unveiled a major recycling initiative involving $1.5 million for municipal grants and increased technical assistance. With money provided to the Office of State Planning by the Governor's Energy Office, a new State Recycling Fund was created. Towns, cities, and solid waste districts may apply to receive funds for up to 50% of approved costs for constructing facilities for recycling, collection, processing, and storage, as well as for purchasing recycling equipment. Nearly 3,000 tons of solid waste was generated daily in New Hampshire and a large portion of that was recyclable, e.g., paper, glass, plastic, and metal wastes.

The Office of the State Geologist continued cooperative projects with the Bureau of Mines, U.S. Geological Survey (USGS), and Minerals Management Service (MMS). Cooperative projects with the USGS included preparation of a new State bedrock geologic map (1:250,000 scale), surficial geologic mapping of 7½-minute quadrangles in the State, and a 5-year cooperative study to determine the location of principal wetlands and the volume, grade, and tonnage of peat in the State. The MMS sponsored funding for oceanographic research on coastal zone deposits, primarily to identify major offshore sand and gravel deposits.

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. Output in 1989 remained virtually unchanged from that of 1988. The clay was used to manufacture face brick and was marketed primarily in the Boston, MA, area.

Gypsum.—National Gypsum Co. operated a wallboard manufacturing plant at Portsmouth, Rockingham County. Crude gypsum was imported from the company's subsidiary in Canada through the Port of Portsmouth. The plant was one of only two operational gypsum wallboard plants in New England. Two additional plants were under construction in New England; one in Newington, NH, and the other in East Providence, RI.

Domtar Gypsum, the third largest manufacturer of gypsum board in North America, continued construction of its $30 million wallboard plant at Newington. Crude gypsum would be shipped from a company-owned quarry in Newfoundland. The facility was expected to be operational in the spring of 1990 and employ about 80 workers.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Based on these estimates, output and value of construction sand and gravel decreased 34% and 37%, respectively. These decreases were largely the result of lower demand by the construction industry and highway departments. Approximately 40 companies and local highway departments operated nearly 60 pits in all of the State's counties. Leading counties in order of output were Hillsborough, Merrimack, Belknap, and Carroll. Main uses were for concrete aggregate, road base and coverings, and asphaltic concrete aggregates.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Crushed stone was the State's third leading mineral commodity produced, after construction sand and gravel and dimension stone. Crushed stone output in 1989 was 771,000 short tons, a 68% decline from that of 1988. Output in 1989 was the lowest since 1982, when 600,000 short tons was produced. The large decrease in 1989 was largely attributed to lower demand by the construction industry, the primary end users of the material.

Crushed granite, limestone, and traprock were produced by eight companies operating eight quarries in four counties. Leading counties in decreasing order of output were Rockingham, Cheshire, Grafton, and Hillsborough. Main uses were for road base, bituminous aggregate, road surfacing, macadam, and concrete aggregate.

Dimension.—New Hamphshire ranked eighth of 34 States that produced dimension stone in 1989. Dimension granite was mined by four companies at five quarries in Coos, Hillsborough, and Merrimack Counties. Primary uses were for curbing, rough blocks, and monumental stone.

[1]State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in New Hampshire for 5 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

TABLE 2

NEW HAMPSHIRE: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse and fine aggregates: Other construction materials[2]	460	2,856
Unspecified:[3]		
Estimated	310	1,164
Total	[4]771	4,020

[1]Includes granite, limestone, traprock, and miscellaneous stone.
[2]Includes stone used in macadam, concrete and bituminous aggregates (coarse), stone sand (concrete), and graded road base or subbase.
[3]Includes production estimated for nonrespondents.
[4]Data do not add to total because of independent rounding.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Clays:			
Kane-Gonic Brick Corp.	Gonic, NH 03867	Pit	Strafford.
Gypsum (calcined):			
National Gypsum Co.	4100 First International Bldg. Dallas, TX 75270	Plant	Rockingham.
Sand and gravel (1988):			
Construction:			
Alvin J. Coleman & Sons Inc.	Route 16 Conway, NH 03818	Pit	Carroll.
Nashua Sand & Gravel Co.	Route 130 Nashua, NH 03060	Pit	Hillsborough.
Plourde Sand & Gravel Co. Inc.	Suncook, NH 03275	Pit and plant	Merrimack.
Torromeo Trucking Co.	33 Old Ferry Rd. Methuen, MA 01844	Pit	Rockingham.
A. Whitcomb Inc.[1]	Lancaster Rd. Gorham, NH 03581	Pits	Belknap, Carroll, Cheshire, Coos, Grafton.
F. W. Whitcomb Construction Corp.[1]	Box 429 Bellows Falls, VT 05101	Pit	Cheshire.
Stone:			
Crushed:			
Brox Paving Materials Inc.	85 Greeley St. Hudson, NH 03051	Quarry	Hillsborough.
Continental Paving Inc.	150 Lowell Rd. Hudson, NH 03051	do.	Do.
John Iafolla Co. Inc.	Peverly Hill Rd. Portsmouth, NH 03801	do.	Rockingham.
Lebanon Crushed Stone Co.	Plainfield Rd. West Lebanon, NH 03784	do.	Grafton.
F. W. Whitcomb Construction Corp.	Box 429 Bellows Falls, VT 05101	do.	Cheshire.
Dimension:			
Leo Belisle Granite Co.	315 Hackett Hill Rd. Hooksett, NH 03106	do.	Merrimack.
Kitledge Granite Corp.	Armory Rd. Milford, NH 03055	do.	Hillsborough.
Rock of Ages Corp.	Box 482 Barre, VT 05641	do.	Coos.
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 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 1989 was at an alltime high of nearly $249 million, a $7 million increase from the 1988 total. The combined value of crushed stone and construction sand and gravel, the State's two leading mineral commodities, accounted for 84% of the mineral production value. Other commodities mined or recovered included clays, greensand, industrial sand, peat, and zircon. New Jersey was the only State that produced greensand, which is used primarily for water filtration. The State ranked ninth of 38 States that produced industrial sand and fifth of 22 States that produced exfoliated vermiculite.

TRENDS AND DEVELOPMENTS

During the 1983–88 period, construction activity in New Jersey far outperformed that in the Nation as a whole. However, during the latter half of 1988 and for most of 1989, this construction boom showed signs of moderating, mirroring developments in the rest of the Nation. The explosive growth of construction that began in 1983 was driven by a broad-based building boom that included new housing, office buildings, commercial facilities, infrastructure, and other types of nonresidential projects.[2] In 1989, the value of total construction projects was down 17% from 1988 figures. The largest decline was in residential contracts (down 29%). Declines were also reported for nonbuilding contracts (down 14%) and for nonresidential contracts (down 3%). Because most of New Jersey's mineral value is composed of aggregate sales, the slump in construction influenced demand for these commodities. In 1989, decreases in output were reported for construction sand and gravel and for common clay. Although production of crushed stone remained virtually unchanged from 1988 estimates, the average unit value rose 6%, from $6.40 per short ton in 1988 to $6.78 in 1989. The State's record mineral value in 1989 can largely be attributed to this increase in average unit value.

Until it closed in 1986, the Sterling Hill Mine was the only remaining zinc mine in New Jersey and the last working underground mine in the State. The Sterling Hill Mine produced zinc ore for more than two centuries and was one of the world's top mineral-specimen producers, with more than 300 mineral varieties identified. Many were unique to that deposit. In 1989, private interests purchased this former New Jersey Zinc Co.'s mine in Ogdensburg. They were in the process of restoring the mine to develop a historical mining museum that would complement the Franklin Mineral Museum 3 miles away. The new venture, called the Sterling Hill Mining Co., was formed not to mine ore but to present to

TABLE 1

NONFUEL MINERAL PRODUCTION IN NEW JERSEY[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	metric tons	5,430	$140	14,954	$368	18,492	$400
Gem stones		NA	3	NA	3	NA	3
Peat	thousand short tons	32	614	43	797	W	638
Sand and gravel:							
Construction	do.	e15,200	e61,200	18,318	74,183	e15,200	e68,400
Industrial	do.	2,112	27,872	1,860	25,437	1,797	26,138
Stone (crushed)	do.	3 17,576	3 111,951	e 3 19,300	e 3 123,500	20,799	140,998
Zircon concentrates	metric tons	W	W	W	W	W	8,988
Combined value of clays (common), marl (greensand), stone (crushed limestone, 1987–88), and values indicated by symbol W		XX	12,444	XX	17,544	XX	3,318
Total		XX	214,224	XX	241,832	XX	248,883

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

the general public a complete display of the mine's activities, equipment, and memorabilia. The venture was also designed to preserve and protect the zinc ores found there. Another goal included the eventual opening of walk-in adits so that the general public can see and learn about the unique ores of this world-renowned deposit. The expected opening date was August 1, 1990.

EMPLOYMENT

During 1989, nearly 2,400 persons were employed in the minerals extractive industry in the State. In the mineral-dependent construction industry, slumping housing starts, as well as slippage in the volume of new office, commercial, and nonresidential projects, led to a steady erosion of construction employment in New Jersey beginning early in 1989. Jobs in this sector, after climbing by about 63,000 during the 1983–88 boom period and averaging more than 170,000 during 1988, declined to approximately 165,000 by yearend 1989.[3]

REGULATORY ISSUES

In September, the Environmental Protection Agency (EPA) cited 12 New Jersey companies, including steel and nonferrous metal producers, for failure to file a report on the toxic chemicals that their plants release into surrounding communities. The EPA, acting under a 1986 community right-to-know law, said that the companies "failed to report their chemical emissions into the environment during 1987 to the EPA and to the State by July 1, 1989" as required by the law. New Jersey metals companies cited by the agency were New Jersey Steel Corp., Sayreville; U.S. Aluminum Inc., Haskell; American Copper Products Inc., Edison; and Teledyne Inc.'s Clifton-based tungsten alloy operation. Other New Jersey metals companies cited included Berger Industries Inc., Metuchen; Industrial Tube Corp., Somerville; the York Wire Co., Clifton; and Alfred Heller Heat Treating Co. Inc., Clifton.[4]

The Engineering Department of Jersey City announced that it was preparing to remove 65,000 tons of chromium-contaminated soil from 27 sites throughout the city at an estimated cost of $30 million. Although 148 sites containing 2.3 million tons of contaminated soil have been identified, the first phase of the cleanup would address only the 27 sites, all in residential areas. The sites were believed to have been contaminated by the use of chromium slag as fill and diking material by four chromite processing firms. The contaminated soil would be shipped to another State, possibly Ohio or Alabama, because New Jersey had no landfills that were federally approved for the disposal of hazardous waste. The State of New Jersey and some of the companies originally responsible for the contamination would pay for the work, which was slated for completion in 1992.

In September, Warren County officials announced a program designed to collect automotive batteries for recycling. The action was initiated because the State's first waste-to-energy plant in Warren County was faced with the problem of disposing of lead-contaminated ash from the incinerator that came on-stream in 1988. Disposal transportation costs rose because the ash had to be taken to out-of-State hazardous waste facilities. Earlier in the year, the county began a collection program for household batteries, which commonly contain alkali, nickel, cadmium, mercury, and lithium.

LEGISLATION AND GOVERNMENT PROGRAMS

Chapter 146, signed into law in August, made permanent the prohibition against mining or milling of fissionable source materials in the State. The bill was introduced after the State Department of Environmental Protection (DEP) conducted a study that indicated that the exploration, mining, or processing of these materials posed safety and health risks to the public.

Chapter 186, signed into law in September, required the State to adopt radon construction standards and to develop preconstruction tests thereafter. Radon, a naturally occurring radioactive gas produced from the breakdown of uranium in bedrock or soils, was believed to cause lung cancer. In 1987, nearly 33% of 6,000 homes tested by the State exceeded Federal guidelines for maximum acceptable levels.

In the solid waste sector, Chapter 109 was signed into law, prohibiting DEP from issuing, after December 31, 1991, a discharge permit to private, industrial, and commercial applicants for the discharge of solid, semi-solid, or liquid wastes into the ocean waters of the State. Early in the year, DEP also released two reports on New Jersey's Hazardous Waste Program—"Hazardous Waste Program Status Report" and "Site Status Reports on Hazardous Waste Remediation." The reports described the major issues faced by the Hazardous Waste Program and underlined the initiatives that were being developed to provide solutions for the solid waste problems.

The New Jersey Geological Survey (NJGS) was the primary agency for investigating the State's mineral resources and groundwater. Some of the areas in which the agency worked included offshore mineral analyses, geophysical techniques to determine mine subsidence hazards, an inventory of historical iron and copper mines, and a continuing Statewide scientific study of radon.

During the year, the NJGS, in a cooperative project with the U.S. Geological Survey (USGS) and Rutgers University, completed mineralogic analyses of heavy minerals in 75 offshore sediment grab samples. The work was supported by a grant from the Minerals Management Service. Information from this study should help in assessing the economic mineral potential of the offshore areas of New Jersey. The heavy minerals included metals such as titanium, zirconium, and the rare earths.

An exhibit entitled "Early Mining in New Jersey" was completed by the NJGS and sent to the National Mining Hall of Fame and Museum in Leadville, CO. The exhibit included eight 20-inch by 30-inch panels with text, maps, and photos. In addition, approximately 40 ore samples, including 13 fluorescent mineral samples from Franklin Marble, were included in the display.

A Geographic Information System (GIS) database was completed by the NJGS for all known historical iron and copper mines in the State. The GIS files contain field locations and 17 descriptive parameters for each mine. Computer listings were available from the NJGS.

The NJGS provided emergency assistance to the Borough of North Arlington, Bergen County, following the sudden collapse of the Victoria shaft of the Schuyler Mine on November 30, 1989. The Schuyler copper mine, one of the oldest mines in the United States, was active at various times between 1720 and 1901. Housing was constructed in the area of the mine between 1930 and 1960 without knowledge of the locations of 42 additional shafts. The survey provided archived maps and reports on the mine workings, information on shaft stability, assessment of drilling, and geophysical surveys for mine shaft detection. Some of the old shafts were found to lie under driveways and streets, and some possibly, were under the houses. The NJGS was continuing to evaluate data and meet with local officials, consultants, and the Bureau of Mines.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Clays.—Two companies produced clay in the State. Glen-Gery Brick produced common clay and shale at an operation in Somerset County, and The Morie Co. Inc. mined fire clay in Cumberland County. Output of common clay was used primarily for manufacturing common brick; fire clay was used primarily in foundries.

Greensand.—New Jersey was the only State that produced greensand. The greensand, produced in Gloucester County, 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.—Three companies mined peat in 1989, two in Sussex County and one in Warren County.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Construction sand and gravel was the State's second leading mineral commodity produced, accounting for 27% of the State's mineral value. Construction sand and gravel was produced by approximately 60 companies in 15 of the State's 21 counties. Leading counties in order of output were Ocean, Camden, Cumberland, Cape May, and Morris. Major uses were for concrete aggregates, asphaltic concrete aggregates, fill, and roadbase and coverings.

Amboy Aggregates became the new name for the former McCormack Aggregates, which had been dredging sand from the Ambrose Channel between Staten Island and Brooklyn, NY, since 1986. The newly formed company, the Nation's largest offshore producer of sand and gravel, was equally owned by Ralph Clayton & Sons Materials and Great Lakes Dredge & Dock Co. Amboy would continue to operate out of South Amboy, NJ, and distribute aggregate in New Jersey, New York, and Connecticut. With the operation of a new dredge, the company was mining at a rate of 800,000 cubic yards per year.[5]

Industrial.—Nationally, New Jersey ranked ninth in industrial sand production in 1989. Industrial sand production in New Jersey also accounted for more than two-thirds of the Northeast region's production, which included the six New England States, New York, Pennsylvania, and New Jersey. In 1989, a total of 7 companies operated 18 pits in 6 counties and produced 1.8 million short tons valued at $26 million. Cumberland County, where most of the operations were located, was the largest source for glass, foundry, and blast sand in the Northeast region of the United States.

The Morie Co. Inc., a division of South Jersey Industries, began industrial sand mining operations at its new $700,000 facility in Maurice River Township. The new installation was on the site of George Pettino's former sand mining operation. Morie constructed an automated, five-story wash plant with a projected capacity of 750,000 short tons per year.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

TABLE 2

NEW JERSEY: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate, graded:		
Concrete aggregate, coarse	1,187	8,156
Bituminous aggregate, coarse	1,177	7,537
Bituminous surface treatment aggregate	306	2,552
Railroad ballast	355	2,071
Coarse and fine aggregates:		
Graded road base and subbase	1,387	8,695
Crusher run or fill or waste	333	1,901
Other construction materials[2]	1,185	8,889
Other miscellaneous uses[3]	469	4,360
Unspecified:[4]		
Actual	13,801	92,474
Estimated	599	4,363
Total	20,799	140,998

[1] Includes limestone, granite, and traprock.
[2] Includes stone used in macadam, rirap and jettystone, filter stone, stone sand (concrete and bituminous mix or seal), screenings-fine, unpaved road surfacing, and terrazzo or exposed aggregate.
[3] Includes stone used in agricultural limestone, poultry grit and mineral food, other agricultural uses, flux stone, chemical stone, mine dusting or acid water treatment, asphalt and other fillers or extenders, and roofing granules.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.

NEW J

LEGEND

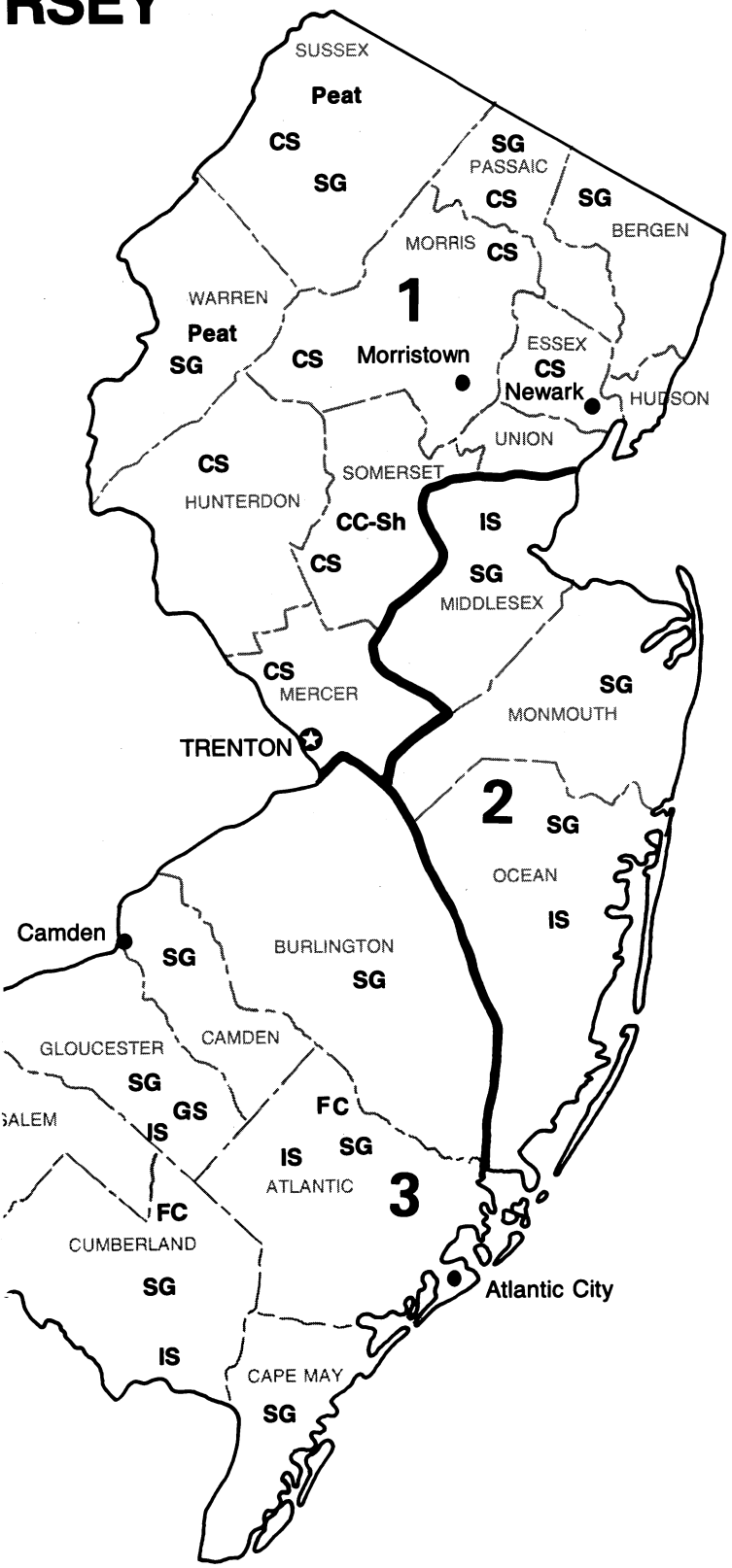
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

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

RSEY


SUSSEX
Peat
CS
SG
SG
PASSAIC
CS
SG
BERGEN
MORRIS
CS
1
WARREN
Peat
SG
CS
Morristown
ESSEX
CS
Newark
HUDSON
UNION
CS
HUNTERDON
SOMERSET
CC-Sh
IS
CS
SG
MIDDLESEX
CS
MERCER
SG
MONMOUTH
TRENTON
2
SG
OCEAN
IS
Camden
SG
BURLINGTON
SG
GLOUCESTER
CAMDEN
SG
GS
IS
FC
IS
SG
ATLANTIC
3
FC
CUMBERLAND
SG
IS
Atlantic City
CAPE MAY
SG

Crushed.—Crushed stone, the State's leading mineral commodity, accounted for 57% of the State's total mineral value. Production was 20.8 million tons valued at $141 million. All of the stone was produced in District 1 in the northern part of the State, as depicted on the principal mineral-producing localities map. Leading counties in order of output were Somerset, Morris, Mercer, and Sussex. Major uses were for concrete aggregate, roadbase and coverings, and bituminous aggregate.

In at least three separate court cases in Hunterdon, Somerset, and Mercer Counties, stone producers were challenging township or court-imposed restrictions that could end stone production. Local officials placed stringent regulations or restrictions on several quarries in areas that were once rural, but were becoming more urbanized. Some of the regulations that towns were allowed to impose on quarry operators were restrictions on the depth and operating hours of the quarries. Quarry owners maintained that they were there first and that residents should expect some inconveniences when they move near a quarry. The court cases and other battles over licenses were testing the limits of municipal regulation as the towns enacted safety regulations and control of activities over which the State did not have jurisdiction.[6]

Zircon.—Heritage Minerals Inc. recovered zircon and lecontite from dry tailings at the former ASARCO Incorporated ilmenite mine at Lakehurst. These tailings had been stockpiled during the 10 years that Asarco produced ilmenite. The tailings were expected to be depleted by the end of 1990. Heritage also announced that it may install dredging equipment that would extend the operation for another 6 years.[7] Also, near yearend, Nord Ilmenite Corp., a wholly owned subsidiary of Nord Resources Corp., began recovering zircon and other heavy minerals from tailings near Lakewood at Glidden Co.'s former mineral sands operation. The mine reportedly contained 280,000 short tons of tailings containing zircon, ilmenite, and rutile.

At least three companies produced zirconium materials in the State. Magnesium Elektron Ltd. manufactured zirconium chemicals at a plant in Flemington. American Minerals Inc. produced milled zircon in Camden, and Singh Industries, formerly Foote Mineral Co., produced cubic zirconia at a plant in Cedar Knolls.

Other Industrial Minerals

In addition to the commodities mined and listed in table 1, the production and value of some processed or manufactured mineral commodities were also surveyed by the Bureau of Mines.

CCF Inc. Research Laboratory produced high-modulus synthetic graphite fibers at a plant in Summit. Gypsum imported from Nova Scotia, Canada, was calcined by the National Gypsum Co., Burlington County, and by Domtar Gypsum, Camden County. The calcined gypsum was used primarily to manufacture wallboard. Crude iodine was shipped into New Jersey by six companies to manufacture various iodine-containing compounds. The compounds were used as laboratory reagents and in sanitation, pharmaceuticals, and specialty organic and inorganic compounds. Rowan Industries Inc., Monmouth County, used cultured quartz crystal, primarily for electronic applications. Crude perlite from out-of-State sources was expanded by The Schundler Co., Edison, and used for roof insulation, plaster aggregate, and masonry insulation and as a soil conditioner. Elemental sulfur was recovered as a nondiscretionary byproduct at two petroleum refineries in the State. The sulfur was used in the manufacture of sulfuric acid, fertilizers, plastics, and other products. Crude vermiculite was exfoliated at W. R. Grace & Co., Construction Products Division, Trenton, and by Schundler in Edison. Its principal uses included fireproofing, loose-fill insulation, block insulation, and horticultural agents.

Metals

The State's last operating metal mine closed in 1986 when the New Jersey Zinc Co. ceased operations at the underground Sterling Hill zinc mine in Ogdensburg. However, a number of companies in the State continued to process or manufacture metal commodities.

Operations ceased at the Alumet Smelting Corp., a secondary aluminum smelter in Newark. During the year, American Technology Systems Inc., Cleveland, OH, proposed to purchase the Alumet operations, but announced that environmental contamination at the Newark Plant prevented the purchase.[8] AMAX Specialty Coppers Corp. produced oxygen-free copper (OFHC™) and copper alloys at a plant in Carteret. The products were used in a broad range of markets including the electronics, plating, and construction industries.[9] CP Chemicals Inc. and Madison Industries Inc. both produced copper sulfate at plants in Middlesex County. Shieldalloy Corp., a subsidiary of Metallurg Inc., produced alloys of aluminum, boron, columbium, titanium, and vanadium at an electric and metallothermic furnace in Newfield, Gloucester County. Iron oxide pigments were produced by two companies in Camden and Middlesex Counties. Rhône-Poulene Inc. produced rare-earth materials at a plant in Princeton. New Jersey Steel Corp. produced steel at an electric furnace minimill in Sayreville, Middlesex County. Nearly all of the production was rebar. Raritan River Steel Co., a leading producer of wire rod, operated a plant in Perth Amboy, Middlesex County.

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[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in New Jersey for 7 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2] New Jersey Department of Labor. New Jersey Economic Indicators, v. 300, Dec. 22, 1989, p. 4.

[3] ———. New Jersey Economic Indicators, v. 303, May 4, 1990, p. 4.

[4] American Metal Market. EPA Cites 12 New Jersey Companies. V. 97, No. 206, Oct. 25, 1989, p. 3.

[5] Rock Products. McCormack Aggregates Now A Joint Venture. V. 92, No. 3, Mar. 1989, p. 7.

[6] ———. New Jersey Towns Try To Restrict Quarries. V. 93, No. 2, Feb. 1990, pp. 25–26.

[7] Mining Engineering. Zirconium. V. 42, No. 6, June 1990, p. 583.

[8] American Metal Market. American Recovery's New System Finished. V. 97, No. 154, Aug. 9, 1989, p. 9.

[9] AMAX. 1989 Annual Report. P. 16.

TABLE 3

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	Box 490 Somerville, NJ 08876	Pit and plant	Somerset.
Greensand:			
Inversand Co., a subsidiary of Hungerford & Terry Inc.	Box 45 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.
The Morie Co. Inc.	1201 North High St. Millville, NJ 08332	do.	Atlantic, Cape May, Cumberland.
South State Inc.	Box 68 Bridgeton, NJ 08302	Pit and dredge	Burlington and Ocean.
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.
Whitehead Bros. Co.	Box 259, River Rd. Leesburg, NJ 08327	Pits	Do.

See footnotes at end of table.

TABLE 3—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone:			
Granite (crushed and broken):			
Mt. Hope Rock Products Inc.	625 Mt. Hope Rd. Wharton, NJ 07885	Quarry	Morris.
Riverdale Quarry Co.	125 Hamburg Turnpike Riverdale, NJ 07457	do.	Do.
Tri-County Asphalt Corp.	Route 15 Hopatcong, NJ 07843	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.
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.	Paulsboro, NJ 08066	do.	Gloucester.
Vermiculite (exfoliated):			
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	Plant	Mercer.
Zircon:			
Heritage Minerals Inc.	Box 468 Route 70, Mile Marker 41 Lakehurst, NJ 08733	do.	Ocean.
Nord Ilmenite Corp.	Box 118 Jackson, NJ 08527	do.	Do.

[1] Also industrial sand.
[2] Also milled zircon.
[3] Also exfoliated vermiculite.

THE MINERAL INDUSTRY OF NEW MEXICO

This chapter has been prepared under a Memorandum of Understanding between the 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 Michael N. Greeley[1] and Robert W. Eveleth[2]

New Mexico retained its national 10th place ranking during 1989 for the production of nonfuel minerals. The value of output rose to a record high of more than $1.1 billion, about 10% more than that of 1988.

Approximately 70% of the total mineral value was contributed by metals. Copper, gold, and silver were the leading metallic minerals. The mines of the State also produced important quantities of mica, molybdenum, perlite, potassium salts, pumice, and zinc.

TRENDS AND DEVELOPMENTS

During the decade of the eighties, a dramatic drop in nonfuel mineral production occurred in 1982 when prices for copper and molybdenum plummeted and demand for minerals used in the agricultural and construction industries fell sharply. In that year, the total value of output was about $429 million.

With but one minor downturn since then, production in the State has continued a steady climb through the end of the decade. Both segments of mineral output, metals and industrial minerals, have contributed to the growth. The value of production has practically doubled in the past 3 years.

Programs that supported this increased output were the construction of a new concentrator and completely renovated smelting facilities at a major copper mine, the installation of solvent extraction-electrowinning plants at two copper mines, startup of a copper-zinc mine, reopening a molybdenum mine, and reactivating or expanding production of potash.

During most of the decade, output of construction-related commodities generally declined or showed little change, while both residential and nonresidential construction activity stagnated. In dollar value for all categories of construction contracts, there was about 10% less construction in 1989 than in 1988.[3] New Mexico's construction industry has experienced a general decline for 6 consecutive years.

EMPLOYMENT

There were 6,290 employees in the

TABLE 1

NONFUEL MINERAL PRODUCTION IN NEW MEXICO[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	46,491	$141	28,555	$83	31,012	$94
Copper[2]	do.	246,532	448,373	258,660	687,182	259,432	748,939
Gem stones		NA	200	NA	200	NA	279
Gold[2]	kilograms	W	W	W	W	1,076	13,231
Perlite	short tons	437,000	13,611	458,000	14,294	487	13,080
Potassium salts	thousand metric tons	1,323	174,200	1,271	213,800	1,365	242,619
Pumice	do.	79	991	76	852	77	795
Sand and gravel (construction)	thousand short tons	e8,600	e31,000	8,787	31,367	e11,800	e45,400
Stone:							
Crushed	do.	4,503	15,919	e3,500	e13,900	2,784	11,672
Dimension	short tons	21,893	626	e21,893	e626	W	W
Combined value of cement, gypsum, helium (Grade-A), iron ore (includes byproduct material), lead, mica (scrap), molybdenum, pyrites (1987), salt, silver, zinc (1989), and values indicated by symbol W		XX	52,783	XX	r60,368	XX	48,483
Total		XX	737,844	XX	1,022,672	XX	1,124,592

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

nonfuel minerals industry according to the New Mexico Energy, Minerals and Natural Resources Department (EMNRD).[4] In 1989, the industrial minerals sector employed about 53% of the workers; the metals sector employed the balance. During the year, the average weekly earnings of a worker in the nonfuel minerals industry was about $450.

REGULATORY ISSUES

Chino Mines Co. continued discussions with the New Mexico Environmental Improvement Division (EID) concerning a water release that occurred during the summer of 1988 at the company's mining operation near Hurley. Unusually heavy rainfall had forced Chino, pursuant to its Federal permit, to release stormwater runoff mixed with mine process water into Whitewater Creek. At the end of 1989, although the U.S. Environmental Protection Agency (EPA) found no substantive problems with the event, the EID continued to seek possible penalty assessments against the company.

At its Hidalgo smelter, the Phelps Dodge Corp. continued to monitor ground water in the vicinity of the smelter's compacted, clay-lined evaporation pond. The pond had received blowdown water from the acid plant. In accordance with a discharge plan approved by the EID, the company continued to assess any impact on ground water quality and to investigate alternative technologies to mitigate any adverse impact. The company also agreed to cease discharging acidic solutions into the pond as originally constructed, to neutralize or remove acidic fluids contained in the pond, and to commence a ground water remediation program for any existing contamination.

Potential ground water contamination was also investigated by the Homestake Mining Co. at its tailings site near Grants. The EPA asserted that leachate from the uranium mill tailings had contaminated a shallow aquifer used by adjacent residential subdivisions. During 1989, the company continued to operate an injection and collection system that has improved quality of the aquifer to levels that comply with State ground water standards.

Late in the year, Molycorp Inc. received conditional approval from the Bureau of Land Management (BLM) to build a new tailings pond on Guadalupe Mountain northwest of the company's Questa Mine. A tailings management plan still had to be approved by the BLM, and permits were required from the EID, the State Engineer, and the EPA. Molycorp originally proposed the plan to construct the tailings facility in 1982. Several environmental organizations have objected to the plan, however, claiming the proposed tailings disposal pond would ruin scenic views of the area.

Throughout the year, the Copar Pumice Co. had difficulty operating its Las Conchas Mine in Sandoval County. Although the company received permission from the U.S. Forest Service to begin mining in January, court-imposed delays prevented startup until April; mining was restricted to 5 of the originally approved 33 acres. Eventually, approval to mine the entire parcel was granted and, in September, Copar filed an application to patent 1,700 acres of mining claims in the area. Several organizations objected to the mining and patenting, primarily because the mine location was considered too close to the East Fork of the Jemez River, which was proposed for a national Wild and Scenic River designation.

EXPLORATION ACTIVITIES

The level of exploration effort for nonfuel minerals increased noticeably in New Mexico during the year. Records maintained by the BLM indicated the State ranked 10th in the Nation during 1989 in the number of active claims for all commodities.

LAC Minerals Ltd. signed an agreement during the year with Pegasus Gold Inc. to jointly explore and develop the Ortiz property in Santa Fe County. Pegasus was designated the operator and was allowed under the agreement to earn a 50% interest in the venture by spending a minimum of $27.5 million by late 1992. Several lode gold occurrences containing a total of more than 1 million troy ounces have been identified. According to its annual report, Pegasus expected production within 2 years. Late in 1989, the company began driving a decline to obtain bulk samples for metallurgical testing.

The Canyon Resources Corp. conducted exploration drilling for gold on its Signal Peak prospect in the Tierra Blanca district south of Kingston (Grant County). Nova Gold Resources Inc. continued exploration drilling for gold on its Summit property in the Steeple Rock district of western Grant County. Other gold properties that received some attention in 1989 included the American-Helen Rae and Vera Cruz prospects in Lincoln County, the Hopewell district in Rio Arriba County, and several properties in the Black Range of Sierra County. Geophysical surveys were conducted by Gerle Gold Ltd. on the BP massive sulfide deposit in Bernalillo County.

At midyear, Molycorp Inc. announced the discovery of a large deposit of yttrium and zirconium on the Mescalero Apache Indian Reservation in Otero County. Reserves were stated to be 2.7 million short tons containing 0.18% yttrium oxide and 1.2% zirconium oxide. The mining firm and the tribe planned to develop the deposit under a joint lease and operating agreement. When it begins producing, the mine will be the first mine in the United States to produce yttrium as a principal product.

Much exploration activity occurred in the industrial mineral sector during the year. Projects included the drilling and evaluation of perlite deposits near Lordsburg (Hidalgo County) and Silver City (Grant County). A sampling and testing program was conducted on a humate deposit near Regina in Rio Arriba County, and several dimension stone occurrences in the State were investigated.

LEGISLATION AND GOVERNMENT PROGRAMS

The 1989 State legislature enacted Senate bill 303, designating the Director of the New Mexico Bureau of Mines and Mineral Resources (BMMR) as State Geologist. House bill 526 gave to the Santa Fe-based Mining and Minerals Division of the New Mexico Energy, Minerals and Natural Resources Department (EMNRD) authority over mine registration, annual reporting, and safeguarding of surface mine openings. The bill also limited the duties of the State Mine Inspector to mine safety training

and the enforcement of laws governing certain underground operations. Jurisdiction of the Inspector's office was transferred to the New Mexico Institute of Mining and Technology in Socorro.

Pursuant to the enactment of House bill 526, the Mining and Minerals Division of the EMNRD issued new rules and regulations applicable to annual mine registration, reporting, and map submittal; change in registration of mines, mills and smelters; and safeguarding of mine surface openings in the State. New reporting forms were also distributed to all operators of mines, mills, and smelters.

The Mining and Minerals Division and the University of New Mexico's Institute for Public Policy continued a joint effort to develop an economic strategy for the extractive industries in the State. As a part of this program in 1989, firms in the extractive industry were asked to assess the impact of environmental, reclamation, taxation, employment, transportation, and utility policies on their operations. A statistical analysis of all replies incorporated in the final report was to be submitted to State authorities in 1990.

As part of its ongoing function, the Mining and Minerals Division published the "Annual Resources Report" for 1988. This report contains tables and discussions of statistics on the extractive resources of New Mexico. Also issued in 1989 was the "Directory of New Mexico Mines and Mills."

The New Mexico BMMR issued several publications that addressed mineral resources in the State. Bulletin 127, "Adobe, Pressed-Earth, and Rammed-Earth Industries in New Mexico" was released in 1989. Open-file reports published during the year included OFR-357, "Reconnaissance Gold Geochemical Survey of Five Selected Areas in Southwestern New Mexico;" OFR-359, "A Compilation of Trace-Metal Values in Water and Sediments Collected Along the Rio Grande and its Tributaries in New Mexico;" and OFR-360, "Mineral Resources of the Gray Ranch Area, Hidalgo County, New Mexico." Published maps included GM-65, "Geology and Mineral Resources of Jones Ranch School Qadrangle, McKinley County, New Mexico;" and RM-18, "Uranium Resources in New Mexico."

The Bureau of Mines continued to supervise the administration of the New Mexico Mining and Mineral Resources Research Institute (MMRRI) during 1989. The Institute was housed at the New Mexico Institute of Mining and Technology and was administered by a faculty member of the Department of Materials and Metallurgical Engineering. Total funds allocated by the Bureau to the MMRRI was $138,000.

In 1989, the Bureau released a special report, "Availability of Federally Owned Minerals for Exploration and Development in Western States: New Mexico, 1987." This report compared the availability of federally owned minerals in the State with lands considered favorable for discovery of mineral resources. The study was made to determine the extent to which Federal lands with mineral potential in New Mexico have been withdrawn by legal action or restricted by management practice.

During the year, the Bureau began a project to prepare a directory that will present comprehensive nonproprietary data on the principal deposits of strategic and critical minerals in New Mexico. This geographically based report will show the relationships between favorable geology and infrastructure and institutional factors to indicate the potential of a region for mineral development.

An investigation of Great Plains Margin-type deposits in New Mexico was continued during the year by the Bureau in conjunction with the New Mexico BMMR and the U.S. Geological Survey. In 1989, this study identified rare-earth-bearing carbonatites in association with known occurrences of thorium- and rare-earth-bearing veins and intrusive breccias in the Laughlin Peak area of Colfax County.

In another joint effort, the Bureau and the U.S. Geological Survey published "Mineral Summaries—Bureau of Land Management Wilderness Study Areas in New Mexico." The summaries covered more than 900,000 acres of public land currently under consideration for Federal wilderness status in New Mexico. Studies were conducted on 28 of the 48 proposed wilderness areas. According to the report, nearly 79% of the areas studied have identified mineral resources; about 73% have moderate or high potential for mineral resources.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Copper.—Production of copper in New Mexico remained relatively constant in 1989, showing only a slight increase over that of the previous year. The total mine output, however, sustained the State's position as the second leading source of primary copper in the Nation. Continued strong demand and an increase in the average, producer-delivered cathode copper price, from $1.21 per pound in 1988 to $1.31 in 1989, resulted in a 9% rise in the total value of copper production. This value represented about two-thirds of the total value of New Mexico's nonfuel mineral output.

During the year, the Tyrone Mine in Grant County was the largest producer of copper in the State and the third largest in the Nation. According to the 1989 annual report of the mine owner, Phelps Dodge Corp., 138,800 metric tons (153,000 short tons) of recoverable copper was produced at the property. Approximately 25% was electrowon copper, produced by Phelps Dodge's wholly owned subsidiary Burro Chief Copper Co.

In January, Phelps Dodge announced plans to extend the life of the Tyrone open pit mine through 1991. The company cited strong copper prices that would allow a lower grade ore body to be mined. An expansion of the solvent extraction-electrowinning (SX-EW) facility to approximately 50,000 metric tons (55,000 short tons) annual capacity was completed in 1989 at a cost of $20.5 million. Operation of this facility was expected to continue for 15 years after cessation of sulfide ore production.

At the Chino Mine (Grant County), the Phelps Dodge 1989 annual report stated that about 79,600 metric tons (87,700 short tons) of recoverable copper was produced for the company's account. The SX-EW plant at Chino was operated for its first full year during 1989 and produced almost 29% of the total copper output. Annual capacity of the plant is about 40,800 metric tons (45,000 short tons) of electrowon copper. A partner, the MC Minerals Corp. (Mitsubishi), received one-third of the total copper and byproduct production from the mine at Santa Rita and the smelter at Hurley. The Chino operation was the fourth largest producer of copper in the Nation during the year.

The underground Pinos Altos Mine in Grant County, leased by the Cyprus Minerals Co., produced about 3,300 metric tons (3,650 short tons) of copper according to the Goldfield Corp. in its Form 10-K for 1989. Goldfield's wholly owned subsidiary, the St. Cloud Mining

Co., processed Pinos Altos ore at its mill near Winston (Sierra County), under a joint-venture agreement with Cyprus. Goldfield reported that the ore milled during the year averaged 2.63% copper, 3.00 troy ounces of silver per short ton, and 0.009 troy ounce of gold per short ton. An additional tonnage of siliceous ore from the Pinos Altos property, mixed with similar ore from other mines, was shipped by St. Cloud as smelter flux containing 2.62% copper, 4.48 troy ounces of silver per short ton, and 0.013 troy ounce of gold per short ton.

The joint venture between Cyprus Minerals and St. Cloud Mining ended in 1989. Cyprus announced plans to continue operations alone at Pinos Altos, with full production of 400 short tons of ore per day. At yearend, the ore was being hauled by truck to the Groundhog concentrator in Deming. The concentrator was leased from ASARCO Incorporated and was to be refurbished for about $1 million.

In August, Cyprus signed a letter of intent with the Sharon Steel Corp. to consider a joint venture at the Continental copper mine in Grant County.[5] This mine was shut down by Sharon Steel in 1982. If a production agreement is made after a thorough evaluation of the property, Cyprus would be the mine operator. Initially, production would be limited to the open pit mine and its concentrator, which has a daily capacity of about 4,500 metric tons (5,000 short tons). Other parts of the property, including an underground mine and its concentrator and the Hanover Mountain deposit of mixed oxide and sulfide mineralization, could be put into production at a later date.

Gold.—There was a small increase in gold output during the year compared with that of 1988. The total value dropped significantly, however, owing to a decrease in the average price.

The largest amount of gold produced in New Mexico originated as a byproduct of copper ores and metal-bearing silica flux materials. The Chino and Tyrone copper mines were significant contributors to total production. Additional gold was recovered from direct smelting ore shipped from underground mines in Grant County by the Mount Royal Mining and Exploration Co. and Royal Minerals Inc. Mount Royal operated the Center Mine, which also produced copper, lead, and silver, and Royal Minerals operated the Carlisle Mine, which produced byproduct silver.

Molybdenum.—New Mexico mines tripled their output of molybdenum in 1989 over that of the previous year. The total value increased more than 100%.

Much of the increased production was due to the reopening late in the year of the Questa Mine in Taos County. Citing improved market and operating conditions, Molycorp Inc. resumed production at approximately 50% of capacity. In addition to higher metal prices, improved labor and utility contracts had been negotiated by the company.

According to the 1989 annual report of its parent company, Unocal Corp., Molycorp produced about 1,540 metric tons (3.4 million pounds) of molybdenum during the year at the Questa Mine. The underground mine, having an annual capacity of about 20 million pounds, had been on standby since 1986. The metal was also produced as a byproduct at the Chino copper mine.

Silver.—In 1989, the State slipped from sixth to seventh place nationally in the production of silver. Output of the precious metal fell more than 16% during the year and, because of lower prices, the total value dropped nearly 30%.

Most of the silver produced in New Mexico was a byproduct of primary copper ores. Silver recovered from copper concentrates at the Tyrone Mine, for example, qualified that property as the 13th largest silver-producing mine in the United States during 1989. Substantial amounts of silver were also produced at the Chino and Pinos Altos Mines.

Another source of silver in the State normally has been precious-metal flux ores mined by St. Cloud Mining Co. at its properties in Sierra County. In 1989, however, the company did not sell this ore or concentrate to copper smelters, but instead mined and stockpiled the materials at the mine site.[6]

Zinc.—In response to favorable prices, zinc was produced in New Mexico for the first time since 1981. St. Cloud installed a new zinc circuit at a cost of $400,000 in its concentrating facility in Sierra County and began processing ore shipments from the Pinos Altos Mine early in the year. This ore averaged 7.3% zinc.[7] Cyprus Minerals stated in its 1989 annual report and Form 10-K that the Pinos Altos property has the capacity to produce 15 million pounds of zinc per year. During the startup phase in 1989, the mine was credited with an output of 1.9 million pounds.

Other Metals.—The Sharon Steel Corp. continued to ship a small amount of magnetite stockpiled at its Continental Mine in Grant County. The iron ore was originally recovered as a byproduct of copper production. Some of the magnetite was purchased by a potash refinery in southeastern New Mexico to prepare a heavy-media fluid that was used to separate various saline minerals.

The Center Mine at Steeplerock and the Pinos Altos Mine produced lead as a byproduct during 1989. Although small compared to total domestic production, New Mexico's output increased 85% over that of the previous year.

The State produced approximately 19% of the Nation's domestically mined uranium in 1989. Production was derived from 11 separate properties operated by 3 companies. Recovery was either by conventional milling of ores or by low-cost, ion-exchange techniques applied to uranium-bearing mine waters. New Mexico was reported to have the second largest mineral reserve of uranium in the United States.[8]

Industrial Minerals

Cement.—The production of cement continued to trend downward in 1989. Output in the State has declined steadily since 1984.

Although there was no change in the production of masonry cement, output of portland cement in 1989 was down about 10% from that of the previous year. Low construction levels and weak cement consumption, as well as high levels of imported cement, were frequently cited as the principal factors causing this decline.

The reduced demand in New Mexico, coupled with excess production capacity, forced the average value of portland cement down approximately 9% to about $47.09 per short ton. This was about 3% less than the national average. The average value of masonry cement in the State increased more than 21% over that of 1988.

Ideal Basic Industries Inc., the fifth largest producer of portland cement in the Nation during 1989, operated a cement plant in Tijeras (Bernalillo County) and a distribution terminal in Albuquerque. The Ideal Basic plant, which is the only cement facility in the State,

has a rated annual capacity of 505,000 short tons. According to a company proxy statement and prospectus issued February 14, 1990, the plant was built in 1959 and modernized in 1980. In 1989, the dry-process plant operated at 39% of capacity.

Gypsum.—Crude gypsum output in New Mexico has continued to decrease since 1986. Production in 1989 dropped almost 10% from that of 1988, and the average value fell more than 16%. The output and average value of calcined gypsum in the State decreased about 6% from that of the previous year.

The Centex American Gypsum Co. continued to operate its gypsum wallboard plant in Albuquerque (Bernalillo County) at full capacity in 1989 according to the annual report of the company's parent firm, the Centex Corp. Crude gypsum supplied to this plant originated at the company-operated White Mesa Mine in nearby Sandoval County. Construction of a new wallboard plant at Bernalillo in Sandoval County proceeded on schedule during the year.

Mica.—New Mexico is one of just two Western States that reported mica production in 1989. Mineral Industrial Commodities of America Inc. produced muscovite and sericite at its MICA Mine in Taos County and beneficiated the mica at its mill in Velarde in Rio Arriba County. This mica was among some of the highest unit-value micas in the Nation. During the year, production rose about 14% over that of 1988; the total value increased nearly 8%.

Perlite.—Mining more than 82% of the domestically produced perlite in 1989, New Mexico producers continued to dominate the industry in the United States. An increase in perlite sales of about 6% over that of 1988 was registered during the year while production was derived from four mines. Grefco Inc., the largest producer of perlite in the Nation, operated mines in Socorro and Taos Counties; two other producers operated perlite mines in Cibola and Taos Counties.

Although sales volume rose for the sixth consecutive year, the average value of the ore declined almost 14% to $26.86 per short ton. Crude perlite was shipped out of state for expanding because there were no expansion facilities in New Mexico.

Potash.—New Mexico's mines were responsible for nearly 90% of the Nation's potash production in 1989. The value of potash sales, $242.6 million, represented more than 21% of the total nonfuel mineral production in the State. The average potash value during the year rose about 6% over that of 1988 to almost $178 per metric ton. More than $2.7 million in revenues were generated for New Mexico by potash leasing on State and Federal lands during the year.[9]

The large potash deposit in southeast New Mexico supported six mining and processing operations. The operating properties were composed of underground mines and ancillary surface facilities near Carlsbad in Eddy County. With more than 1,900 workers, the Carlsbad Basin potash industry employed more than 30% of the State's nonfuel, mineral work force in 1989.

Toward the end of the year, the BLM issued an order extending the royalty rate on all Federal potassium leases in New Mexico. The royalty rate for the next 2 years will continue to be 2% of the gross value of output at the point of shipment. About 85% of the total potash mined in the State has been derived from Federal leases.

To further lower potash costs and keep local producers competitive, Lea and Eddy Counties explored the feasibility of forming a Transportation Development District. It was thought that the District could enable potash producers to lower freight rates to eastern markets by tying new rail lines into closer, established rail routes. Discussions were held during the year with the State Transportation Authority.

According to the Form 10-K of AMAX Inc., its subsidiary, AMAX Potash Corp., produced about 446,300 metric tons (492,000 short tons) of potash in 1989. AMAX announced that the potash business was for sale because it no longer fit into the company's long-range strategic plans.

Effective January 1, 1989, Rayrock Resources Ltd. of Canada became the sole owner of the Western Ag-Minerals Co., operator of the Nash Draw potash mine. The change in ownership occurred when Rayrock purchased, for $19.5 million, the U.S. Mineral Co. U.S. Mineral's only asset was a 65% interest in Western Ag.

IMC Fertilizer Group Inc. produced a record 904,500 metric tons (997,000 short tons) of potash from its mine in New Mexico during the fiscal year ended June 30, 1989, according to the company's Form 10-K. IMC Fertilizer reported that the New Mexico operation was the largest domestic producer of double sulfate of potash magnesia (langbeinite) and the largest producer of sulfate of potash.

The Mississippi Chemical Corp. operated its potash mine in the State for the entire year following resumption of production in late 1988. With the startup of compaction and granulation facilities at the company-owned National Potash Co. property in early 1989, Mississippi Chemical reported in its Form 10-K for the fiscal year ended June 30, 1989, that it had the capacity to produce about 250,000 short tons per year of granular muriate of potash and 150,000 short tons per year of standard muriate of potash. The company spent approximately $7.8 million to improve and reopen the potash facilities.

Pumice.—In 1989, New Mexico was the third largest producer of pumice in the Nation. The combined output of the three operating mines in the State was equivalent to approximately 18% of total U.S. production. In comparison with 1988, production increased slightly, but the average value fell about 8% to $10.32 per metric ton.

Rio Arriba, Sandoval, and Santa Fe Counties each had one active pumice mine and accompanying mill during the year. Another mill that continued to operate near Santa Fe (Santa Fe County) purchased ore from the mines and sold a variety of sized products.

Salt.—Although the production of salt in the State remained essentially constant in 1989, the value of the production increased more than 25%. The average value per short ton of salt rose to $15.07. Three companies recovered salt from potash tailings in Eddy County, and one other employed solution mining in Lea County to recover brines and the contained salt.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Most of the sand and gravel production of New Mexico was concentrated in the population centers of Albuquerque

NEW MEXICO

LEGEND

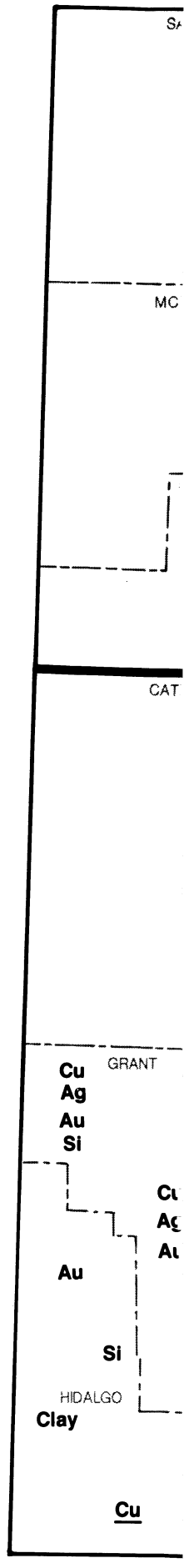
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

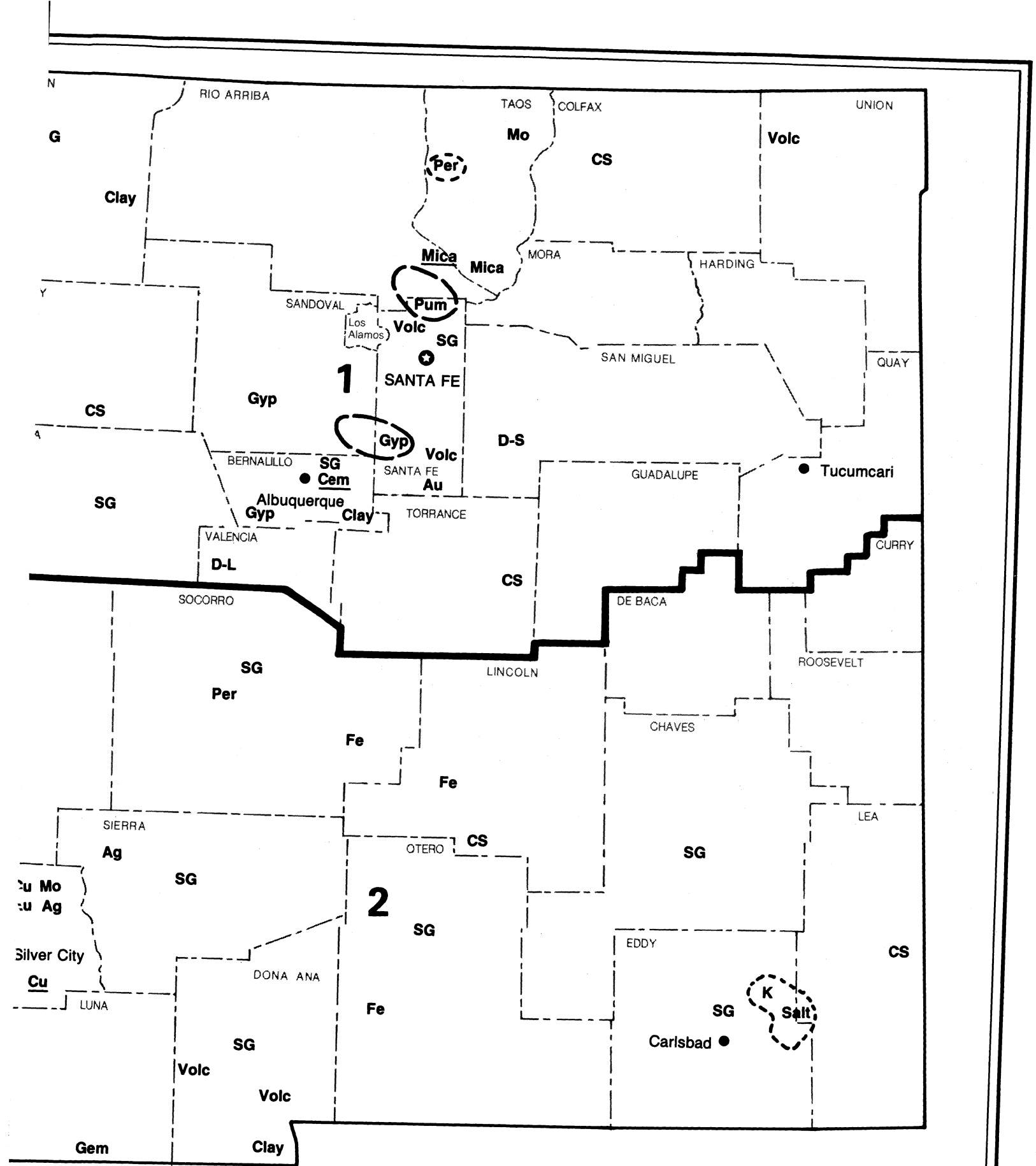
MINERAL SYMBOLS

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




RIO ARRIBA
TAOS
COLFAX
UNION
Clay
Per
Mo
CS
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Los Alamos
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VALENCIA
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Volc
Gem
Clay

and Santa Fe. Sand and gravel district 1, shown on the State map, encompasses these centers. In 1989, the estimated production for the State rose about 34% over that of the previous year. The average value, estimated to be $3.85 per short ton, increased about 8%.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Statistics for crushed stone production are separated into two geographical districts as depicted on the State map. Table 3 presents end-use statistics for these districts. Because of the decline of the construction industry in the State, the quantity and value of crushed stone produced in 1989 continued to fall. Production dropped about 38% from that of 1987.

Dimension.—In the 2-year period since 1987, the production of dimension stone decreased; the total value, however, increased considerably in the same period. Three principal producers reported production from several quarries. Most material was either limestone or marble.

Other Industrial Minerals.—The value of the total clay and shale output in New Mexico rose about 13% over that of 1988, even though there was a slight decrease in the production of common clays. A major component of the increased value was the sharp rise in production and corresponding value of fire clay. In 1989, the amount of fire clay produced in the State was more than twice that of the previous year.

Gem stones and gem materials produced in the State included agate, azurite, fluorite, onyx, smithsonite, and turquoise. The value of reported production during 1989 increased approximately 40% over that of 1988.

New Mexico is one of only four States that produced Grade-A helium during the year. Production within the State was comparatively small and declined about 8% from that of 1988.

Humate, derived from weathered coal and associated carbonaceous shales and claystones, has become an important nonfuel mineral commodity in the State. Enormous reserves of the humic acid-rich

TABLE 2

NEW MEXICO: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate, graded (+1 1/2 inch):		
Concrete aggregate, coarse	248	790
Bituminous aggregate, coarse	99	373
Fine aggregate (-3/8 inch):		
Stone sand, concrete	27	154
Screening, undesignated	9	25
Coarse and fine aggregates:		
Graded road base or subbase	419	1,071
Unpaved road surfacing	136	183
Crusher run or fill or waste	70	239
Other construction materials[2]	864	6,220
Other miscellaneous uses[3]	363	1,339
Unspecified:[4]		
Actual	307	422
Estimated	243	855
Total[5]	2,784	11,672

[1]Includes limestone, granite, volcanic cinder and scoria; traprock, quartzite, and miscellaneous stone witheld to avoid disclosing proprietary data.
[2]Includes stone used in macadam, riprap and jetty stone, railroad ballast, bituminous surface-treatment, stone sand (bituminous mix or seal), and terrazzo and exposed aggregates.
[3]Includes stone used in cement manufacture, flux stone, and roofing granules.
[4]Includes production reported without a breakdown of end use and estimate for nonrespondents.
[5]Data may not add to totals shown because of independent rounding.

TABLE 3

NEW MEXICO: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2	
	Quantity	Value	Quantity	Value
Construction aggregates:				
Coarse aggregate (+1 1/2 inch)[1]	13	66	—	—
Coarse aggregate, graded[2]	842	4,681	217	824
Fine aggregate (-3/8 inch)[3]	17	62	49	147
Coarse and fine aggregates[4]	442	2,558	244	511
Other construction aggregates	44	185	6	23
Chemical and metallurgical[5]	W	W	W	W
Special[6]	4	W	—	—
Other miscellaneous	317	1,069	42	270
Unspecified:				
Actual[7]	177	254	130	169
Estimated[8]	12	41	231	814
Total[9]	1,866	8,914	919	2,758

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1]Includes macadam and 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), and fine aggregate (screening-undesignated).
[4]Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run or fill or waste.
[5]Includes crushed stone for cement manufacture and flux stone.
[6]Includes crushed stone for roofing granules.
[7]Includes production reported without a breakdown by end use.
[8]Includes estimates for nonrespondents.
[9]Data may not add to totals shown because of independent rounding.

material have been identified, and, in 1989, there were two producing mines. Although figures are withheld because of confidentiality, the New Mexico Mining and Minerals Division reported that production increased over that of 1988. Humate is used chiefly as an additive in drilling muds and soil conditioners.

Elemental sulfur, recovered as a byproduct of natural gas production, increased slightly in 1989 from the previous year. Total shipments for the State were 45,000 metric tons valued at $3 million. Most of this production was in southeastern New Mexico.

The State was the second largest domestic producer of sulfuric acid, recovered as a byproduct of the roasting and smelting of base metals. All acid produced in this manner was obtained at two copper smelters operated by Phelps Dodge. Although production decreased slightly from that of 1988, the total value reported in 1989 rose about 6%.

[1]State Mineral Officer, Bureau of Mines, Tucson, AZ. He has covered the mineral activities in New Mexico for 2 years. Assistance in the preparation of the chapter was given by Donna Bruns, editorial assistant.

[2]Senior mining engineer, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM.

[3]Odenwald, A. Construction and Civil Engineering. New Mexico Bus. Jour., Nov. 1990, pp. 13–21.

[4]New Mexico Energy, Minerals and Natural Resources Dep. Annual Resources Report, Jan. 1990, 106 pp.

[5]Pay Dirt Magazine, Southwestern ed. Cyprus May Go Joint Venture on Long Closed Copper Mine., Sept. 1989, pp. 10A–11A.

[6]The Goldfield Corp. 1989 Form 10-K, 42 pp.

[7]Reference cited in footnote 6.

[8]Reference cited in footnote 4.

[9]Reference cited in footnote 4.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Ideal Basic Industries Inc., Ideal Cement Co.[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.
Garcia & Son Inc.[1]	Box 841 Farmington, NM 87401	Pit	San Juan.
Mathis & Mathis Mining & Exploration Co.[1]	Box 2577 Silver City, NM 88061	Pit	Luna.
New Mexico Brick Co. Inc. (doing business as Kinney Brick Co. Inc.)	Box 1804 Albuquerque, NM 87102	Pit	Sernalillo.
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.
Royal Minerals Inc.[7]	Box W Duncan, AZ 85534	do.	Do.
Gypsum:			
Centex American Gypsum Co.	Box 6345, Station B Albuquerque, NM 87197	Pit and plant	Sernalillo and Sandoval.
Ernst Teeter Trucking Inc.	Box 27317 Albuquerque, NM 87125	Pit	Sandoval.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Humate:			
Agronics Inc.	701 Madison St., NE. Albuquerque, NM 87110	Surface mine	Do.
Mesa Verde Resources	Box 8632 Albuquerque, NM 87198	Surface mine and mill	McKinley and Sandoval.
Mica:			
Mineral Industrial Commodities of America Inc.	Box 2403 Santa Fe, NM 87504	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.
Manville Sales Corp., a division of Manville Products 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:			
AMAX Potash Corp., a subsidiary of AMAX Inc.	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.
New Mexico Potash Corp., a subsidiary of Trans-Resources Inc.[8]	Box 610 Hobbs, NM 88240	do.	Do.
Western Ag-Minerals Co., a subsidiary of Rayrock Resources Ltd.	Box 511 Carlsbad, NM 88220	do.	Do.
Pumice:			
American Pumice Co.	Box 4305 Santa Fe, NM 87502	Mill	Santa Fe.
Copar Pumice Co. Inc.	Box 38 Espanola, NM 87532	Surface mine	Do.
General Pumice Corp.	Box 5135 Santa Fe, NM 87502	Surface mine and crushing and screening plant	Rio Arriba and Santa Fe.
Utility Block Co.	Box 6036 Albuquerque, NM 87197	Surface mines and crushing and screening plants	Sernalillo and Sandoval.
Salt:			
New Mexico Salt & Minerals Corp.	Box 2262 Carlsbad, NM 88220	Tailings treatment	Eddy.
Unichem International Co.	Box 1659 Eunice, 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:			
Armstrong & Armstrong Inc.	Box 1873 Roswell, NM 88202	Pit and plant	San Miguel.
CalMat Co.	Box 829 Albuquerque, NM 87103	do.	Sernalillo.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel—Continued			
Colony Materials Inc.	Box 4337 Santa Fe, NM 87502	Pit and plant	Santa Fe.
Connie H. Danley Construction Inc.	Drawer K Alamogordo, NM 88310	do.	Otero.
Espanola Transit Mix Co.	Box 38 Espanola, NM 87532	do.	Rio Arriba.
J. R. Hale Contracting Co. Inc.	Box 25667 Albuquerque, NM 87125	do.	Sernalillo.
Ribble Construction Inc.	Box 25411 Albuquerque, NM 87125	do.	Do.
Rio Grande Rock Inc.	Box 28 Las Cruces, NM 88005	do.	Do.
Springer Building Materials Corp.[1]	Drawer S Albuquerque, NM 87103	do.	Do.
Valley Transit Mix Inc.	Drawer L Las Cruces, NM 88001	do.	Dona Ana Co.
Silver:			
St. Cloud Mining Co.[9]	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 HH Gallup, NM 87305	Quarry	McKinley.
Rose Gravel Co.	Box 220 Carlsbad, NM 88220	do.	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.	4007 Mission Bell Las Cruces, NM 88001	do.	Do.
Rocky Mountain Stone Co.	Box 6608 Albuquerque, NM 87197	Quarries	Socorro and Valencia.
Uranium-Vanadium:			
Chevron Resources Co.	Box 1150 Grants, NM 87020	Underground mine	Cibola.
Homestake Mining Co.	Box 98 Grants, NM 87020	Underground mines, concentrator, ion-exchange from mine waters.	Cibola and McKinley.
Quivira Mining Co., a subsidiary of Rio Algon Ltd.	Box 218 Grants, NM 87020	do.	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 silver.
[8]Also salt.
[9]Also copper, gold, and lead.

THE MINERAL INDUSTRY OF NEW YORK

This chapter has been prepared under a Memorandum of Understanding between the 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 1989 was $745.2 million, nearly a $50 million increase over that of 1988. Leading mineral commodities produced in terms of value were crushed stone, salt, portland cement, construction sand and gravel, and zinc.

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 that mined garnet. 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 fifth in primary aluminum output.

LEGISLATION AND GOVERNMENT PROGRAMS

During the 1989 Legislative Session, three assembly bills (A 1226, A 4961, and A 8040) concerning the regulation of mining in the State were introduced. The aim of the bills was to amend the State's environmental conservation law to determine what roles the State and local governments should have in the regulation of mining and reclamation. Although no action was taken on the three bills, they remained in committee and may be addressed again in the 1990 Legislative Session.

The New York Geological Survey, the geological research agency of the New York State Museum, continued statewide landslide inventory mapping, earthquake preparedness studies, beach erosion investigation on Long Island, evaluation of disposal sites for low-level radioactive waste, bedrock and surficial quadrangle mapping of the Adirondack Mountains and publication of surficial geologic maps at 1:250,000, paleontologic and stratigraphic analysis in eastern New York, mineral resource inventory of the Adirondack Mountains, and geologic and petrologic studies of the raw materials of the dimension sandstone industry.

The Survey extended a program to study the aggregate and heavy-mineral resources in marine waters offshore New York. Shoals south of Long Island were found to contain 20% to 40% coarse sand and gravel within the 20-foot sub-

TABLE 1

NONFUEL MINERAL PRODUCTION IN NEW YORK[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	610,205	$3,562	551,375	$3,654	531,559	$3,429
Emery	short tons	1,945	W	W	W	—	—
Gem stones		NA	135	NA	200	NA	350
Peat	thousand short tons	1	34	W	W	W	10
Salt	do.	4,918	119,962	4,614	127,994	5,424	161,427
Sand and gravel:							
Construction	do.	e31,400	e112,900	33,884	124,341	e31,600	e118,500
Industrial	do.	58	651	53	625	53	633
Stone:							
Crushed	do.	38,103	188,694	e39,900	e193,500	39,851	201,749
Dimension	short tons	38,553	5,822	e30,751	e4,333	23,756	3,575
Combined value of cement, garnet, gypsum, iron ore (includes byproduct material, 1988–89), lead, silver, talc and pyrophyllite, wollastonite, zinc, and values indicated by symbol W		XX	218,620	XX	241,053	XX	255,495
Total		XX	650,380	XX	695,700	XX	745,168

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

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

bottom section sampled. These shoals are within reasonable shipping range of markets in the Greater New York City Metropolitan Area and were within reach of current dredging technology. As an adjunct to this program, grade and value of industrial minerals contained as potential coproducts in offshore aggregate deposits were investigated.

Under the State Mining and Mineral Resources Research Institute Program Act, the Bureau of Mines awarded an allotment grant of $261,448 to Columbia University's Henry Krumb School of Mines to conduct research and training in the mineral-related disciplines. Since Columbia first started receiving funds in 1987, it has received nearly $676,000 from the Bureau of Mines. Under stipulations of the act, the State of New York was required to match this grant on a 2-to-1 basis.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—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 the Independent Cement Corp. at its Catskill plant. All the plants used the wet process except for Glens Falls, which used the dry process. In 1989, shipments of portland and masonry cement fell 9% and 3%, 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.

Clays.—In 1989, common clay production and value decreased 4% and 6%, respectively. The clay was produced by six companies in five counties and was used principally in the manufacture of portland cement, face brick, concrete block, and structural cement.

The Norlite Corp. was ordered by the State Department of Environmental Conservation to shut down its hazardous waste management facility in Albany County until new air pollution control equipment was installed. The company manufactured lightweight aggregate from shale using liquid hazardous waste, such as paint thinner and chemical solvents, as fuel. Norlite indicated that it would use conventional fuels, such as oil, gas, and coal, until it can install pollution control equipment that would be up to standards. The change in fuel was not expected to affect the company's mining business or the manufacture of the aggregate, which was used in cement.

Garnet.—Garnet was produced at three sites in New York. Barton Mines Corp., Warren County, operated a surface mine and produced garnet for use in coated abrasives, glass grinding and polishing, and metal lapping. The NYCO Div. of Processed Minerals Inc., Essex County, recovered garnet as a byproduct from its wollastonite mining operation. The garnet was sold to a garnet producer for refinement and sale. International Garnet Abrasives Inc., Clinton County, produced garnet for use as blasting and filtration media.

Gem Stones.—Value of gem stones and mineral specimens collected by mineral dealers and amateur collectors in New York, based on a survey by the curator of mineralogy of the New York State Museum, was estimated at $140,000 in 1989. Of this amount, approximately $98,000 entered the market as specimens and educational-grade samples and $42,000 remained in private collections and museums. Popular gem- and mineral-collecting areas include Gore Mountain near North Creek, Warren County; refuse areas of zinc mines operating near Balmat, St. Lawrence County; and southern Herkimer and western Montgomery Counties where "Herkimer Diamonds," doubly terminated clear quartz crystals, were found.

Gypsum.—USG Corp., the State's only crude gypsum producer, mined the mineral from an underground mine at Oakfield in Genesee County. Output remained essentially the same as that of 1988. The crude gypsum mined at Oakfield 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 72 plants that calcined gypsum in the United States. Two other companies also calcined gypsum using imported ore. National Gypsum Co. operated a plant in Rensselaer, Rensselaer County, and Georgia-Pacific Corp. operated a plant at Buchanan, Westchester County. Total gypsum calcined in the State in 1989 was 1.1 million short tons valued at $15.6 million.

Peat.—One company mined peat in Seneca 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 5.4 million short tons and was valued at $161 million. Rock salt was produced by Cargill Inc. in Tompkins County and by AKZO Salt Corp., formerly known as International Salt Co., in Livingston County. Both companies also produced evaporated salt at plants in Schuyler County. Morton International Inc. also produced evaporated salt in Wyoming County. Texas Brine Corp. produced brine for use as feedstock to chloralkali producers in the region.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Based on these estimates, output and value of construction sand and gravel declined 5% and 7%, respectively. More than 380 companies and government agencies mined construction sand and gravel from 573 operations in 53 counties. Leading counties in order of output were Suffolk, Dutchess, and Rensselaer. Main uses were for road base and coverings, concrete aggregate, and fill.

During 1989, numerous hearings were held in towns throughout the State concerning sand and gravel mining. Most of these hearings were the result of citizen concern about noise, truck traffic, and potential water well disrup-

tions. Although mining and reclamation are regulated by the State, local zoning boards can restrict or limit mining through zoning regulations. Because of these restrictive zoning laws, competition from other land developers, urban sprawl, and environmental concerns, some producers could not enter the market; others were forced to close, move elsewhere, or restrict their operations.

In one such case involving a possible archeological conflict, the chief of the Turtle Clan of the Onondaga Nation and about 15 others concerned with Native American history asked the Sidney Town Board not to allow a permit to a company to mine gravel on a possible Iroquois burial ground. The chief told the board that if mining was allowed on the land off Route 357, up to 8,000 years of Iroquois culture could be erased. The Onondaga, Mohawk, Oneida, Cayuga, Seneca, and Tuscarora peoples make up the Iroquois Confederacy. In 1988, the town received a request to grant a special use permit to Burton F. Clark Inc. of Delhi to mine 593,000 cubic yards of gravel at the site. During an environmental assessment of the property, flint fragments, bones, and teeth dating back 8,000 years were unearthed, indicating a possible seasonal burial ground. At yearend, the town board had not decided whether to allow mining at the site.

Industrial.—Whitehead Bros. Inc. was the only industrial sand producer in New York. The company operated one pit in Saratoga County and another in Oneida County. Major uses of industrial sand were for glass containers, moldings, and filtration.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

New York stone statistics are compiled by geographical districts as depicted in the State map. Table 3 presents end-use statistics for New York's eight districts.

Crushed.—Crushed stone, the State's leading commodity, accounted for 27% of the State's total nonfuel mineral value. In 1989, production remained virtually unchanged from that of 1988. However, average unit value per ton rose 21 cents, from $4.85 to $5.06 per short ton.

Limestone accounted for more than two-thirds of the crushed stone produced in the State. Other rock types quarried in descending order of tonnage were dolomite, granite, traprock, sandstone, marble, and slate. Leading counties in order of output were Albany, Dutchess, Onondaga, Niagara, Erie, and Monroe. The crushed stone was used mainly for cement manufacture, bituminous aggregate, road base, and fill.

Dimension.—Dimension stone was produced by 13 companies operating 19 quarries. Both output and value decreased, compared with that of 1988. Types of stone quarried included granite, limestone, quartzite, sandstone, and slate.

Talc.—New York ranked fourth of 10 States that produced talc in 1989. Gouverneur Talc Co., a subsidiary of R. T. Vanderbilt Co. Inc., mined the talc from both a surface and an underground operation in St. Lawrence County. The ore was ground and processed at an on-site mill and used primarily for ceramics and paint additives.

Wollastonite.—New York was the only State that produced wollastonite. Two companies, both in Essex County, mined wollastonite in 1989. The largest producer, NYCO, operated the Lewis surface mine 14 miles west of Willsboro. During the year, the company announced the introduction of chemically modified wol-

TABLE 2

NEW YORK: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	509	2,579
Riprap and jetty stone	346	1,648
Filter stone	84	277
Coarse aggregate, graded:		
Concrete aggregate, coarse	1,483	9,835
Bituminous aggregate, coarse	4,129	20,523
Bituminous surface-treatment aggregate	645	3,929
Railroad ballast	69	412
Fine aggregate (−3/8 inch):		
Stone sand, concrete	269	1,888
Stone sand, bituminous mix or seal	1,203	4,623
Other fine aggregate	849	4,442
Coarse and fine aggregates:		
Graded road base or subbase	3,480	21,041
Unpaved road surfacing	60	477
Crusher run or fill or waste	3,216	14,112
Other construction materials[2]	1,675	13,725
Agricultural: Agricultural limestone[3]	174	1,736
Chemical and metallurgical: Cement manufacture	4,457	12,433
Unspecified:[4]		
Actual	14,474	74,586
Estimated	2,729	13,482
Total	39,851	[5]201,749

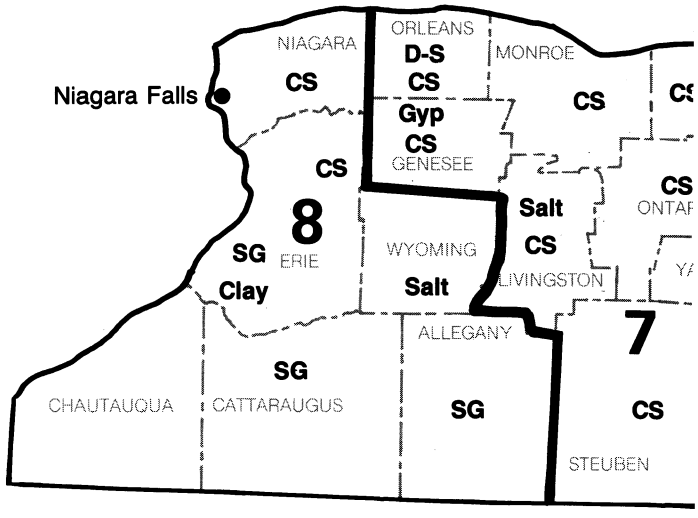
[1] Includes limestone, dolomite, granite, traprock, sandstone, marble, slate, and miscellaneous stone.
[2] Includes stone used in fine aggregate.
[3] Includes stone used in other agricultural uses.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data do not add to total shown because of independent rounding.

LEGEND

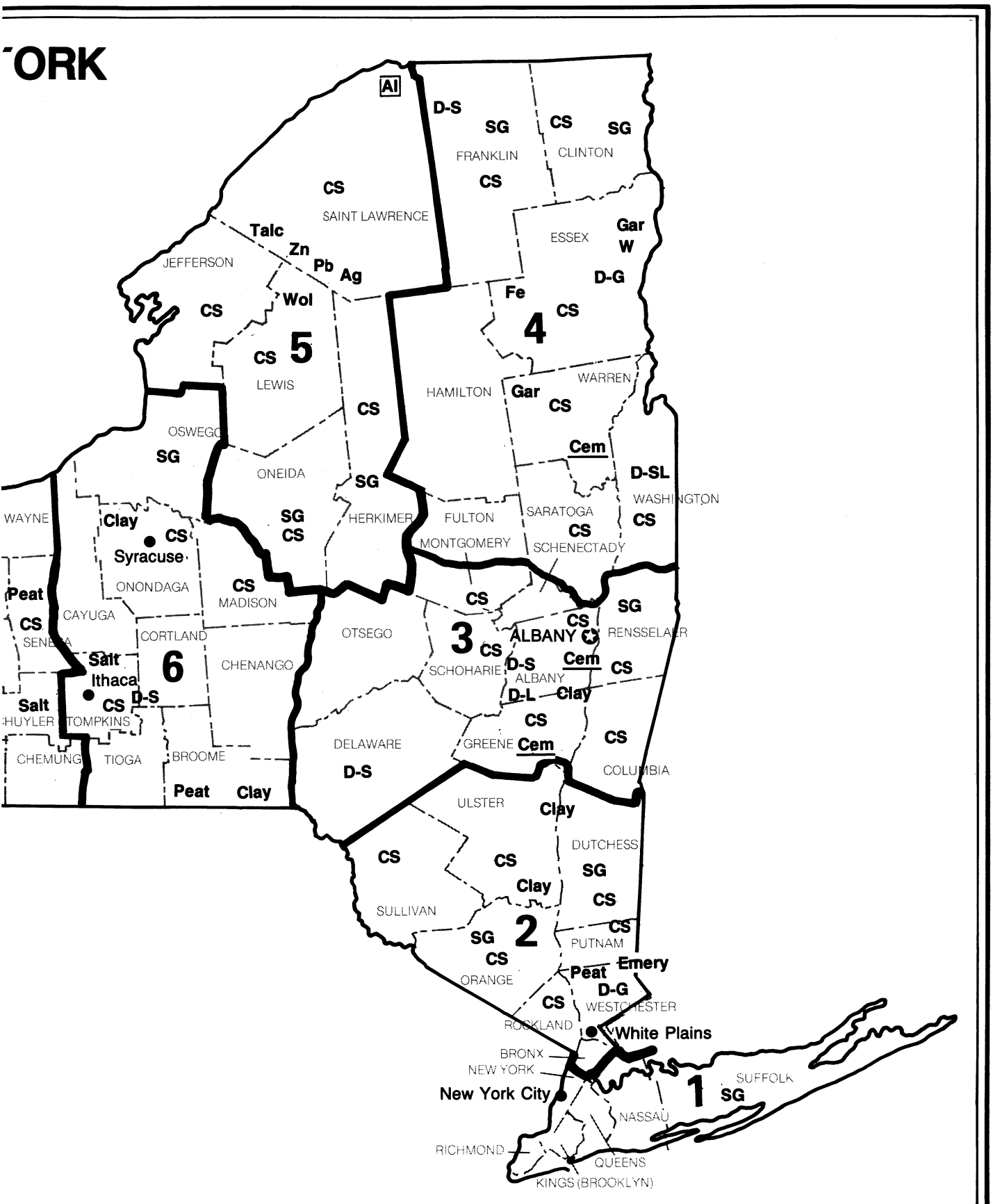
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Ag	Silver
Al	Aluminum plant
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-G	Dimension Granite
D-L	Dimension Limestone
D-S	Dimension Sandstone
D-SL	Dimension Slate
E	Emery
Fe	Iron
Gar	Garnet
Gyp	Gypsum
Pb	Lead
Peat	Peat
Salt	Salt
SG	Sand and Gravel
Talc	Talc minerals
Wol	Wollastonite
Zn	Zinc



Principal Mineral-Producing Localities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SAINT LAWRENCE
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LEWIS
HAMILTON
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OSWEGO
Cem
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D-SL
ONEIDA
SG
WASHINGTON
WAYNE
Clay
SG
HERKIMER
FULTON
SARATOGA
CS
CS
CS
MONTGOMERY
SCHENECTADY
Syracuse
Peat
CS
ONONDAGA
CS
MADISON
CS
SG
CAYUGA
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OTSEGO
3
ALBANY
RENSSELAER
SENECA
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CORTLAND
Cem
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Ithaca
6
CHENANGO
SCHOHARIE
D-S
ALBANY
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Clay
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D-S
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HUYLER
TOMPKINS
DELAWARE
GREENE
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CHEMUNG
TIOGA
BROOME
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COLUMBIA
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ULSTER
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DUTCHESS
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SULLIVAN
CS
2
PUTNAM
SG
CS
Peat
Emery
ORANGE
D-G
CS
WESTCHESTER
ROCKLAND
White Plains
BRONX
NEW YORK
SUFFOLK
New York City
1
SG
NASSAU
RICHMOND
QUEENS
KINGS (BROOKLYN)

TABLE 3

NEW YORK: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(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 aggregate (+1 1/2 inch)[1]	—	—	W	W	218	896	376	1,303
Coarse aggregate, graded[2]	—	—	1,313	10,164	1,389	6,227	826	3,033
Fine aggregate (−3/8 inch)[3]	—	—	755	5,314	758	2,899	W	W
Coarse and fine aggregates[4]	—	—	506	4,682	876	4,252	W	W
Other construction aggregates	—	—	1,309	11,496	95	269	627	1,941
Agricultural[5]	—	—	—	—	23	127	(6)	(6)
Chemical and metallurgical[7]	—	—	—	—	3,723	10,605	(6)	(6)
Other miscellaneous	—	—	—	—	—	—	704	1,612
Unspecified:								
Actual[8]	—	—	3,137	25,456	2,428	7,197	10	100
Estimated[9]	—	—	1,057	6,175	177	996	157	821
Total[10]			8,076	63,288	9,687	33,467	2,699	8,811

	District 5		District 6		District 7		District 8	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregate (+1 1/2 inch)[1]	20	59	45	266	55	303	W	W
Coarse aggregate, graded[2]	962	7,784	443	1,761	W	W	W	W
Fine aggregate (−3/8 inch)[3]	73	745	410	1,577	W	W	16	62
Coarse and fine aggregates[4]	359	5,374	942	2,594	1,640	8,461	W	W
Other construction aggregates	—	—	55	338	1,354	6,895	2,596	10,815
Agricultural[5]	(6)	(6)	(6)	(6)	—	—	(6)	(6)
Chemical and metallurgical[7]	(6)	(6)	—	—	—	—	—	—
Other miscellaneous	48	340	22	316	—	—	112	1,169
Unspecified:								
Actual[8]	3,000	12,541	1,447	6,077	2,894	16,365	1,558	6,851
Estimated[9]	138	662	403	1,517	700	3,115	97	195
Total[10]	4,600	27,505	3,768	14,447	6,643	35,139	4,379	19,091

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[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), fine aggregate (screening-undesignated), and other fine aggregates.
[4] Includes graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[5] Includes agricultural limestone and other agricultural uses.
[6] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[7] Includes crushed stone for cement manufacture.
[8] Includes production reported without a breakdown by end use.
[9] Includes estimates for nonrespondents.
[10] Data may not add to totals shown because of independent rounding.

lastonite (wollastokups) for engineering thermoplastics for fascia and body panels. The products reportedly improved physical properties and provided the dimensional stability required to pass electrocoat temperatures in excess of 400°F.[3] During 1989, NYCO was also offered for sale. In October, Engelhard Corp. agreed in principle to purchase the company for $110 million but, at yearend, announced that it would not go through with the purchase due to undisclosed reasons.

R. T. Vanderbilt, the State's other producer, operated an underground mine near Harrisville, Lewis County, through its talc mining subsidiary, Gouverneur Talc Co. Inc. The ore differed from that of NYCO material in that garnet was not present in the ore. 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 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.

New York continued to rank second of the 13 States that produced synthetic graphite. Three companies, all in Niagara County, produced and shipped graphite. Principal uses were for electrodes, anodes, unmachined graphite shapes, and crucibles and vessels.

Indium Corp. of America, one of two indium producers in the United States, produced indium at a plant in Utica.

Crude iodine was shipped into New York by RSA Corp., Westchester County, and by Sterling Organics US, Rensselaer County. RSA used the iodine to produce specialty organic chemicals. Sterling used it in the manufacture of pharmaceuticals, catalysts, and sanitation products.

Electric-furnace-fused mullite was produced by Washington Mills Electro Minerals (US) Corp. 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 loose 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.

W. R. Grace & Co. ceased operations at its exfoliated vermiculite plant in Weedsport, Cayuga County. No production was reported in 1989.

Metals

Aluminum.—In 1989, New York ranked fifth in the Nation in primary aluminum output and value. Two companies, both in Massena, St. Lawrence County, operated primary aluminum plants. 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. Estimated production by the Bureau of Mines in 1989 was about equal to that of 1988.

Near yearend, the Environmental Protection Agency (EPA) issued Superfund administrative orders to Alcoa and Reynolds Metals Co. to perform the necessary studies and cleanups of sediments tainted with polychlorinated biphenyls (PCB's) in the St. Lawrence River system near Massena. The orders were part of a joint effort by the EPA, the New York State Department of Environmental Conservation, and the St. Regis Mohawk Tribe to clean up pollution in the area. It was alleged that Alcoa and Reynolds both used PCB-based hydraulic fluids during the operation of their primary aluminum production plants in Massena. The EPA indicated that as a result of water outfalls, sewer drain overflows, and surface water runoff, PCB's were discharged into the river system. Earlier in the year, Alcoa and Reynolds challenged New York's proposal to limit PCB discharges at the sites, saying it would be too costly in light of the questionable ability of the State to measure very low levels of PCB's. State officials countered that the technology to measure the lower levels already existed.[4]

Alcan Rolled Products Co., a unit of Alcan Aluminum Corp., announced plans to spend $175 million to upgrade its sheet rolling facility at Oswego. The project included a major modernization of the plant's hot rolling mill, a new melting and casting center, a pusher-furnace-preheat facility, a new high-speed precision slitting line, and a new roll grinder.[5]

Iron Ore.—Stockpiled byproduct magnetite concentrate from NL Chemicals Inc.'s (formerly NL Industries Inc.) MacIntyre Mine was shipped by rail to eastern coal mines for use in coal washing. In November, the company shipped its last trainload of ore and shut down its concentrating operation at Tahawus, Essex County. However, NL Chemicals announced that it would maintain an active presence at the mine and that voluntary reclamation efforts beyond those required by the State Department of Environmental Conservation would go forward.

The company was also keeping its State mining permit in force, and it planned to truck magnetite from existing stockpiles and sell crushed stone from the tailings to contractors. In anticipation that the mine will someday reopen, NL Chemicals paid $950,000 at public auction for a 72-year lease on the 35-mile-long railroad line extending from the mine to the trunk line of the Delaware & Hudson Railway at North Creek. Had the company not acquired the lease, the rail would have been sold to scrap metal dealers. The availability of the rail line was crucial for any future mine development because Tahawus is in an isolated locality.

Lead and Silver.—Lead and silver were recovered as byproducts at the Zinc Corp. of America's (ZCA) zinc operations in St. Lawrence County.

Zinc.—New York ranked third behind Tennessee and Missouri in zinc output in 1989. Although zinc production increased 10%, value rose nearly 50%, the result of higher average zinc prices in 1989. Zinc Corp. of America 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 1989, the Pierrepont Mine was the Nation's second leading zinc mine in terms of total output; the Balmat Mine ranked fourth. Concentrate from the mill was shipped by rail to a company-owned smelter in Monaca, PA.

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[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in New York for 7 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] Industrial Minerals. NYCO's New Wollastonite Products. No. 264, Sept. 1989, p. 89.

[4] American Metal Market. EPA Superfund Orders Go to Alcoa, Reynolds. V. 97, No. 198, Oct. 11, 1989, p. 2.

[5] ———. Alcan Rolled Plans $175M Upgrading. V. 97, No. 97, May 18, 1989, p. 1.

TABLE 4

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:			
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	Do.
Garnet:			
Barton Mines Corp.	North Creek, NY 12853	Pit	Warren.
Gypsum:			
Calcined:			
Georgia-Pacific Corp.	Box 105605 133 Peachtree St., N.E. Atlanta, GA 30348	Plant	Westchester.
National Gypsum Co.	2001 Rexford Rd. Charlotte, NC 28211	do.	Rensselaer.
Crude:			
USG Corp.[3]	101 South Wacker Dr. Chicago, IL 60606	Underground mines and plant	Genessee and Rockland.
Iron ore:			
NL Chemicals Inc.	Tahawus, NY 12879	Pit	Essex.
Peat:			
Malcuria Bros Inc.	1436 Gates Rd. Geneva, NY 14456	Bog	Seneca.
Perlite (expanded):			
Scolite International Corp.	6 Madison St. Troy, NY 12181	Plant	Rensselaer.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Salt:			
AKZO Salt Corp.	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 (1988):			
Construction:			
Broad Hollow Construction Estates Inc.	Box 483 Farmingdale, NY 11735	Pit	Suffolk.
Clemente Latham Concrete Corp.	RD No. 5, Box 56 Buffalo, NY 14224	Pits	Albany and Rensselaer.
William M. Larned & Sons Inc.	RD No. 3, Box 200A, Burdeck St. Schenectady, NY 12306	Pits and plant	Albany and Schenectady.
Industrial:			
Whitehead Bros. Inc.	Box 259, River Rd. Leesburg, NJ 08327	Pits	Oneida and Saratoga.
Slag (iron):			
Buffalo Crushed Stone Corp.[2]	2544 Clinton St. Buffalo, NY 14224	Plant	Erie.
Stone:			
Crushed:			
Beazer East Inc., a subsidiary of Beazer USA	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.
Finger Lakes Stone Co. Inc.	Box 401 Ithaca, NY 14850	do.	Tompkins.
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.	Main St. Middle Granville, NY 12849	Quarries	Washington.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
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.[4]	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[5]	Balmat, NY 13607	Underground mines	St. Lawrence.

[1] Also clays.
[2] Also stone.
[3] Also calcined gypsum.
[4] Also garnet.
[5] Also byproduct lead and silver.

THE MINERAL INDUSTRY OF NORTH CAROLINA

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 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 mineral commodities produced in North Carolina in 1989 increased 9.8% over that reached in 1988 to an alltime high of $581.6 million. The State's three leading commodities, lithium minerals, phosphate rock, and crushed stone, accounted for over 82% of the total. The State led the Nation in the production of lithium minerals, feldspar, scrap mica, olivine, and pyrophyllite. It also ranked second in phosphate rock production. Nationally, North Carolina ranked 11th in the value of industrial minerals produced and 19th in overall mineral production. No production of metal from mining operations was reported to the Bureau of Mines, although one small industrial sand and gravel operation in western North Carolina reputedly recovered a minor amount of gold and rare-earth minerals in its milling operation.

TRENDS AND DEVELOPMENTS

The total value of mineral production in North Carolina increased to a new record high for the seventh consecutive year. The increase resulted primarily from increases in the total value of lithium minerals, phosphate rock, sand and gravel, crushed stone, and dimension stone produced. The increase in value resulted from a combination of both higher production and higher unit values, except for industrial sand and gravel, the unit value of which decreased slightly. The value of dimension stone increased more than 100% but still accounted for only slightly more than $5 million of the increase. Crushed stone, on the other hand, increased only 3.2% but accounted for almost $8 million of the increase. The largest dollar increases were recorded for phosphate rock and lithium minerals, both of which gained more than 18%.

North Carolina's mineral production during the 1980's paralleled that of most of the other southeastern States. A record high was established in 1980, and then the demand for minerals decreased in 1981 and 1982. The resulting decline reflected the recession that affected the entire country in the early 1980's. From 1983 through 1989, mineral production increased steadily from $380 million to almost $582 million, establishing a new record high each year.

TABLE 1

NONFUEL MINERAL PRODUCTION IN NORTH CAROLINA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	2,929,351	$15,282	2,880,103	$16,349	2,270,384	$15,529
Feldspar	short tons	512,386	15,562	507,986	17,312	480,436	14,024
Gem stones		NA	550	NA	688	NA	784
Mica (scrap)	thousand metric tons	91	5,607	79	4,512	73	4,192
Peat	thousand short tons	W	W	21	W	W	W
Sand and gravel:							
Construction	do.	e8,600	e30,100	11,076	38,459	e11,200	e43,700
Industrial	do.	1,184	15,329	1,246	15,953	1,627	19,902
Stone:							
Crushed	do.	48,847	237,181	e50,500	e250,000	51,519	257,976
Dimension	short tons	32,669	5,128	e31,977	e5,026	62,665	10,477
Combined value of lithium minerals, olivine, phosphate rock, talc and pyrophyllite, and values indicated symbol W		XX	152,178	XX	181,135	XX	214,984
Total		XX	476,917	XX	529,434	XX	581,568

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

One of the year's most widely circulated news stories relating to North Carolina's mineral industry was an announcement by Amoco Corporation that it had selected a Mount Airy granite quarry to supply the stone facing for recladding the Amoco Building in Chicago. Deliveries began in the fourth quarter of 1989. The 80-story building was originally faced with 43,000 Italian marble panels 1.5 inches thick. Exposure to Chicago's harsh weather had caused the marble to deteriorate since the building was completed 15 years ago.[4]

Major financial transactions were headed by the awarding of more than 100,000 acres of wetland owned by First Colony Farms Inc. to the Conservation Fund by the U.S. Bankruptcy Court. The Conservation Fund, financed by a grant of $8.8 million from the Mellon foundation, outbid Nissho Iwai American Corp. $8.5 million to $8.1 million. Nissho, in cooperation with Westinghouse Electric Corp., had planned to build a peat-fueled electrical generating plant on the property.

Lone Star Industries Inc. of Greenwich, CT, completed in January the sale of its remaining 40% interest in the Tarmac-Lone Star joint venture to Tarmac American Division of Herndon, VA. Tarmac, a subsidiary of Tarmac PLC, Wolverhampton, United Kingdom, acquired complete control of aggregate quarries and concrete product facilities in North Carolina, South Carolina, and Virginia.

Falconbridge Ltd., the parent company of Indusmin, a producer of feldspar, mica, and silica at Spruce Pine, was the object of takeover bids and tender offers by several companies. The initial offer was made by Amax Inc. This was followed by an offer made jointly by Noranda Inc. and Trelleborg AB. At yearend, the Noranda-Trelleborg offer was still pending.

Texasgulf Inc. (Tg), which is owned by the French conglomerate Elf Aquitaine Inc., celebrated the 25th anniversary of its phosphate operations at Aurora, Beaufort County. The celebration coincided with the announcement of a major change in its mining operations and the scheduling of construction on a $20 million water-recycling system. A $40 million purified phosphoric acid plant, built as a joint venture by Tg; Albright and Wilson, Americas; and Olin Corporation, neared completion as the year ended. The plant at the Aurora site was designed to produce approximately 120,000 tons of phosphoric acid a year.

The U.S. Army Corps of Engineers was studying a request by Tg to deepen the harbor at Morehead City from 40 feet to 45 feet to permit bulk ocean transportation in larger, deeper draft vessels.

Hitachi Metals announced that it would build a 250,000-square-foot facility in China Grove, Rowan County, to manufacture ceramic magnets primarily for the automotive industry. The magnets would be used in motors for windshield wipers and ventilation, fuel pumps, power windows, starters, and power steering units. Construction was scheduled to begin during December and to be completed in January 1991. The plant was expected to employ 130 people, increasing to 250 within 24 months.

EMPLOYMENT

U.S. Department of Labor statistics indicated that 4,900 people were employed in North Carolina's mining industry, increasing from 4,800 in 1988. Almost one-half, 2,300, were employed by the crushed stone segment. The largest single employer was Tg, which employed 268 in its mining operation. Tg had a total employment of 1,200 workers at its phosphate operation and an annual payroll of $48 million.

REGULATORY ISSUES

Regulatory issues in North Carolina in 1989 revolved almost entirely around the opposition of environmentalists and local residents to new or enlarged mining plans, or allegations that existing operations were causing pollution in violation of terms of their mining permits. Often, the confrontations ended in court, as illustrated by the following examples.

Vulcan Materials Corp. filed an appeal of a decision, by a Buncombe County Superior Court judge, that voided Vulcan's Flat Creek Quarry mining permit. Vulcan's appeal contended that a resolution by the County Commission requiring an environmental impact statement (EIS) was selectively enforced against Vulcan, that Buncombe County was without authority to require the EIS by resolution, and that the judge had no jurisdiction over the permit.

Orange County Superior Court dismissed a $2.5 million lawsuit filed by Nello L. Teer Company against Orange County and the County Commissioners. The suit alleged that the county and commissioners acted illegally in denying Teer's request for a special use permit to develop and mine a property that it had purchased.

Tg and the State of North Carolina agreed out of court on a $1 million settlement of a $5.7 million fine assessed against Tg in 1986 for more than 1,000 air pollution violations that occurred between 1983 and 1986 and for altering air-pollution control equipment without notifying the State. Environmentalists were split on the fine reduction, but agreed that a change in the company's management since the 1986 decision had improved its environmental stance.[5]

The Southern Environmental Law Center, representing four environmental protection groups, announced that its suit challenging a ruling by the U.S. Army Corps of Engineers had been settled out of court. The ruling had found that 7,000 acres containing potentially minable peat were not wetland and therefore not subject to Clean Water Permit requirements. The settlement was reached when the Corps agreed to withdraw its earlier determination, and the Environmental Protection Agency (EPA) agreed to make a new determination on the extent of wetland on the tract.

The High Shoals City Council unanimously approved a zoning ordinance designed to prevent development of a proposed Vulcan Materials Co. quarry near Hardin. Vulcan was engaged in exploration drilling while waiting for approval of their State mining permit at the time the ordinance was passed.

Currituck County officials placed a moratorium on new mining permits until an environmental impact study was completed. The action resulted from dissatisfaction expressed by local residents after the State Division of Environmental Management issued an amended mining permit for a sand and gravel pit operated by Outer Banks Contractors. Opponents

of the amended permit believed that it never should have been issued because the company was violating the terms of the original permit.[6]

Complaints by local residents led to four inspections in 2 months by North Carolina Air Quality Section personnel at the Carolina Solite Company plant near Aquadale in Stanly County. The plant burned an average of 62 million pounds of hazardous waste annually to fuel kilns that produced lightweight aggregate. Inspection test results showed concentrations of emissions of toluene, methyl ethyl ketone, styrene, hexane, and methylene chloride as much as 2.5 times proposed State limits.[7] State officials gave Solite until December 31, 1989, to submit a written plan for reducing emissions and for correcting other violations cited during the inspections.

A team of East Carolina University scientists studying sediments in the Pamlico River reported five well-defined zones in which concentrations of heavy metals were as much as 25 times higher than in the rest of the river.[8] One "hotspot" was west of Washington, Beaufort County, NC, in Kennedy Creek near a Superfund cleanup site that served as an agricultural chemical dump for 20 years. It showed excessive concentrations of cadmium, chromium, copper, lead, mercury, nickel, and zinc, all considered priority pollutants by the EPA. A second zone in the Pamlico River near the Tg phosphate operation showed high concentrations of cadmium, which occurs in phosphate-based fertilizers and naturally in phosphate ore. The other three zones were identified as Broad Creek (copper), the Pungo River off the Belhaven sewage treatment plant outfall (phosphorus and cadmium), and the upper reaches of the Pungo River (phosphorus).

EXPLORATION ACTIVITIES

The discovery of potentially economic occurrences of ancient beach sands containing titanium-rich heavy minerals (rutile, ilmenite, and leucoxene) and zircon resulted in exploration by at least eight companies. The sands occurred along the Fall Line in a zone approximately 3 miles wide and 120 miles long extending from Petersburg, VA, to Bailey in Wilson County, NC. Companies reported as having leased or attempted to lease land include: RGC (USA) Minerals Inc. (a subsidiary of Australia's Renison Goldfields Consolidated Inc.) in the Aurelian Springs area; Southeast Tisand Co., a joint venture of Becker Minerals Inc. (UK) and CRL America Inc. (a subsidiary of Consolidated Rutile Ltd. (Australia) near Roanoke Rapids; and Du Pont Chemical and Pigments Co. in Halifax County.

Published estimates[9] indicated reserves of over 200 million tons of sand averaging approximately 6.5% heavy minerals.

Dia Em Resources Ltd. and LKA International Inc. disposed of their Rist Mine and Ellis Emerald Mine near Hiddenite, Alexander County, after completing an evaluation of the properties in 1988. Piedmont Mining Co. conducted an exploration program on the Russell-Coggins gold property near Ablemarle.

LEGISLATION AND GOVERNMENT PROGRAMS

A bill creating a $9.1 billion Highway Trust Fund to be paid with a gasoline tax of 5.5 cents per gallon and a 2% vehicle title transfer fee was ratified in July. According to North Carolina Department of Transportation officials, the fund will allow completion of a 3,600-mile system of four-lane intrastate highways, which would mean that nearly all North Carolinians would live within 10 miles of a four-lane highway. The plan also called for improving 113 miles of interstate highways, paving 10,000 miles of dirt roads by 1999, and paving all of the State's secondary roads by 2006. An amendment requiring that all construction aggregate used in the program come from the United States was defeated.

The North Carolina General Assembly amended the Geologists Licensing Act to include 5 years experience as a condition of eligibility for licensing as a geologist in North Carolina. The amendment became effective July 6, 1989.

The North Carolina Low-Level Radioactive Waste Management Authority (WMA) selected Chem-Nuclear Corp. as its contractor to select a site, design and build a disposal facility, and operate a facility for the disposal of low-level radioactive wastes over the next 24 years. The site selection process, including site characterization, will be one of the most intense geological, hydrogeological, and geotechnical investigations ever undertaken in North Carolina. The WMA and its operator are expected to spend as much as $8 million studying two or more sites.

The North Carolina Geological Survey (NCGS) continued to play a significant support role to the WMA and to the State Division of Radiation Protection. NCGS staff will review relevant sections of the site characterization plan and license application. The NCGS will provide long-term storage and classification of geological and geotechnical samples acquired in site studies and will provide geological assistance to local government review committees or their contractors.

The NCGS began digitizing all of its geologic maps by using U.S. Geological Survey computer software (GSMAP and GSDRAW). This would enable the NCGS to open file maps that have been unavailable to the public because of the expense of conventional cartographic methods. It would also allow the Survey to update maps as new information becomes available.

A long-term 1:100,000 scale geologic mapping program was initiated in 1989. The Raleigh and Asheville 1:100,000 sheets were the initial focus of the mapping. Geologic mapping in the Raleigh sheet would be a joint project with the U.S. Geological Survey in an urban area. Production and compilation of geologic maps would be facilitated by the digital cartography work station.

NCGS published two bulletins, two 7.5-minute geologic maps, and three geologic guides. Geologic framework studies of the Pamlico-Albemarle Sound area were continued under the American Association of State Geologists/Minerals Management Services cooperative program.

The Land Quality Section, another section of the Division of Land Resources, administered the State Mining Act. During the year, 776 mines were under permit. Of these mines, 653 were active and 123 were inactive. The permits were distributed as follows: 491 sand and gravel operations, 129 crushed stone, 64 clay and shale, 23 dimension stone, 15 gemstone, 9 olivine, 8 mica, 7 pyrophyllite, 5 feldspar, 3 gold, 3 peat, 2 lithium, and 2 phosphate. A total of 467 acres

was disturbed during 1989. Approximately 9,000 acres of mined land was reclaimed during the year.

Support for a State-mandated Mountain Area Management Act (MAMA), similar to the Coastal Area Management Act enacted in 1974, appeared to be growing. The original MAMA was proposed to the State legislature in 1974 but died in committee.

The Department of Environment, Health, and Natural Resources (DEHNR), formerly Natural Resources and Community Development, appropriated $75,000 to conduct a 2-year program on growth management in Avery County. Sponsors of the program hoped the program would become a model for the entire State.

The North Carolina Department of Labor's Mine and Safety Division established a traveling school to teach safe quarrying practices at quarry sites. The first course, Explosives Safety, was taken by more than 750 people during the year.

A 2-day workshop to introduce science teachers to North Carolina's rocks and minerals was held in August. The course was sponsored by the East Carolina University (ECU) Science and Mathematics Education Center, the North Carolina Mining Commission, and the ECU Department of Geology.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Thirteen industrial minerals were mined in North Carolina in 1989. Eight additional industrial mineral commodities (andalusite, synthetic graphite, byproduct gypsum, calcined gypsum, iodine, expanded perlite, sodium sulfate, and steel slag) were produced from raw materials mined within the State, shipped from other States, or imported. The 13 mined commodities accounted for all of the value of minerals reported in Table 1.

Clays.—North Carolina ranked 4th nationally in volume and 12th in the value of clay produced in 1989. The volume decreased by more than 20% from 1988 to 2.3 million tons, although its value decreased only 5% to $15.5 million. A slowdown in building construction appeared to be the principal reason for the decline.

Common Clay and/or Shale.—Common clay and phyllite were mined mainly for the production of bricks and other structural clay products in 1989. DEHNR records[10] show 38 companies permitted 64 clay pits, all but 2 of which are active, in 29 counties.

North Carolina once again led the Nation in the production of building bricks, although sales decreased significantly because of a general weakening in the Nation's economy. The weakened economy caused a downturn in construction that was aggravated by wet weather in the southern and eastern parts of the country. North Carolina clay production for bricks decreased from 2.5 million metric tons valued at $10.4 million in 1988 to 1.9 million metric tons valued at $9.5 million.

Kaolin.—Waterwashed and unprocessed kaolin were produced as byproducts by the Unimin Corp. at its Brushy Creek mica operation in Avery County. KMG Minerals Inc. produced waterwashed kaolin as a byproduct at its Moss mica mine in Cleveland County. Kaolin was used in the manufacture of insulators, ceramics, and specialty brick products.

Feldspar.—North Carolina, with 71% of the total, once again led the Nation in the production of feldspar. Continuing a trend that began in 1987, both the volume and the value of feldspar produced declined, the former by 5.4% to 480,000 short tons and the latter by 19.0% to $14.0 million.

Feldspar was produced by six companies at nine operations in three counties. The Feldspar Corp., Unimin Corp., and Indusmin Inc. produced sodium-rich feldspar from pegmatites at their feldspar-silica operations in the Spruce Pine area. The Feldspar Corp., owned by Zemex Corp., New York City, was the largest feldspar producer in the country, with a capacity of 180,000 tons per year[11] from its mines (two active, one inactive) and two flotation plants at Spruce Pine. The sodium-rich feldspar produced is sold to the glass and ceramic industries.

Potassium feldspar was produced by KMG Minerals Inc. as a coproduct from its mica operation at Kings Mountain. The Cyprus operation at Kings Mountain produced byproduct feldspar from feldspathic sands recovered from its lithium flotation circuit. Feldspar production capacity was given as 30,000 tons per year for KMG and 100,000 tons per year of feldspathic sand for Cyprus. KMG's feldspar production was sold primarily to the television picture tube market and Cyprus' to the glass container industry.

FMC, Lithium Division, formerly Lithium Corp. of America, also produced feldspathic sand as a byproduct from its lithium operations in Gaston County. The ore was mined from pegmatite dikes and recovered as a feldspar-silica concentrate.

Gem Stones.—North Carolina ranked eighth nationally in the production of gem stones, with a reported value of $784,000. Fifteen companies operated 14 mines in 3 counties. Most, if not all, of the mines catered to amateur prospectors, selling buckets of potentially gem-bearing ore and providing facilities to recover the gem stones by sluicing the material. The most commonly recovered gems included emerald, garnet, hiddenite, ruby, and sapphire. Reports of finding mineral specimen staurolite crystals have been questioned by local geologists. The reported crystals were in the cruciform twinned form commonly called "fairy crosses."

A 1,154-carat star sapphire, Star of America, claimed the title of world's largest star sapphire, only to be replaced later in the year by the 1,445-carat Star of the Carolinas. The two largest North American emeralds, the 1,438-carat Stephenson and the 1,686.3-carat LKA, were also found in North Carolina. Both gems were found during LKA International Inc.'s exploration of the Ellis Emerald Mine.

Lithium.—North Carolina, accounting for approximately 70% of the Nation's production, remained the leading State of only two States in which lithium was mined. The volume of lithium produced showed only a slight increase; the value increased significantly due to higher unit selling prices for the lithium carbonate produced.

FMC, Lithium Division, remained the leading producer in North Carolina, producing lithium carbonate and a full line of downstream products in-

cluding lithium metal and organic lithium compounds. The lithium was derived from spodumene mined from pegmatite dikes near Bessemer City. The Cyprus Foote Division of Cyprus Specialty Metals, the world's largest lithium producer, continued to operate their lithium carbonate plant at Kings Mountain on an intermittent care-and-maintenance basis, as it has done since acquiring the property in 1986. As in previous years, only a limited amount of spodumene concentrate was produced.

Mica.—North Carolina, with more than 60% of both the total production and the value of mica produced, was the leading State of seven that produced scrap mica. Both decreased significantly, 7.7% and 7.1% respectively, in 1989 from the preceding year.

Although three companies had eight mica mining operations permitted by the State, only two companies and three mines were active during 1989. Mica was also produced as a coproduct or byproduct of lithium, feldspar, and industrial sand operations by three companies at five other locations, down from four companies at seven locations in 1988.

Olivine.—Although production decreased by almost 20%, North Carolina produced 1.6 times as much olivine with double the value than did Washington, the only other State reporting olivine production. The decrease in production was caused in part by increased competition from Norwegian olivine, which had a higher MgO content and lower freight costs because of the economics of oceanic shipping versus inland shipping.

Applied Industrial Minerals Corp. (AIMCOR) produced olivine from mines in Yancey and Avery Counties. The Addie Mine in Granville County was idled in 1989.

Phosphate Rock.—North Carolina continued to trail Florida as the Nation's leading phosphate-producing State. Phosphate was also the second most valuable mineral mined in North Carolina, ranking below crushed stone. Although the tonnage produced increased only slightly, the value of phosphate produced in North Carolina increased significantly over 1988 figures.

Tg, the sole phosphate producer in North Carolina, revised its method of mining with the introduction of two bucket-wheel excavators that replaced the dredges formerly used to remove overburden. One began operation in January and the second in August. The excavators, each having 12 1-cubic-yard buckets, were used to remove 37 feet of overburden at a rate of 2,000 tons per hour. The new method eliminated the need for flooding the stripping areas before removing overburden, thereby reducing the amount of water discharged, improving efficiency, and accelerating restoration of mined land. Tg also announced that it had scheduled work on a $20 million water recycling system designed to reduce by 90% and 75%, respectively, the amounts of phosphorus and fluoride discharged into the Pamlico River. Construction began in August 1989 and was scheduled to be completed in 1992.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; this chapter contains actual data for 1988 and estimates for 1987 and 1989. Data for odd-numbered years are based on annual company estimates.

Estimated construction sand and gravel production decreased slightly from 1988, although the value increased because the average unit value rose from $3.47 per ton to $3.90 per ton. DEHNR issued permits to 318 companies and government departments, mainly county and municipal road departments, operating 511 mines in 77 of North Carolina's counties. Sixty-nine of the permitted operations were listed as inactive. Principal uses of construction sand and gravel were road base and cover, concrete aggregates, asphalt concrete, fill, plaster, gunite, and other concrete products.

Industrial.—Industrial sand and gravel increased more than 30% in volume and almost 25% in value to record highs of 1.6 million tons and $19.9 million. It was the fourth most valuable industrial mineral mined in North Carolina, ranking behind crushed stone, phosphate rock, and lithium minerals.

Unimin Corporation's plant at Marston in Richmond County was one of the largest producers of sand for the glass and foundry markets in the southeastern United States. Unimin also produced silica sand from its quartz-feldspar-mica operation at Spruce Pine.

W. R. Bonsal and Co. and B. V. Hedrick Gravel and Sand Co. produced most of the industrial gravel used in the processing of silicon and ferrosilicon in the southern States from their operations located near Lilesville in Anson County. Bonsal also produced large quantities of roofing granules. Sand for the silicon and ferrosilicon market was also produced by Becker Minerals Co. at its Senter mine and plant in Harnett County. Southern Products and Silica Co. produced blasting and filtration sand from its operation near Hoffman in Richmond County.

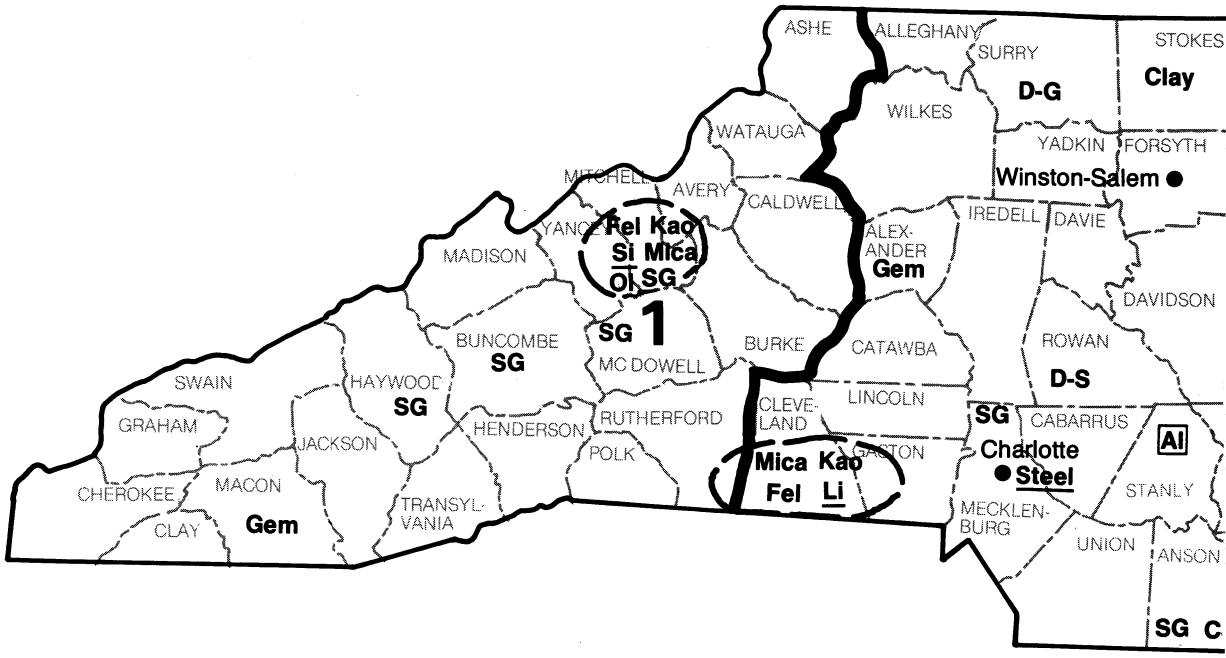
Silica sand was also produced as a coproduct or byproduct by KMG Minerals Inc. at its Kings Mountain mica operation and by The Feldspar Corp. and Indusmin Inc. at their Spruce Pine feldspar operations. The Lithium Division of FMC Corp. produced byproduct feldspar-silica sand at its Bessemer City plant.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

North Carolina stone statistics are compiled by geographical districts as depicted in the State map.

Crushed.—Crushed stone was the leading mineral commodity produced in North Carolina both in volume and in value. The volume increased 2.0% to 51.5 million short tons, and the value increased 3.2% to $258 million, accounting for almost 45% of the value of all the minerals mined.

A total of 131 crushed stone quarries in 64 counties were permitted by 35 companies. The DEHNR listed 30 of the operations as inactive. Crushed stone production was reported to the Bureau of Mines by 30 companies operating 88 crushing facilities and 87 quarries in 52 counties. The eight largest crushed stone producers were: Martin-Marietta Aggregates Co., Vulcan Materials Co., Beazer USA (Nello L. Teer Co.), Wake Stone Corp., Ashland Oil Inc. (Arkhola Sand and Gravel Co.), The North Carolina Granite Co., B. V. Hedrick and Co., and Becker



NORTH (

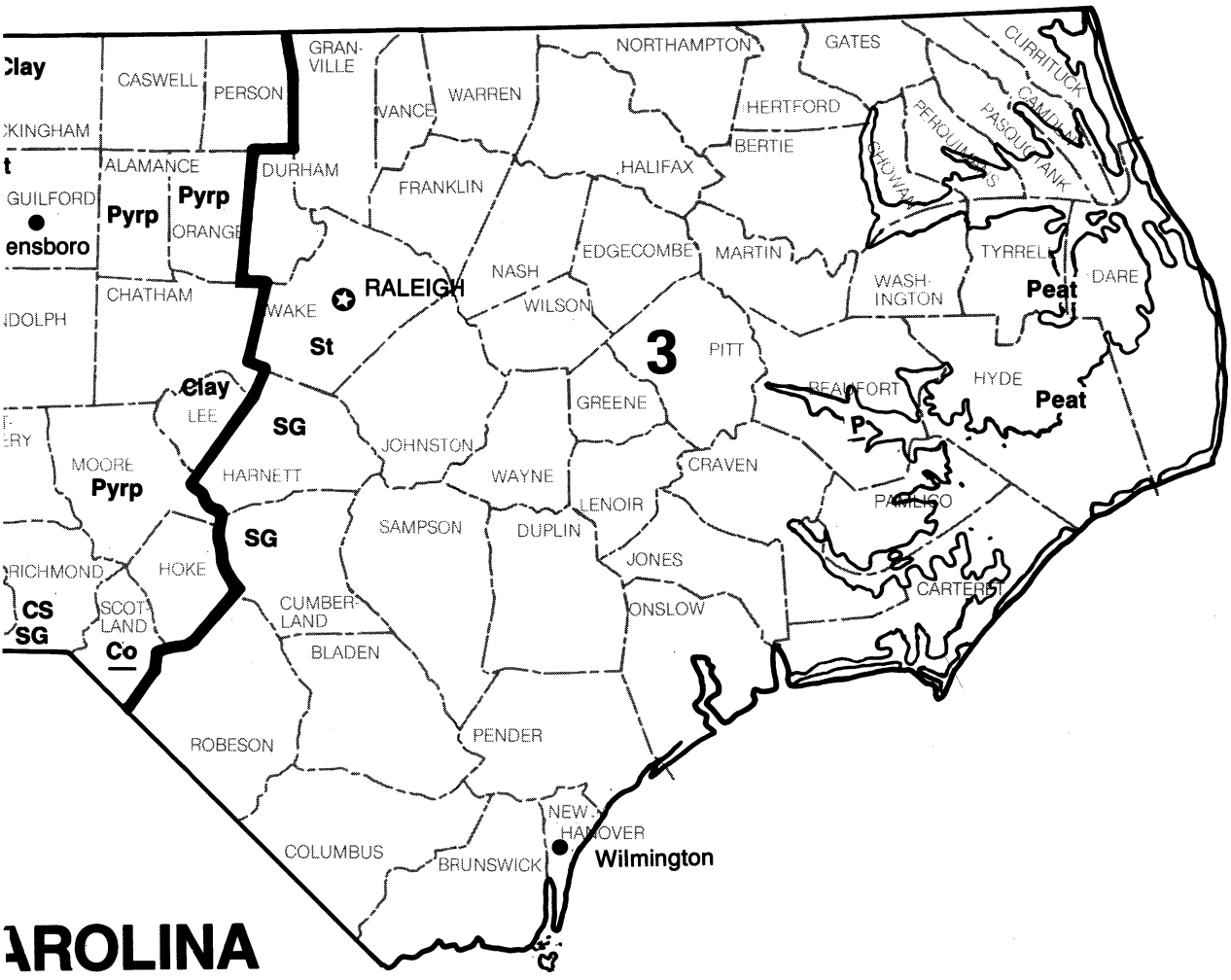
LE

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

MINERA

Al Alumin
Clay Clay
Co Cobalt
CS Crushe
D-G Dimens
D-S Dimens
Fel Feldsp
Gem Gemsto
Kao Kaolin
Li Lithium

Principal Mineral-Producing Localities



AROLINA

ND

SYMBOLS

plant

nt

tone

Granite

Sandstone

s

ne and plant

Mica	Mica
Ol	Olivine
P	Phosphate rock
Peat	Peat
Pyrp	Pyrophyllite
SG	Sand and Gravel
Si	Silica plant
St	Stone
Steel	Iron and Steel plant
	Concentration of mineral operations

Minerals Corp.

The types of rock produced, in order of descending volume, were: granite, limestone, volcanic cinder, trap rock, slate, quartzite, marl, and sandstone. The major end uses of the crushed stone, each accounting for more than 1 million short tons, were: graded road base, concrete aggregate, surface treatment, fine screenings, railroad ballast, crusher-run fill, and other uses in construction and maintenance.

Dimension.—Both the volume and value of dimension stone roughly doubled those of 1988. The increase appears to have resulted primarily from the North Carolina Granite Company's contract to reclad the Amoco Building. The State permitted 24 quarries in 8 counties owned by 14 companies. Three of the quarries were listed as inactive. During the fourth quarter of 1989, Mine Safety and Health Administration inspected 11 operations, 4 of which operated intermittently. This suggested that many of the dimension stone quarries in North Carolina were operated intermittently although their owners kept their mining permits active.

Three companies, The North Carolina Granite Co., Granite Panelwall Co., and Jacobs Creek Stone Co., accounted for 93% of the dimension stone produced. Granite, sandstone, and quartzite were used as dimension stone.

North Carolina Granite Co. indicated that it planned to spend about $1 million for additional sawing and finishing equipment and to hire six additional employees to complete the order for recladding the Amoco Building. Approximately 600,000 square feet of granite will be required to complete the project, which began during the fourth quarter of 1989 and was scheduled for completion in 1992.

TABLE 2

NORTH CAROLINA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	690	4,990
Filter stone	189	1,195
Coarse aggregate, graded:		
Concrete aggregate, coarse	4,009	23,445
Bituminous aggregate, coarse	2,843	17,640
Bituminous surface-treatment aggregate	407	2,611
Railroad ballast	1,773	7,563
Fine aggregate (-3/8 inch):		
Stone sand, concrete	392	1,831
Stone sand, bituminous mix or seal	336	1,646
Screening, undesignated	2,439	9,177
Coarse and fine aggregates:		
Graded road base or subbase	10,134	45,291
Unpaved road surfacing	203	886
Crusher run or fill or waste	1,445	5,478
Other construction materials[2]	1,109	6,354
Other miscellaneous uses[3]	485	2,655
Unspecified:[4]		
Actual	22,549	117,269
Estimated	2,518	9,947
Total[5]	51,519	257,976

[1] Includes limestone, granite, traprock, dolomite, sandstone, slate, volcanic cinder and scoria, quartzite, and marl.
[2] Includes stone used in coarse aggregate, macadam, and terrazzo and exposed aggregate.
[3] Includes stone used in agricultural limestone, poultry grit and mineral food, cement and lime manufacture, flux stone, and other fillers or extenders.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

Talc and Pyrophyllite.—Pyrophyllite was one of five industrial minerals in which North Carolina, producing 99% of the U.S. total, led the Nation. California was the only other State reporting pyrophyllite production. Glendon Pyrophyllite Inc. operated one mine and mill in Moore County. Piedmont Minerals Co. operated a mine and mill in Orange County, and Standard Minerals Co. Inc. operated two mines and one mill in Moore County. Mines operated by three companies in Alamance, Granville, and Moore Counties remained idle in 1989. A talc mine in Cherokee County owned by The Warner Corp. was also idle during the year and is reported to have been permanently closed.

Other Industrial Minerals.—Andalusite, an aluminum silicate closely related to kyanite, was reported to have been recovered as a byproduct from the pyrophyllite operations; no production figures were reported to the Bureau of Mines. Andalusite is used by the ceramic and refractory industries.

Great Lakes Carbon Corp. produced electrodes, electric motor brushes, and machined and unmachined graphite shapes at its synthetic graphite operation in Morgantown.

Byproduct gypsum was produced by Tg at its Aurora phosphate operation. Production decreased significantly, 38.1% in volume and 38.5% in value, from 1988 because of the lack of a market for the material. Much of the byproduct gypsum produced was blended with overburden and used in reclaiming mined-out land. Calcined gypsum was produced by National Gypsum Co. at its Wilmington wallboard plant.

Crude iodine was imported by Mallinckrodt Inc. to manufacture potassium iodate, calcium iodate, and diatrizoic acid. Sodium sulfate was produced from lithium carbonate ore by FMC, Lithium Division, at Bessemer City and by Cyprus Foote at Kings Mountain. Sodium sulfate was also produced during the sodium dichromate manufacturing process by Occidental Chemical Co. at Castle Hayne in New Hanover County.

Expanded perlite was produced by Carolina Perlite Co. Inc. at its Gold

TABLE 3

NORTH CAROLINA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	187	1,099	310	2,177	458	3,140
Coarse aggregate, graded[2]	2,107	10,742	3,984	23,211	2,941	17,305
Fine aggregate (−3/8 inch)[3]	561	2,695	1,485	6,391	1,121	3,567
Coarse and fine aggregates[4]	2,723	12,236	3,990	17,391	5,069	22,028
Other construction aggregates	49	300	966	5,723	18	99
Agricultural[5]	W	W	—	—	W	W
Chemical and metallurgical[6]	W	W	W	W	—	—
Special[7]	—	—	W	W	—	—
Other miscellaneous	21	220	453	2,395	10	41
Unspecified:						
Actual[8]	1,192	5,316	13,621	69,722	7,736	42,231
Estimated[9]	240	689	2,258	9,126	20	132
Total[10]	7,080	33,297	27,066	136,135	17,373	88,543

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[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), and fine aggregate (screening-undesignated).
[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run or fill or waste.
[5] Includes agricultural limestone and poultry grit and mineral food.
[6] Includes crushed stone for cement manufacture, lime manufacture, and flux stone.
[7] Includes crushed stone for other fillers or extenders.
[8] Includes production reported without a breakdown by end use.
[9] Includes estimates for nonrespondents.
[10] Data may not add to totals shown because of independent rounding.

Hill plant in Rowan County for use as horticultural aggregate, cavity fill insulation, concrete aggregate, oil-water absorbent, plaster aggregate, filter aid, and fillers. W.R. Grace and Co. did not produce expanded vermiculite in 1989. The company produced expanded vermiculite for the aggregates, insulation, and agricultural markets from its plant in High Point in 1988.

Air-cooled iron slag produced as a waste product by Florida Steel Co. at its electric furnace operation at Charlotte was sold as aggregate by the Hackett Co.

Metals

North Carolina was one of 25 States with no metal production in 1989. A minor amount of gold was reportedly[12] recovered as a byproduct at a micaceous sand, rare-earth, and gold mining and processing operation in McDowell County. A number of metallic raw materials were shipped into the State for processing into finished, higher value products.

Aluminum.—In terms of value, aluminum was the most important metal refined in North Carolina. A large percentage of this value was derived from the Aluminum Company of America smelter at Baden. The 115,000-metric-ton-per-year primary aluminum plant operated at full capacity again this year.

National Intergroup Inc. (NII) announced the sale of its light gauge foil mill at Salisburg to Noranda Inc. of Toronto. NII is the parent of National Aluminum Corp. Plasma Energy Co. of Raleigh provided the technology used by Alcan Aluminum Corp. to develop a process for recycling aluminum dross that reportedly eliminated the use of the salt fluxes required in conventional treatment methods.

Gold.—Imperial Mining Co. mined alluvial deposits and thin quartz veins at the Christy Destiny Mine. The company completed a processing plant to separate the quartz sand, mica, gold, and rare-earth minerals. The operation was offered for sale late in the year.

Carolina Gold Mines received a permit to process some of the mine dumps and tailings at the Conrad Hill Mine east of Holly Grove in Davidson County. The permit was for surface materials only, and the company indicated that it had no plans to reopen the old underground mine.

Other Metals.—Steel was produced from scrap by Florida Steel Co. in its electric furnace minimill at Charlotte. Chromium chemicals were produced by Occidental Chemical Corp. at Castle Hayne. SCM Co., Glidden Metals Division, operated a powdered-copper plant in Durham. Lithium metal was manufactured from compounds produced at its Bessemer City mine and plant by FMC, Lithium Division, at Cherryville. Hilemn Laboratories manufactured silver compounds at Greensboro.

[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL. He has 32 years of industry and government experience 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]Chicago Tribune. Amoco Chucks All the Marble on Its Tower. Mar. 7, 1989.

[5]Sun Journal (New Bern). Texasgulf, State Agree on $1 Million Fine. June 6, 1989.

[6]Daily Advance, Elizabeth City. Currituck Puts Stop to Mining. Sept. 6, 1989.

[7]Morning Herald (Durham). Complaints Prompt 4th Plant Inspection. Dec. 31, 1989.

[8]Daily Reflector (Greenville). Dangerous Pollution 'Hotspots' Found in the Fragile Pamlico River Estuary. Mar. 26, 1989.

[9]Industrial Minerals. US Minisands Discovery. No. 266, Nov. 1989, p. 21.

[10]North Carolina Geological Survey. Open File Report 90-6. Permitted Active/Inactive Mining Operations in North Carolina as of May 1990. May 1990, 134 pp.

[11] Burger, J. Feldspar and Nepheline Syenite. Industrial Minerals (London), No. 275, Aug. 1990, p. 33.

[12] McDowell News (Marion). There's Gold in Them Thar Hills of McDowell County. Oct. 13, 1989.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum, smelter:			
Aluminum Co. of America	1501 Alcoa Bldg. Pittsburgh, PA 15219	Plant	Stanly.
Clay:			
Cherokee Sanford Co.	Box 458 Sanford, NC 27330	Open pit mines and plant	Chatham and Lee.
Hammill Construction Co.	Route 2, Box 33H Gold Hill, NC 28071	do.	Cabarrus and Rowan.
Virginia Solite Corp.	Box 27211 Richmond, VA 23261	do.	Rockingham and Stanly.
Feldspar:			
The Feldspar Corp., subsidiary of Zemex Corp.[1]	Box 99 Spruce Pine, NC 28777	do.	Mitchell.
Indusmin Inc.[1]	Box 309 Spruce Pine, NC 28777	do.	Do.
Unimin Corp.[1]	23157 Sanders Rd. Northbrook, IL 60062	do.	Do.
Lithium:			
Cyprus Foote Mineral Co.[2]	Box 689 Kings Mountain, NC 28086	Open pit mine and plant	Cleveland.
FMC, Lithium Div.[1 2]	Box 795 Bessemer City, NC 28016	do.	Gaston.
Mica:			
FMC, Lithium Division	do.	Open pit mines	Yancey.
KMG Minerals Inc.[2 3]	Box 729 King Mountain, NC 28086	do.	Cleveland.
Unimin Corp.[3]	Box 628 Spruce Pine, NC 28777	do.	Avery.
Olivine:			
AIMCOR	Rt. 2, Box 167-C Green Mountain, NC 28740	do.	Jackson and Yancey.
Perlite (expanded):			
Carolina Perlite Co. Inc.	Box 158 Gold Hill, NC 28071	Plant	Rowan.
Phosphate rock:			
Texasgulf Inc.[4]	Box 48 Aurora, NC 27806	Open pit mine and plant	Beaufort.
Pyrophyllite:			
Glendon Pyrophyllite Inc.	Box 306 Carthage, NC 28327	Open pit mines and plant	Alamance and Moore.
Piedmont Minerals Co.[5]	Box 7247 Greensboro, NC 27407	do.	Orange.
Standard Minerals Co. Inc.	Box 278 Robbins, NC 27325	Open pit mine and plant	Moore.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Becker Sand & Gravel Co.	Box 698 Lillington, NC 27546	Pits	Anson and Harnett.
W. R. Bonsal Co.	Box 38 Lilesville, NC 28091	do.	Anson.
B. V. Hedrick Gravel and Sand Co.[1]	Box 8 Lilesville, NC 28091	do.	Buncombe.
Stone:			
Crushed:			
Martin Marietta Corp.	Box 30013 Raleigh, NC 27622	do.	Various.
Nello L. Teer Co.	Box 1131 Durham, NC 27702	do.	Do.
Vulcan Materials Co., Mideast Division	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, and Stokes.
The NC Granite Co.	Box 988 Mt. Airy, NC 27030	do.	Cabarrus and Surry.
Vermiculite (exfoliated):			
W. R. Grace & Co.	62 Whittemore Ave. Cambridge, MA 02140	Plant	Guilford.

[1] Also mica.
[2] Also feldspar.
[3] Also clay.
[4] Also byproduct gypsum.
[5] Also sericite.

THE MINERAL INDUSTRY OF NORTH DAKOTA

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

By Leon E. Esparza[1]

The value of North Dakota's nonfuel mineral production was about $13.7 million in 1989, a decrease of more than 27% from that of 1988. The decreased value was attributed mainly to a 23% drop in the value of lime production and the 1988 termination of salt solution mining operations. The State ranked 48th nationally in nonfuel mineral production, accounting for less than 1% of the U.S. total. Construction sand and gravel contributed the greatest amount to the State's nonfuel mineral value, accounting for 59% of the total. Other commodities produced, in order of decreasing value, included lime, clays, peat, and gem stones. Elemental sulfur was recovered from natural gas processing.

Most of North Dakota's nonfuel mineral production was used in construction. According to the U.S. Department of Commerce, 2,210 residential units were authorized in 1989, an increase of 22% over the number issued in 1988. The value of nonresidential construction in 1989 was $93.9 million, an increase of about 1% compared with the 1988 value. The value of State road contract awards increased more than 5% and totaled about $103 million during the period.[2]

Nonfuel mining employment remained at 350 jobs in 1989, unchanged from the 1988 figure. North Dakota's 1989 unemployment rate, the number of people unemployed as a percent of the total labor force, was 4.3% compared with 4.8% in 1988. The Job Service of North Dakota reported that, since 1981, nearly 11,000 jobs have been lost in the goods-producing sector, including 7,000 from mining, which includes the oil and gas industry. Mining provided 3,950 jobs in the fuel and nonfuel extractive industries, the fewest since 1977.[3]

The North Dakota State Soil Conservation Committee reported there were 29 surface mining operators with 77 pits affecting 277 acres (112 hectares) statewide in 1989. The State Surface Mining Reports Law, passed in 1975, requires any person conducting surface mining operations for minerals other than coal to report removal of 10,000 cubic yards (7,646 cubic meters) or more of earthen material or products, including overburden. Disturbance of one-half acre or more in combined mining operations also must be reported. Mineral production specifically requiring a report includes production of cement rock, clay, gravel, limestone, manganese, sulfate, stone, zeolite, or other minerals, except coal. Minerals mined included gravel and sand, scoria, clay, and rock for a total of 2.2 million cubic yards (1.7 million cubic meters), about 819,000 yards (626 cubic meters) of which was overburden.[4]

The North Dakota Lignite Council estimated 1989 lignite coal production in the State to be 29 million short tons (26.3 million metric tons). About 18,000 North Dakotans were employed directly or indirectly by the coal industry. Lignite coal resources in the State were estimated at 350 billion tons (317.5 billion metric tons).

North Dakota celebrated a landmark event in its oil and gas industry in 1989. On October 23, the one-billionth barrel of crude oil was produced. The barrel came from the Clarence Iverson No. 1, North Dakota's discovery well and site of the State's first oil production in 1951. During 1989, North Dakota's 3,558 oil wells produced a total of 36.7 million barrels of oil for a daily average of 28 barrels per well. This was a decline of nearly 7% from that of 1988.[5]

Dakota Gasification Co., a subsidiary of Basin Electric Power Cooperative and owner of a coal gasification plant near Beulah, signed a 15-year contract in July

TABLE 1

NONFUEL MINERAL PRODUCTION IN NORTH DAKOTA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays	metric tons	45,451	$100	76,918	$147	47,903	W
Gem stones		NA	2	NA	2	NA	$10
Lime	thousand short tons	127	11,912	108	7,094	107	5,439
Sand and gravel (construction)	do.	e4,900	e10,200	3,772	8,079	e3,600	e8,100
Combined value of peat, salt (1987-88), sand and gravel (industrial, 1987), stone (crushed miscellaneous, 1987-88) and value indicated by symbol W		XX	4,097	XX	3,485	XX	111
Total		XX	26,311	XX	18,807	XX	13,660

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

NORTH

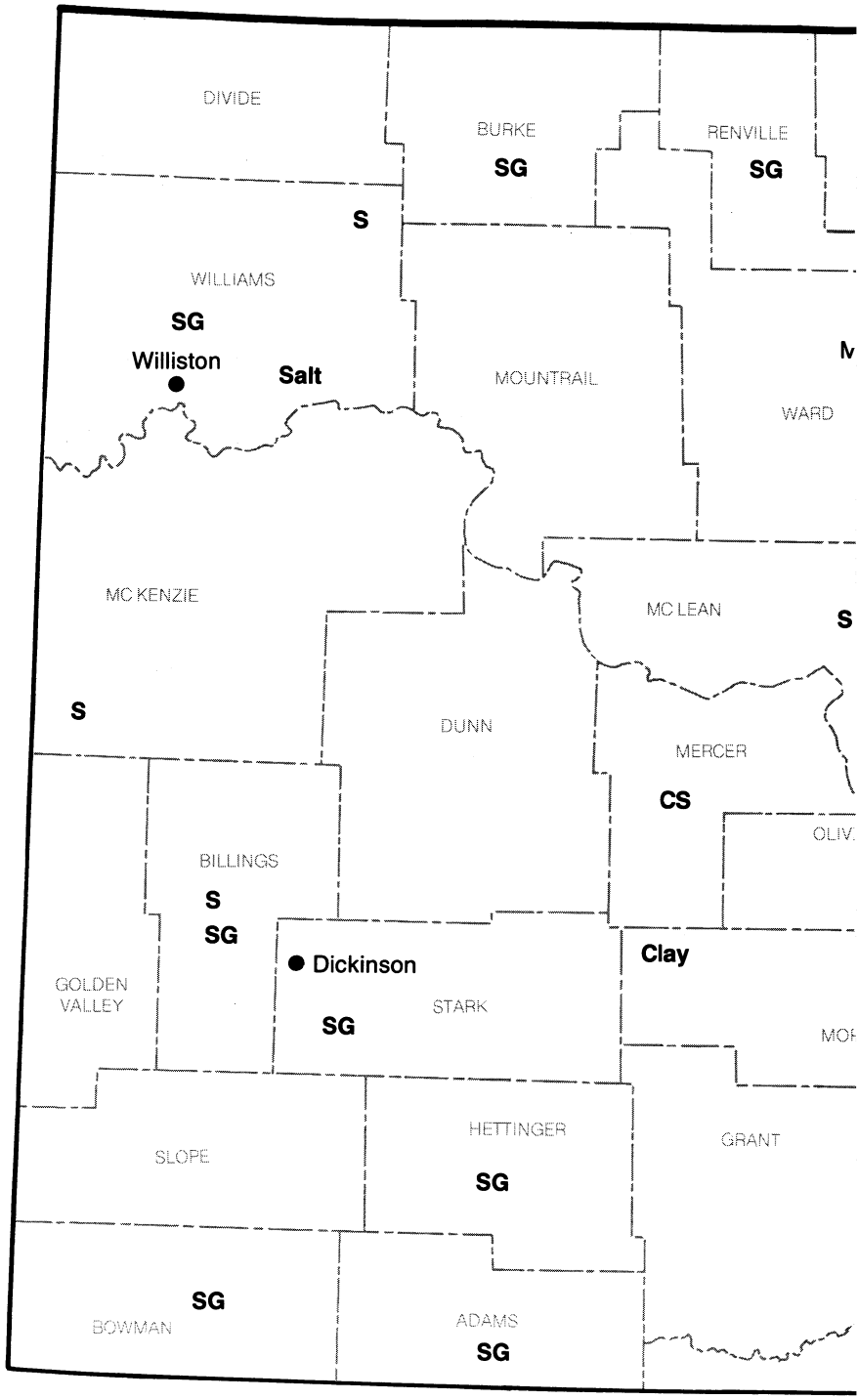
LEGEND

- State boundary
- County boundary
- Capital
- City

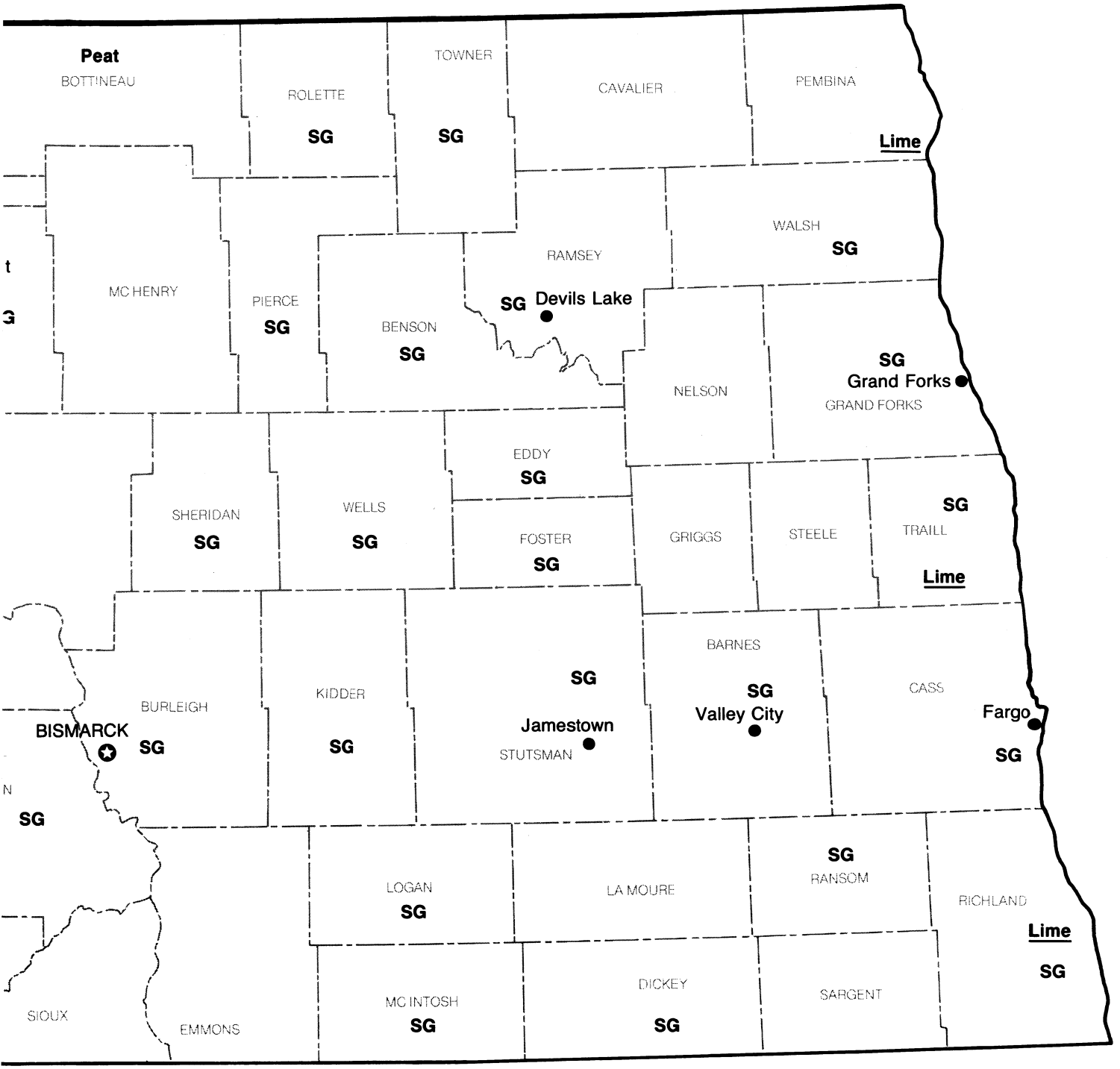
MINERAL SYMBOLS

Clay	Clay
CS	Crushed Stone
Lime	Lime plant
Peat	Peat
S	Sulfur
Salt	Salt
SG	Sand and Gravel

Principal Mineral-Producing Localities



AKOTA


Peat
BOTTINEAU
ROLETTE
SG
TOWNER
SG
CAVALIER
PEMBINA
Lime
WALSH
SG
RAMSEY
SG
Devils Lake
MC HENRY
PIERCE
SG
BENSON
SG
NELSON
SG
Grand Forks
GRAND FORKS
EDDY
SG
SHERIDAN
SG
WELLS
SG
FOSTER
SG
GRIGGS
STEELE
SG
TRAILL
Lime
BARNES
SG
Valley City
CASS
Fargo
SG
BURLEIGH
BISMARCK
SG
KIDDER
SG
SG
Jamestown
STUTSMAN
SG
LOGAN
SG
LA MOURE
SG
RANSOM
RICHLAND
Lime
SG
MC INTOSH
SG
DICKEY
SG
SARGENT
SIOUX
EMMONS

to sell all the krypton and xenon produced at the plant to the Linde Div. of Union Carbide Industrial Gases Inc. These two chemical elements, byproducts of coal gasification, are used in manufacturing halogen and long-life electric light bulbs.

LEGISLATION AND GOVERNMENT PROGRAMS

The North Dakota State Legislature passed House Bill 1028, which increased the coal severance tax by 2 cents to 77 cents per short ton of coal produced in the State and sold or used for industrial purposes. Proceeds from the tax increase will be deposited in the Lignite Research Fund. The State Industrial Commission will use the fund for contracts with State research facilities for land reclamation research projects, lignite development research, and hydroelectric dam impact studies.

The legislature also passed Senate Bill 2261, which reorganized the State Geological Survey and placed it under the Oil and Gas Division of the Industrial Commission at Bismarck. Previously, the survey was under the Board of Higher Education and associated with the University of North Dakota at Grand Forks. The survey's office has moved from Grand Forks to Bismarck.

The University of North Dakota Energy and Mineral Research Center at Grand Forks conducted basic research on the State's mineral and energy resources and innovative technologies for using these resources and their wastes. The center was funded through the Federal Government and private-sector contracts, grants, or other arrangements; it did not directly receive State funding. The center was composed of three institutes: the Mining and Mineral Resources Research Institute, the Fuels and Process Chemistry Research Institute, and the Combustion and Environmental Systems Research Institute. Through cooperative efforts, the three institutes functioned as a team to foster research on mine land reclamation, mine waste disposal, ground water studies, and coal gasification. Although research largely involved fossil fuels and related topics, researchers also studied precious-metals extraction techniques, agricultural chemical contamination and cleanup technology, and geothermal resources.

Federal royalties received for minerals produced on Federal lands leased by producers in North Dakota in 1989 totaled about $20.1 million (coal, $3.6 million; gas and related products, $2.2 million; and oil, $14.2 million). Royalties for leonardite and sulfur, produced in very small quantities, also were received.

In January, the city of Bismarck, through its Economic Development Association, announced plans to seek a larger role in mineral research. Bismarck business leaders proposed closer ties to energy research and the synthetic fuel-energy byproducts industry. Specifically, the goals identified included getting Bismarck chosen as the site for a proposed energy and mineral research center and supporting production and sale of synthetic natural gas and energy byproducts at the Great Plains Coal Gasification Plant.

The National Stone Association and the American Society of Landscape Architects cosponsored a mining landscape beautification and postmining land-use contest. The annual competition drew 14 entries from 9 universities nationwide. Landscape architecture students at North Dakota State University placed second and third in the 1989 competition.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988. Production in 1989 was estimated to be down about 5%, with the total value unchanged from levels reported in 1988.

Other Industrial Minerals.—Clay production and value declined about 38% from levels reported in 1988. In March, Lafarge Corp. acquired a wholesale cement distributer, Beyer Cement Co. Inc. of Valley City, for an undisclosed price. Beyer will continue to operate under its own name. The wholesaler distributed cement in North Dakota through outlets in Bismarck, Grand Forks, Minot, Valley City, Wahpeton, and Williston. Beyer bought cement for resale from, among others, Lafarge and South Dakota Cement.

[1]State Mineral Officer, Bureau of Mines, Minneapolis, MN. Assistance in the preparation of the chapter was given by Wanda J. West, editorial assistant.

[2]Highway and Heavy Construction. Market Update: Battle Lines Form Over Gridlock, Gas Tax. V. 132, No. 3, Mar. 1989, p. 34.

[3]North Dakota Labor Market Advisor. 1989—The Year in Review. Job Service North Dakota. V. 6, No. 2, Feb. 1990, p. 1.

[4]North Dakota State Soil Conservation Committee. 1989 Surface Mining Report. 8 pp.

[5]North Dakota Geological Survey. Oil and Gas Activity in North Dakota During 1989. NDGS Newsletter. June 1990, p. 6.

TABLE 2

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 Trail.
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, 1988):			
Bradshaw Gravel Supply	Box 1676 Grand Forks, ND 58206	Pits and plants	Grand Forks, Rolette, Walsh.
Lake Sand & Gravel Co.	Box 236 Lidgerwood, ND 58053	Pits	Richland.
Schriock Construction Inc.	3009 South Broadway Minot, ND 58701	Pit and plant	Various.
Soper Bros. Construction Co.	Box 791 Devils Lake, ND 58301	Pits	Ramsey.
Susag Sand & Gravel Inc.	Box 23 Harvey, ND 58341	do.	Pierce, Wells, Williams.
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.

THE MINERAL INDUSTRY OF OHIO

By L. J. Prosser, Jr.[1]

The value of nonfuel mineral production in Ohio dropped to about $700 million in 1989. However, the production of most mineral commodities remained about the same as in 1988. A significant decrease in the price reported for crushed stone accounted for most of the decline in value.

Demand for mineral aggregates by the construction industry remained strong. Ohio produced more than 90 million short tons of aggregates for only the second time in the past 10 years.

Ohio ranked 15th nationally in the value of nonfuel mineral production, accounting for about 2.2% of the U.S. total. Metals manufacturing remained significant to the State's economy, and Ohio ranked among the top States in production of aluminum and steel.

TRENDS AND DEVELOPMENTS

In the 1980's, Ohio's minerals industry gradually changed from one in which steel and coal were the primary industries to one in which industrial minerals also played a significant part. The transition started in 1985 when production of crushed stone surpassed that of coal by about 3 million tons. The difference in output levels of the two commodities continued to increase each year and, by 1989, was about 15 million tons. Stone production had previously surpassed that of coal but never had it done so for 5 consecutive years.

Strong demand for mineral aggregates by the construction industry, particularly from 1987 through 1989, boosted production to the highest levels ever recorded in Ohio history. At the same time, fuel commodity prices were at their lowest levels of the decade. In addition, demand for Ohio's higher sulfur content coal was expected to erode further if proposed Federal legislation to reduce sulfur dioxide emissions from coal-fired powerplants is enacted in the 1990's.

EMPLOYMENT

Mining employment dropped from 19,500 in 1988 to 18,000 in 1989.[2] Employment in construction increased from about 184,000 to 197,000 workers.

LEGISLATION AND GOVERNMENT PROGRAMS

Legislation to increase the severance tax on limestone, dolomite, and sand and gravel from 1 cent per ton to 2 cents per ton was enacted in July as part of the State's budget bill. Mineral severance taxes in Ohio were used to administer the coal mining and reclamation regulatory program and to reclaim land affected by mining.

The Ohio Division of Geological Survey (DGS) drilled to a depth of 5,380 feet, the deepest continuous core hole ever in the State. Sandstone was encountered at a depth of 3,500 feet; previous geologic information had indicated that granite was expected at such depths. The DGS was continuing to study the core to determine if the sedimentary unit had potential for gas storage, waste injection, or hydrocarbons. The survey also published a report on the chemical analysis of 240 samples of carbonate rocks that were examined from 1974 to 1982. The samples had been collected from outcrops and stockpiles at active quarries in 26 counties.

The number of active mining operations reporting production declined again in 1989, according to the DGS. In 1989, 202 active coal mines and 393 industrial minerals operators reported to the DGS, 73 and 37 fewer operators, respectively, than in 1988.[3]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Lime.—Production declined by 9%, and Ohio dropped from first to second in lime output in the United States. The major consumer of lime manufactured in Ohio, the steel industry, also reported a decline in production in 1989. Lime sold or used in steelmaking in Ohio was down 13% for the year compared with that of 1988.

Nationally, 2 of Ohio's 10 lime plants were among the top 10 in output; Martin Marietta Corp.'s Woodville plant, Sandusky County, ranked 3d, and LTV Steel Co. Inc.'s Grand River plant, Lake County, ranked 10th. An inactive lime plant in Genoa, Ottawa County, was sold by USG Corp. to Gen Lime Group L.P. and reopened.

In December, Ohio Lime Co. withdrew its application with the Ohio Environmental Protection Agency (OEPA) for a permit to burn solvent-derived waste as fuel at its Millersville plant. Ohio Lime, a subsidiary of Steetley Resources Inc., had received approval from OEPA to test burn the waste in 1987. In 1988, a test burn indicated that all organic hazardous materials were destroyed; however, particulate emissions exceeded State limits. In 1989, the company invested more than $1 million to improve air pollution control systems at its plants in Millersville and Woodville.

Salt.—Ohio ranked fourth in the Nation in salt production. Both of the State's producers were renamed in 1989. International Salt Co., with operations in Cuyahoga and Summit Counties, was renamed Akzo Salt Inc. Akzo is owned by a corporation in the Netherlands. The salt division of Morton Thiokol Inc. was separated from the firm in July and called Morton International Inc. The company's Ohio operations are in Lake and Wayne Counties.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

In 1989, Ohio ranked third nationally in output of construction sand and gravel, producing an estimated 44.4 million short tons. During the decade of the 1980's, Ohio produced about 350 million tons of sand and gravel valued at about $1.2 billion.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

TABLE 1

NONFUEL MINERAL PRODUCTION IN OHIO[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Cement:							
Masonry	thousand short tons	139	$11,964	129	$11,140	128	$11,233
Portland	do.	1,748	83,661	1,424	70,816	1,446	73,230
Clays	metric tons	2,891,446	12,714	3,365,164	14,423	3,519,668	14,983
Gem stones		NA	10	NA	10	NA	18
Lime	thousand short tons	1,926	93,108	2,065	87,431	1,888	94,157
Peat	do.	W	W	W	W	8	182
Salt	do.	3,276	104,099	3,795	115,860	W	W
Sand and gravel:							
Construction	do.	e36,400	e136,900	46,104	156,318	e44,400	e148,700
Industrial	do.	1,249	21,292	1,361	23,441	1,394	24,662
Stone:							
Crushed	do.	51,590	300,096	e48,000	e252,000	46,426	183,190
Dimension	short tons	47,816	2,427	e38,300	e3,137	59,923	3,455
Combined value of other industrial minerals		XX	2,510	XX	2,676	XX	145,346
Total		XX	768,781	XX	737,252	XX	699,156

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

TABLE 2

OHIO: LIME SOLD OR USED BY PRODUCERS, BY USE

Mineral	1988 Quantity (short tons)	1988 Value (thousands)	1989 Quantity (short tons)	1989 Value (thousands)
Steel, basic oxygen	1,162,960	$47,139	1,016,540	$50,035
Other[1]	902,808	40,292	871,671	44,122
Total	2,065,768	87,431	1,888,211	94,157

[1]Includes, agriculture, alkalies, calcium carbide and cyanamide, electric steel, finishing lime, glass, magnesia 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.

Ohio stone statistics are compiled by geographical districts as depicted in the State map. Table 4 presents end-use statistics for Ohio's six districts.

For the fifth year in a row, crushed stone was the leading mineral commodity produced in Ohio. In the 1980's, the State's crushed stone industry produced 405 million short tons of stone valued at $1.6 billion. From 1987 to 1989, about 146 million tons of stone was mined in Ohio, the highest 3-year total in State history.

As one indication of the continued strong demand for mineral aggregates, the State's leading producer of aggregates was sold for the second time in 3 years. American Aggregates Corp., with 10 stone quarries and 14 sand and gravel pits in Ohio, was purchased by CSR Corp. of Australia. Standard Slag Co., which also was one of Ohio's principal producers of mineral aggregates, was purchased by Lafarge Corp. The sale included limestone quarries in Adams and Ottawa Counties, along with four sand and gravel operations in Pike, Portage (two), and Scioto Counties. Standard's parent firm, Standard Slag Holding Co., retained ownership of Cleveland Quarries Co., which produced in Lorain County an abrasive sandstone for use as grindstones and a dimension sandstone in Erie County.

Metals

No metals were mined in Ohio in 1989. Information on processed and manufactured metals is presented in this section.

TABLE 3

OHIO: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	1,086	3,694
Riprap and jetty stone	707	3,310
Filter stone	122	522
Coarse aggregate, graded:		
Concrete aggregate, coarse	3,046	11,327
Bituminous aggregate, coarse	1,724	6,619
Bituminous surface-treatment aggregate	697	4,017
Railroad ballast	1,188	3,435
Fine aggregate (-3/8 inch):		
Stone sand, concrete	248	955
Stone sand, bituminous mix or seal	340	1,209
Screening, undesignated	432	1,022
Coarse and fine aggregates:		
Graded road base or subbase	5,018	28,722
Unpaved road surfacing	4,694	18,899
Crusher run or fill or waste	1,638	5,708
Other construction materials[2]	133	611
Agricultural: Agricultural limestone	874	3,820
Chemical and metallurgical:		
Cement manufacture	1,453	3,694
Flux stone	205	816
Other miscellaneous uses[3]	920	4,102
Unspecified:[4]		
Actual	19,834	72,887
Estimated	2,067	7,821
Total	46,426	183,190

[1]Includes limestone, dolomite, sandstone, and quartzite.
[2]Includes stone used in coarse aggregates.
[3]Includes stone used in other agricultural uses, lime manufacture, dead-burned dolomite, asphalt or other fillers or extenders, and whiting or whiting substitute.
[4]Includes production reported without a breakdown by end use and estimates for nonrespondents.

In 1989, fabricated metal products and primary metal industries employed nearly 240,000 workers, which was about 22% of Ohio's total manufacturing employment.[4]

In 1979, these same two sectors employed about 335,000 workers and accounted for 24% of Ohio's total manufacturing work force. Although the number of workers in these industries dropped by 95,000 during the past 10 years, metals manufacturing remained a significant component of the State's overall economy.

Aluminum.—Ohio ranked sixth nationally among the 14 States producing primary aluminum. The State's only producer, Ormet Corp., produced 545,839,953 pounds of aluminum to surpass the company's previous annual production record.[5] In 1989, the United States produced about 4 million metric tons of aluminum, and most plants were operating at or above rated capacity.

Ormet Corp., as part of a $54.4 million modernization and capital improvement plan, introduced a new aluminum billet termed "Satin Plus." The new billet reportedly can be extruded at a lower temperature and 27% faster than conventionally cast billets.[6]

In other aluminum industry developments, A-Mold Corp. announced plans for an aluminum wheel manufacturing plant in Mason, Warren County. A-Mold, a subsidiary of Ube Industries Ltd. of Japan, expected to manufacture about 1 million wheels per year at the plant beginning in 1991.

American Recovery Technology Systems Inc., Cuyahoga County, began full-scale operations of an aluminum dross recycling plant. Aluminum dross is a waste product generated in the recycling of aluminum cans and other materials. American Recovery's process uses a series of impact and filtering steps to break down the dross into pure aluminum, aluminum oxide, and potassium sodium chloride.[7]

Beryllium.—Brush Wellman Inc., at a plant in Elmore, Ottawa County, manufactured beryllium alloys, oxide, and metal from beryllium hydroxide produced at the company's operations in Delta, UT. Brush Wellman was the only company in the United States that mined this mineral commodity. In 1989, Brush Wellman delivered 6 metric tons of hot-pressed beryllium billets to the National Defense Stockpile through a contract with the U.S. Department of Defense.

Iron and Steel.—Output of steel dropped by about 1.3 million short tons to 16.4 million tons. Ohio remained the second leading producer of steel in the United States. Pig iron shipments were not reported to the Bureau of Mines in 1989 because the Nation's major producers declined to respond to the survey for the second consecutive year. However, for the 6-year period from 1982 to 1987, Ohio produced 1.5 tons of steel for every 1.0 ton of pig iron shipped. Based on that ratio, an estimated 10.9 million tons of pig iron was shipped in Ohio in 1989, a decline of about 600,000 tons from the 1988 estimated total.

Armco Inc., effective May 13, 1989, sold a 40% interest in its two flat-rolled carbon steel plants to Kawasaki Steel Corp. for $350 million, forming a joint venture called Armco Steel Co. L.P. (ASC).[8]

Armco's Middletown, Butler County, plant was included in the agreement. In 1989, ASC continued a modernization project at the Middletown facility that

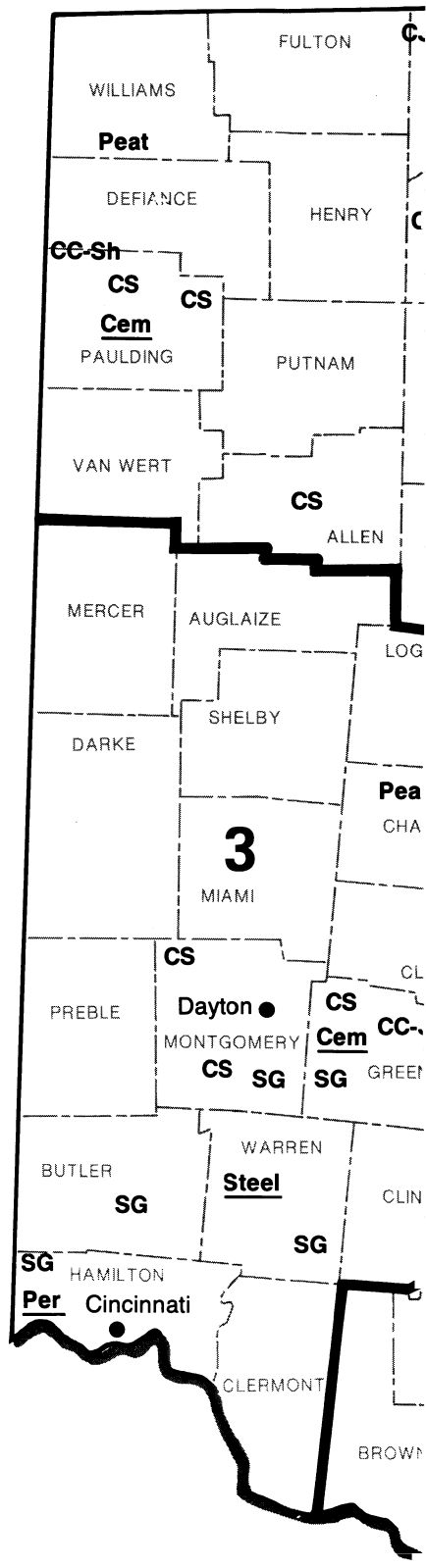
LEGEND

- 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
D-L	Dimension Limestone
D-S	Dimension Sandstone
FC	Fire Clay
Gyp	Gypsum
Gyp	Gypsum plant
IS	Industrial Sand
Lime	Lime plant
Peat	Peat
Per	Perlite plant
Salt	Salt
SG	Sand and Gravel
Steel	Iron and Steel plant
Vm	Vermiculite plant

Principal Mineral-Producing Localities



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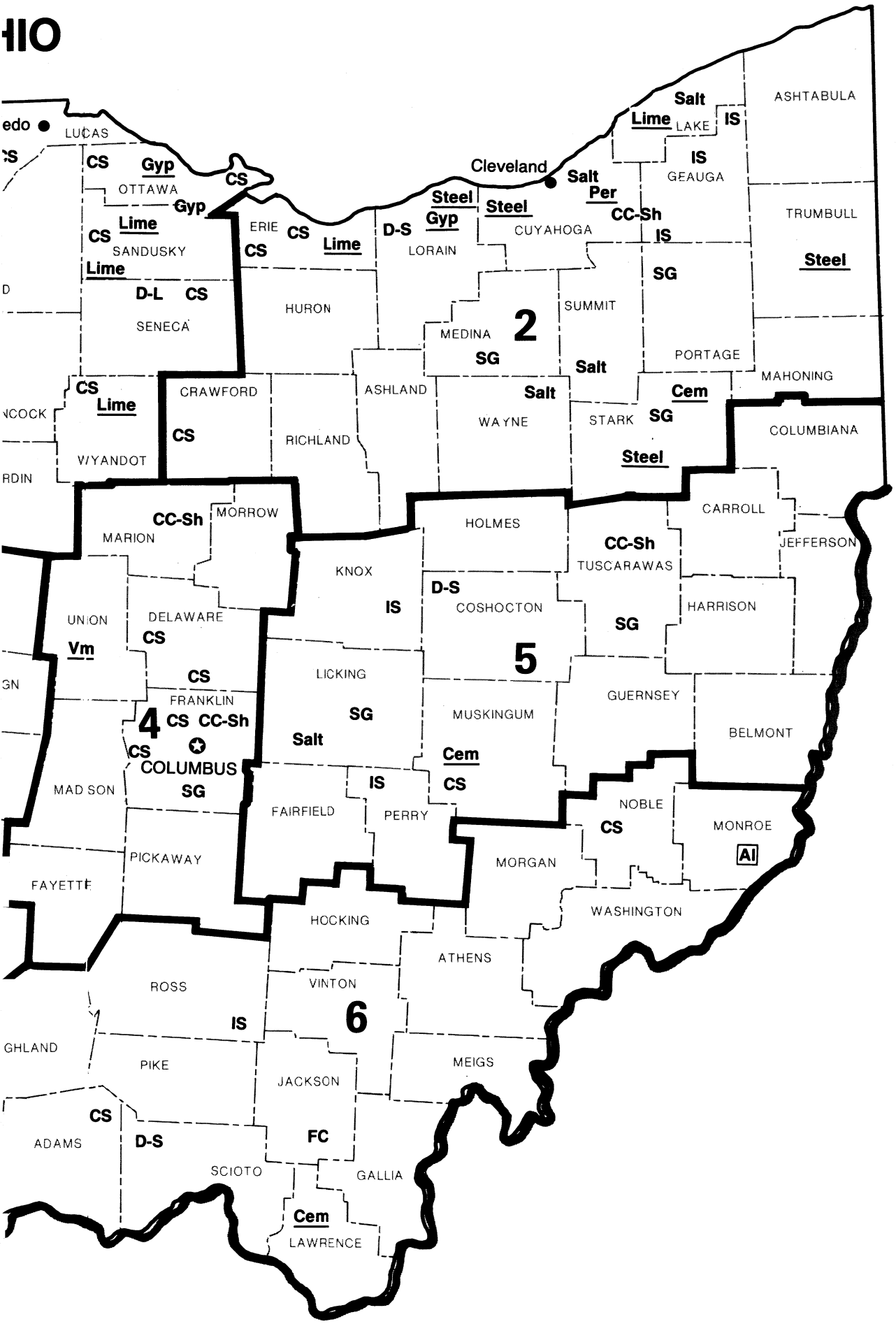
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TABLE 4

OHIO: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	1,130	3,912	400	1,233	169	731
Coarse aggregate, graded[2]	2,462	9,120	2,418	9,313	1,049	3,502
Fine aggregate (-3/8 inch)[3]	291	1,022	316	938	151	542
Coarse and fine aggregates[4]	4,910	18,068	1,959	8,000	1,465	5,498
Other construction aggregates	12	20	—	—	50	198
Agricultural[5]	481	1,701	(6)	(6)	90	784
Chemical and metallurgical[7]	(6)	(6)	—	—	(6)	(6)
Special[8]	(6)	(6)	—	—	(6)	(6)
Other miscellaneous	1,720	4,956	104	388	821	3,478
Unspecified:						
Actual[9]	5,286	19,375	2,587	9,997	2,535	8,749
Estimated[10]	764	3,031	90	211	701	2,514
Total[11]	17,058	61,204	7,875	30,080	7,032	25,997

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	41	180	94	517	98	1,033
Coarse aggregate, graded[2]	269	1,175	W	W	W	W
Fine aggregate (-3/8 inch)[3]	44	123	W	W	W	W
Coarse and fine aggregates[4]	839	3,003	938	4,599	1,240	14,160
Other construction aggregates	10	40	629	2,774	87	347
Agricultural[5]	109	541	(6)	(6)	88	400
Chemical and metallurgical[7]	—	—	—	—	17	63
Special[8]	—	—	—	—	—	—
Other miscellaneous	—	—	22	121	—	—
Unspecified:						
Actual[9]	8,098	29,491	758	2,716	569	2,558
Estimated[10]	—	—	117	426	395	1,640
Total[11]	9,409	34,553	2,558	11,154	2,494	20,202

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[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), and fine aggregate (screening-undesignated).
[4]Includes crushed stone for graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[5]Includes agricultural limestone and other agricultural uses.
[6]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[7]Includes crushed stone for cement manufacture, lime manufacture, dead-burned dolomite, and flux stone.
[8]Includes crushed stone for asphalt fillers or extenders, whiting or whiting substitutes, and other fillers or extenders.
[9]Includes production reported without a breakdown by end use.
[10]Includes estimates for nonrespondents.
[11]Data may not add to totals shown because of independent rounding.

included installation of a $116 million electrogalvanizing line. That work was expected to be completed in 1991.

USX Corp.'s USS steel division also became a partner with a Japanese steel company. The Lorain Works was sold to a joint venture of USS and Kobe Steel Ltd., Tokyo, and began operations as USS/Kobe Steel Co. in June.[9] The Lorain Works has steelmaking capacity of about 2.8 million short tons and operated at about one-half capacity in 1989, producing bar and tubular steel products.

In May, LTV Steel Co. and Sumitomo Metal Industries Ltd. decided on a second joint venture. LTV and Sumitomo operated a 400,000-ton-per-year electrogalvanizing plant in Cleveland. The new operation in Columbus was expected to have a 360,000-ton annual capacity for electrogalvanized steel sheet. Plant construction costs were estimated at $200 million, with completion scheduled for mid-1991.

Titanium.—RMI Co. produced titanium sponge at a plant in Ashtabula County and ingot at a plant in Trumbull County. The Ashtabula plant operated at full capacity because of strong demand from the commercial aerospace industry.[10] During the year, RMI completed a project to expand plant capacity that increased annual capacity of titanium sponge from 9,500 to 10,900 metric tons. The firm also continued testing electrolytic processing technology under an agreement with Electrochimica Marco Ginatta of Turin, Italy.

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[1]State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in Ohio for 5 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. 1990, p. 5.

[3]Ohio Geology Newsletter. Div. of Geol. Survey, Dep. of Nat. Res., Spring 1990, p. 8.

[4]Ohio Labor Market Information. Labor Market Review, Columbus, OH, Jan. 1990, p. 11.

[5]Monroe County Beacon (Woodsfield, OH). Dec. 21, 1989, p. 1.

[6]———. Aug. 10, 1989, p. 5.

[7]Crain's Cleveland Business. Cleveland, OH, Aug. 28, 1989, p. 7.

[8]Armco Inc. 1989 Annual Report. p. 3.

[9]USX Corp. 1989 Annual Report. p. 21.

[10]Tribune Chronicle (Warren, OH). Aug. 25, 1989, p. 3.

TABLE 5

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:			
Lafarge Corp.[2 3 4]	Box 160 Paulding, OH 45879	Plant	Paulding.
Midwest Portland Cement Co.	Box 1531 Zanesville, OH 43702	Plants	Muskingum and Stark.
Southwestern Portland Cement Co.	Box 191 Fairborn, OH 45324	Plant	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]	Rt. 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 177 Oak Hill, OH 45656	Pit	Do.
Gypsum:			
Crude:			
Celotex Corp.	Box 280 Cumberland, OH 43732	Pit and plant	Ottawa.
Lime:			
Huron Lime Co.	Box 451, 100 Meeker Huron, OH 44839	Quarry and plant	Erie.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Lime—Continued			
LTV Steel Co. Inc.	Williams St. Grand River, OH 44045	Plant	Lake.
Martin Marietta Corp.	Box 187 Woodsville, OH 43469	Quarry and plant	Sandusky.
Ohio Lime Co.	128 East Main St. Woodsville, OH 43469	Quarries and plants	Do.
Peat:			
Sphagnum Moss Peat Farm	9797 Thompson Rd., Rt. 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 390 Painesville, OH 44077	Underground mine, wells, and plants	Lake and Wayne.
Sand and gravel:			
Construction:			
American Aggregates Corp.	Drawer 160, Garst Ave. Greenville, OH 45331	Pits and plant (13 operations)	Butler, Champaign, Clark, Franklin, Greene, Hamilton, Montgomery, Warren.
Baker Sand Inc.	9857 Friendsville Rd. Burbank, OH 44214	Pits	Medina.
Boyd Gravel Co.	24270 Township Rd. 1202 Coshocton, OH 43812	Pit	Coshocton.
Dravo Corp.	5253 Wooster Rd. Cincinnati, OH 45226	Pits and plants (8 operations)	Butler, Hamilton, Meigs, Warren.
Ernst Aggregates Inc.	Box 440, 135 East Main St. Tipp City, OH 45371	Pits and plants	Greene, Miami, Warren.
Hilltop Basic Resources Inc.	630 Vine St. Cincinnati, OH 45202	do.	Clark, Greene, Montgomery.
S&S Aggregates Inc.	Box 1585 Zanesville, OH 43705	do.	Franklin, Hocking, Portage, Summit.
Watson Gravel Inc.	2728 Hamilton-Cleves Rd. Box 277 Ross, OH 45061	Pits	Butler, Hamilton, Warren.
Industrial:			
Fairmont Minerals Ltd.	Box 87, 11830 Ravenna Rd. Chardon, OH 44024	Quarries and mill	Geauga.
Oglebay Norton Co.	Box 4477 Zanesville, OH 43701	do.	Knox and Perry.
Stone:			
Crushed:			
American Aggregates Corp.	Drawer 160, Garst Ave. Greenville, OH 45331	Quarries and plants	Clark, Darke, Delaware, Fayette, Franklin, Greene, Montgomery, Warren.
Beazer Materials & Service Inc.	436 7th Ave. Pittsburgh, PA 15219	do.	Lucas, Paulding, Seneca, Wood.
National Lime & Stone Co.	First National Bank Bldg. Findlay, OH 45840	do.	Allen, Auglaize, Crawford, Delaware, Hancock, Marion, Putnam, Wyandot.

See footnotes at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone—Continued			
Crushed—Continued			
Rogers Group Inc.	Box 338 Sandusky, OH 44871	Quarry	Erie.
Stoneco Inc.[4]	221 Allen St. Maumee, OH 43537	Quarries and plant	Lucas, Ottawa, Paulding, Van Wert, Williams, Wood.
Wagner Quarries Co.	4203 Milan Rd. Sandusky, OH 44870	do.	Erie.
Dimension:			
Briar Hill Stone Co.	Box 148, State Route 520 Glenmont, OH 44628	do.	Coshocton, Holmes, Knox.
Waller Bros. Stone Quarry Co.	134 County Rd. McDermont, OH 45652	do.	Scioto.

[1]Also dimension stone.
[2]Also common clay and shale.
[3]Also crushed stone.
[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 Bureau of Mines, U.S. Department of the Interior, and the Oklahoma Geological Survey for collecting information on all nonfuel minerals.

By Jane P. Ohl[1] and Robert H. Arndt[2]

Nonfuel minerals produced in Oklahoma in 1989 were valued at $219 million, compared with $220 million in 1988. The State ranked 35th in the Nation and accounted for less than 1% of the total value of nonfuel mineral production. Crushed stone output, although down from that reported for 1987, was valued at nearly $82 million in 1989 and continued to contribute the greatest dollar amount to the State's total nonfuel mineral production. Some other nonfuel minerals produced were, in order of decreasing value, portland cement, $39 million; iodine, $24 million; and construction sand and gravel, $20 million.

The University of Oklahoma's College of Business Administration stated that "the big news for 1989 is that Oklahoma's economy continued the modest upturn begun in 1988."[3]

EMPLOYMENT

Total unemployment in the State continued the favorable trend, falling from an average of 6.6% for 1988 to an average of 5.9% for 1989, according to the University of Oklahoma, College of Business Administration.[4]

Employment gains were noted in all sectors except mining, where wage and salary employment declined by 1.8%, and in contract construction employment, which dropped by 0.9%.[5]

About 2,100 persons were employed in the nonfuel mining industry in 1989; total mining employment, including oil and gas, averaged 44,100 persons per month.

REGULATORY ISSUES

Kerr-McGee Corp. settled 13 lawsuits concerning the accidental release in January 1986 of toxic fumes at its Sequoyah Fuels uranium processing plant near Gore.

The Federal Superfund law (Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Public Law 96-510) gave State

TABLE 1

NONFUEL MINERAL PRODUCTION IN OKLAHOMA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	41	$2,436	W	W	W	W
Portland	do.	1,415	54,870	1,432	$42,131	1,236	$39,360
Clays	metric tons	723,300	1,783	684,067	1,803	565,956	1,619
Gem stones		NA	8	NA	18	NA	W
Gypsum	thousand short tons	1,828	13,336	2,173	13,393	2,523	14,369
Iodine	kilograms	W	W	1,015,210	W	1,505,714	23,947
Sand and gravel:							
Construction	thousand short tons	e10,500	e24,200	9,273	22,654	e8,500	e20,000
Industrial	do.	1,243	17,078	1,268	17,381	1,216	18,310
Stone:							
Crushed[2]	do.	25,155	83,732	e26,300	e92,000	23,598	81,969
Dimension	short tons	8,311	861	e7,746	e785	8,290	762
Combined value of feldspar, lime, salt (1987-88), stone (crushed dolomite, 1987-88, crushed granite, 1989), tripoli, and values indicated by symbol W		XX	24,915	XX	29,972	XX	18,695
Total		XX	223,219	XX	220,137	XX	219,031

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

and Federal environmental officials wide latitude in determining who shall pay for cleaning up hazardous waste sites. In accordance with this law, the American Exchange Bank was found liable for hazardous waste cleanup of a property northwest of Norman that it had acquired through foreclosure. The Oklahoma State Department of Health had begun its investigation into this cleanup problem after the foreclosure; thus, the bank became responsible for the cleanup. The property had been used by Flynt Mining Co. as a site for the recovery of silver from photographs and X-rays, using a cyanide solution. Wastewater from the processing, which contained traces of the silver and cyanide, was dumped into an on-site pond, drawing complaints from neighbors and the attention of health officials.

The U.S. Environmental Protection Agency reviewed a property belonging to Fansteel Inc. at Muskokee as a possible site to be included on the national priority list for cleanup under the Superfund program. The plant extracted tantalum from various feedstocks. Waste containing antimony, phosphorus, and other elements and materials was deposited in an effluent pond. Preliminary soil sampling at the site had found some contamination near the plant; further study was recommended. Heavy rains in early July damaged the pond embankment, and Fansteel had to replace the embankment lining with a new rubber-plastisol lining.

EXPLORATION ACTIVITIES

NERCO Minerals Co., Newmont Exploration Ltd., and American Copper & Nickel Co. entered into a 5-year joint-venture exploration project in southwestern Kiowa County. Drilling began in 1989 on unstated mineral targets defined by NERCO during the previous 2 years.

LEGISLATION AND GOVERNMENT PROGRAMS

The U.S. Bureau of Land Management (BLM) agreed that the State of Oklahoma be allowed to regulate surface mining on Federal coal leases. BLM also allowed Oklahoma to issue required mining permits, starting in 1990. Part of the agreement eliminated a 250-ton limit on the amount of coal that a firm could mine, without a permit, and deliver to the Applied Energy Services cogeneration plant at Shady Point, Le Flore County, for test burns. The agreement took effect October 11. Officials of the National Wildlife Federation protested that the agreement violated the Surface Mining Control and Reclamation Act of 1977, the Federal Coal Leasing Amendments Act of 1976, the Administrative Procedure Act, and the National Environmental Policy Act.

About 179 acres of abandoned coal mine lands in 12 counties were reclaimed under the Oklahoma Conservation Commission's abandoned mine land reclamation program in 1989. The land was returned largely to arable condition at a total cost of about $1 million. The arable land is principally in Rogers, Le Flore, Okmulgee, Haskell, and Coal Counties. During the decade before 1989, 1,264 acres had been reclaimed in eastern Oklahoma under this program. The program was funded by a 35 cent per ton Federal tax on mined coal. In December, the U.S. Department of the Interior granted Oklahoma $925,000 to administer the reclamation program.

Total royalties derived from Federal mineral leases in Oklahoma amounted to $4.6 million, up from $3.7 million in 1988. Operators paid royalties on oil, gas, coal, chat (a crushed stone), limestone, and sand and gravel. The Federal Government (Minerals Management Service and BLM) distributed $1.9 million to the State of Oklahoma as its share of revenues collected.

BLM planned an accelerated program to survey a 96-mile section of the Arkansas River between Fort Smith, AR, and Muskogee, OK. Some issues were the control, development, and use of mineral deposits in the riverbed, namely sand and gravel and feldspar. The survey was to identify claims to the riverbed by the Cherokee, Choctaw, and Chickasaw Indian Tribes and to resolve boundary disputes among private landowners. The mineral deposits have been mined in the past by private, non-tribal entities.

The closed Keyes Helium Plant was the subject of an agreement between a local Industrial Park Authority and the Federal Government. In October, the President signed a law authorizing the transfer of a 190-acre Federal site near Keyes in Cimarron County to a public trust. The trust was formed as the Cimarron Industrial Park Authority. The Authority expected to take possession of the property on September 30, 1990, and turn it into an industrial park. The property is the site of a former helium plant built in 1959 and operated until 1985 by the Bureau of Mines.

The Oklahoma Geological Survey, in cooperation with the Oklahoma Department of Mines, began compiling a directory of all coal and nonfuel mining companies in the State. The planned directory is to present a master list of firms and headquarters addresses, a list of operating mine sites arranged by county and located according to the public land identification system, and a list of mined commodities identifying counties in which they are mined and the firms engaged in mining them.

REVIEW BY NONFUEL MINERAL COMMODITIES

Oklahoma mines and quarries were the source of industrial minerals only. Some metals, however, were recovered by processing plants in the State.

Industrial Minerals

Cement.—Despite an increase in average value of 8%, or $2.43 per ton, portland cement output declined 14%. Masonry cement total value, production, and price rose 7%, 3%, and 4%, respectively, above figures for 1988.

Three firms operated cement plants in Oklahoma. Ideal Basic Industries Inc. operated only one of its two wet-process kilns at Ada; Blue Circle Inc. and Lone Star Industries Inc. operated five dry-process kilns at their respective plants at Tulsa and Pryor. The kilns were fueled principally by natural gas; a very small amount of coal also was used. Also consumed in the manufacture of portland cement were cement rock and/or limestone, plus smaller quantities of clay, gypsum, iron ore, sand, shale, acids, and other chemicals.

Finished portland cement was moved by rail (51% of shipments) and by truck. Ready-mix companies received 57% of the shipments, and the remainder went to other contractors, highway

contractors, concrete products manufacturers, building materials dealers, miscellaneous customers, and government agencies.

Clays.—Oklahoma clay pits were the source of common clay and shale only, a condition that has prevailed for at least 22 years. Eight companies and one county operated clay pits. The largest portion of the clay was used in making portland cement, followed in declining order of usage, by common brick, face brick, highway surfacing, and pottery. Output was down from 684,000 metric tons in 1988 to 566,000 metric tons in 1989. Total value fell 10% to $1.6 million.

Feldspar.—Feldspar production increased by 22%, and total value of the product rose nearly 18%, despite a decrease in average value of about $2 per short ton to $62.02. The State was one of only seven that produced feldspar in 1989; production came from Muskogee County. Feldspar was used in the manufacture of glass and pottery.

Gypsum.—Crude gypsum output rose more than 16% above that of 1988 and total value rose 7%, although the average value of crude gypsum fell 46 cents to $5.70 per short ton. The output and total value of calcined gypsum rose 34% and 43%, respectively.

One of the State's principal producers was United States Gypsum Co.'s Southard plant in Blaine County. Its calcining plant required rock that was 96% pure, and the best quality gypsum was taken from the Nescatunga Gypsum Member of the Blaine Formation. In June, the firm installed a rock beneficiation system and log washer unit to cleanse dirt and clay from the gypsum. About 200 gypsum products were made at the Southard plant. Most sales were to customers in Oklahoma, Arkansas, Kansas, and Texas, but some products were shipped as far as the north slope of Alaska and to Colombia and Venezuela.

Besides United States Gypsum's mine and calcining facility at Southard, five other firms mined crude gypsum. Two of them, Republic Gypsum Co. and Temple-Inland Forest Products Corp., also calcined gypsum.

Iodine.—Three companies produced iodine from brines in northwestern Oklahoma: Iochem Corp. near Vici, North American Brine Resources near Dover, and Woodward Iodine Corp. at Woodward. The addition of Iochem's operation in late 1988 helped increase annual output to 1.5 million kilograms, about 48% higher than total 1988 output. The average value of iodine was $15.90 per kilogram ($7.74 per pound). Oklahoma brines were the Nation's sole domestic source of iodine.

Iodine uses included animal feed supplements, catalysts, inks and colorants, pharmaceuticals, photographic equipment, and sanitary and industrial disinfectants.

Lime.—Production and total value decreased slightly from 1988. In June 1989, a new Cimprogetti three-stage hydrator was started up at St. Clair Lime Co.'s plant near Sallisaw, Sequoyah County. Company officials stated that the $1 million Italian-made hydrator was the first of its kind installed in North America. Quicklime produced in two adjacent coal-fired rotary kilns was processed and shipped both in bulk and as bagged hydrated limes. About 2 tons of limestone were used to make 1 ton of lime that was 52% to 54% CaO.

Limestone came from an adjacent underground room-and-pillar mine at a shallow depth beneath the surface. Two levels were worked in 1989; pillars of 45 to 50 feet in height measured 35 by 35 feet at the base. The recovery rate in the mine was 70%, and about one-third of the production was sold as lime. A nearby coal-fired powerplant of the Grand River Dam Authority used much of the lime output to neutralize SO_2 in the scrubber system.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Estimated output and value of construction sand and gravel fell about 8% and 12%, respectively, from those of 1988. The average value was estimated to be $2.35 per short ton, down from $2.44 in 1988.

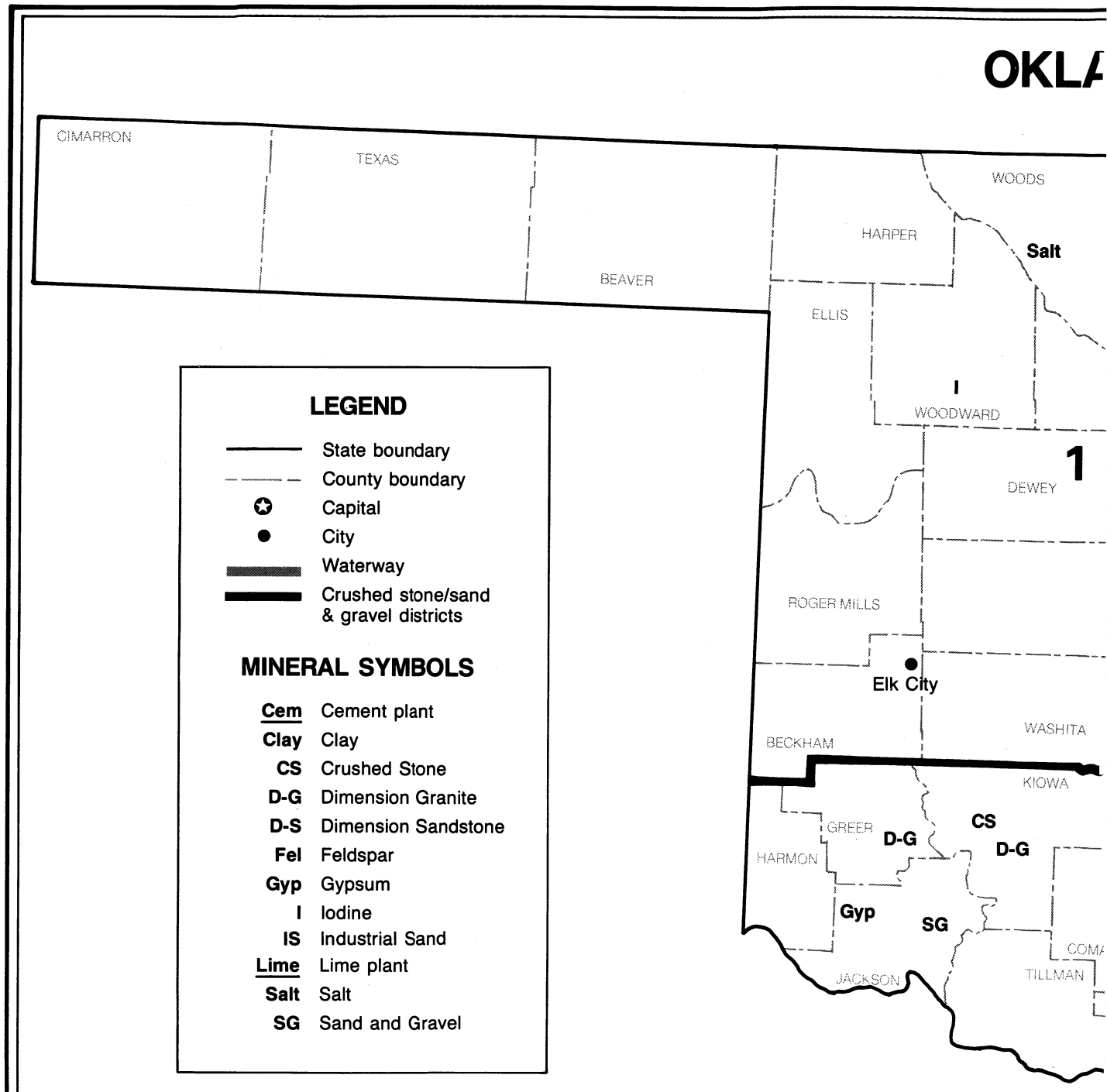
Under terms of a March 1989 agreement, Co-Mate Construction Co. Inc., Brewer Construction Co. Inc., and CBC Materials would pay the Oklahoma City Riverfront Redevelopment Authority as much as $1 million in royalities to extract aggregate (sand and gravel) from riverfront property controlled by the Redevelopment Authority. The Redevelopment Authority would receive 8% of the firms' gross sales on all types of aggregate materials mined during the 7.5-year life of the renewable contract. The firms mine both a fine-grained (fill) sand and a more expensive, coarser-grained sand used in masonry and asphaltic cements.

Industrial.—Three companies operated four industrial sand pits in 1989. Pits were located at Mill Creek, Johnston County (two pits); Muskogee, Muskogee County; and Roff, Pontotoc County. Nearly 39% of the industrial sand mined in Oklahoma was used to make glass containers. Some other products, in decreasing order of tonnage used, were molding and cores, roofing granules, specialty glass, and flat glass. The largest proportion of industrial sand was transported by rail.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Oklahoma stone statistics are compiled by geographical districts depicted in the State map. Tables 2 and 3 present end-use statistics for Oklahoma's five districts.

Crushed.—Deposits of dolomite, granite, limestone, sandstone, and traprock (includes basalt, gabbro, diabase, etc.) were quarried for crushed stone by 39 firms in 33 counties. Production fell about 10% from that of the last survey in 1987. Average value per short ton remained nearly constant, just below $3.50. The largest tonnage quarried of all rock types, dolomite and limestone, were used principally in the manufacture of cement and, in decreasing order of quantities consumed, in concrete aggregates, fill, graded road base, and fine screenings. Some crushed granite was used for railroad ballast, concrete aggregate, stone sand-concrete, and graded road base. Crushed sandstone and traprock were used in similar applications.



Principal Mineral-Producing Localities

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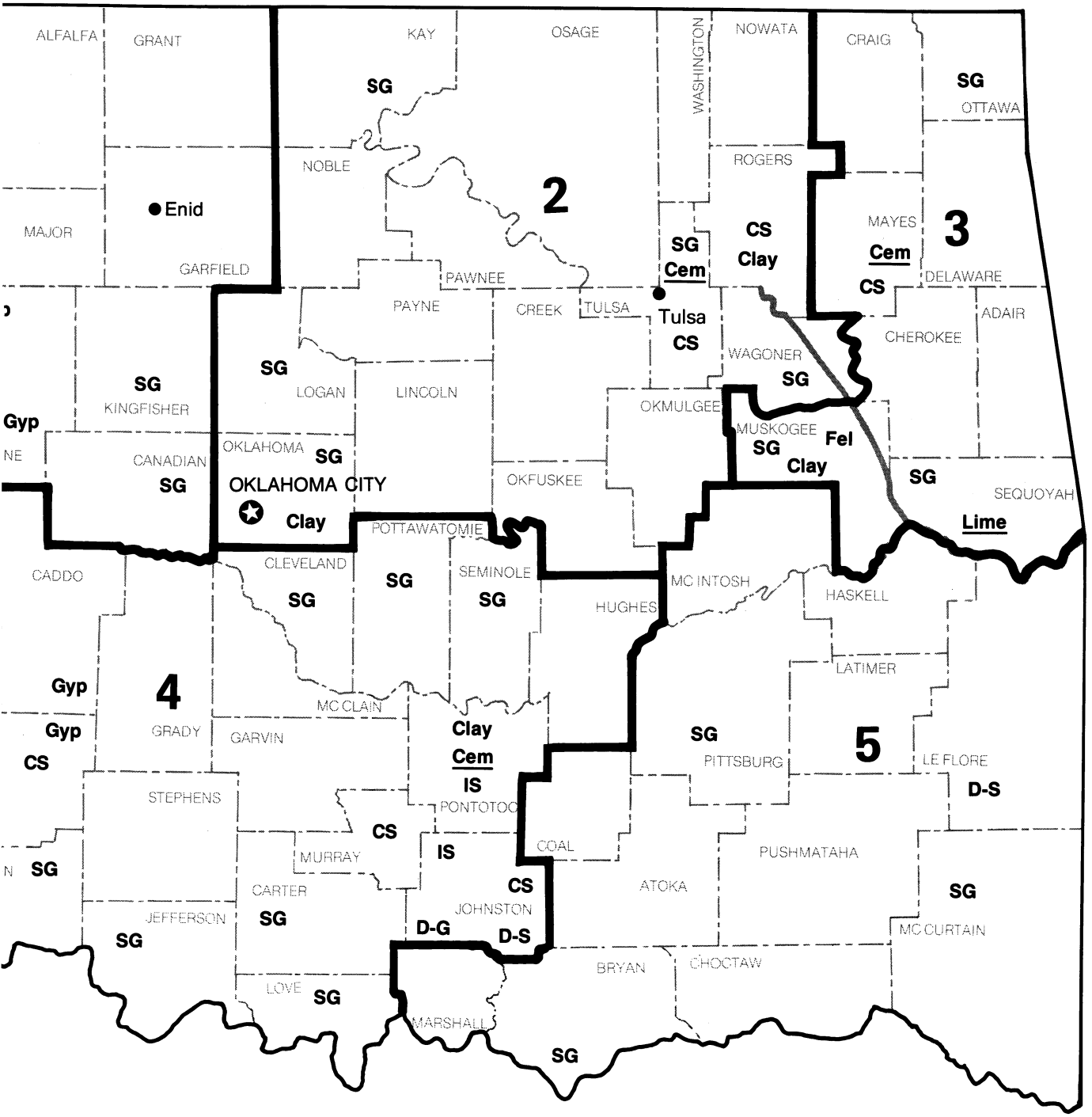
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SEQUOYAH
Lime
POTTAWATOMIE
CADDO
CLEVELAND
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SEMINOLE
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TABLE 2

OKLAHOMA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	118	492
Filter stone	182	763
Other coarse aggregate[2]	197	633
Coarse aggregate, graded:		
Concrete aggregate, coarse	1,689	7,032
Bituminous aggregate, coarse	348	1,497
Bituminous surface-treatment aggregate	296	1,310
Railroad ballast	701	4,313
Fine aggregate (−3/8 inch):		
Stone sand, concrete	131	415
Stone sand, bituminous mix or seal	183	421
Screening, undesignated	720	1,411
Coarse and fine aggregates:		
Graded road base or subbase	1,041	2,966
Unpaved road surfacing	268	827
Crusher run or fill or waste	1,538	4,002
Other construction materials	112	435
Other miscellaneous[3]	1,826	3,425
Unspecified:[4]		
Actual	13,257	48,624
Estimated	992	3,402
Total[5]	23,598	81,969

[1] Includes limestone, traprock, sandstone, and dolomite; granite withheld to avoid disclosing company proprietary data.
[2] Includes stone used in macadam.
[3] Includes stone used in agricultural limestone, and cement manufacture.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

Meridian Aggregates Co., of Littleton, CO, was issued a permit in June to quarry and crush granite at Long Mountain, Kiowa County. The crushed granite was to be used mainly as ballast for railroad tracks. The site, 5.5 miles west of Snyder, was chosen because of the high quality of the granite and its proximity to rail lines. About 10 local families had protested the issuing of a permit, stating that the noise and dust from the quarry and plant would threaten their homes and health.

Dimension.—Granite and sandstone were quarried for use as dimension stone by six firms. The quarries' production was up 7% over that of 1988. Two new companies were started, Rock Island Stone Co., which quarried sandstone, and Oklahoma Red Granite Co., which quarried granite.

Vermiculite (Exfoliated).—W. R. Grace & Co. exfoliated vermiculite from out-of-State sources at its Oklahoma City plant. Output was 7% less than in 1988. The product was sold for use as loose fill and block insulation, concrete aggregates, and soil conditioning.

Metals

Germanium.—Eagle-Picher Industries Inc. recovered primary germanium from zinc smelter residues and reprocessed scrap to recover germanium. The firm's Specialty Materials Division plant was at Quapaw, Ottawa County. In 1989, the Defense Logistics Agency (DLA) paid Eagle-Picher a contract price of $609 per kilogram of germanium metal, for delivery in late 1990. DLA rejected bids ranging from $559 to $582 per kilogram from European and African producers. Eagle-Picher's selection was based on the requirement that DLA follow a "Buy America Policy."

Iron and Steel Slags.—Sold or used iron and steel slags increased in both quantity and value over figures for 1988.

[1] State Mineral Officer, Bureau of Mines, Denver, CO. She has covered the mineral activities in Oklahoma for 4 years. Assistance in the preparation of the chapter was given by Pat La Tour, editorial assistant.

[2] Geologist IV, Oklahoma Geological Survey, Norman, OK.

[3] Dikeman, N. J., Jr. Business Highlights, Oklahoma Business Bulletin. V. 58, issue 3, pp. 8-10.

[4] Oklahoma, University of. 1990. Oklahoma Business Bulletin, Table: Selected Economic Indicators. V. 58, issue 3, Mar. 1990, p. 2.

[5] Dikeman, N. J., Jr. Business Highlights, Oklahoma Business Bulletin. V. 58, issue 3, pp. 8-10.

TABLE 3

OKLAHOMA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	—	—	224	926	19	67
Coarse aggregate, graded[2]	—	—	1,647	7,118	231	966
Fine aggregate (−3/8 inch)[3]	—	—	621	1,267	W	W
Coarse and fine aggregates[4]	—	—	1,462	4,401	147	484
Other construction aggregates	—	—	23	56	88	153
Agricultural[5]	—	—	([6])	([6])	([6])	([6])
Chemical and metallurgical[7]	—	—	([6])	([6])	—	—
Other miscellaneous	—	—	834	1,246	9	36
Unspecified:						
Actual[8]	—	—	1,587	5,406	1,846	4,646
Estimated[9]	—	—	—	—	294	1,008
Total[10]	—	—	6,398	20,420	2,634	7,359

	District 4		District 5	
	Quantity	Value	Quantity	Value
Construction aggregates:				
Coarse aggregate (+1 1/2 inch)[1]	48	222	204	674
Coarse aggregate, graded[2]	1,030	5,478	125	590
Fine aggregate (−3/8 inch)[3]	148	270	W	W
Coarse and fine aggregates[4]	557	1,145	682	1,766
Other construction aggregates	89	379	177	556
Agricultural[5]	—	—	—	—
Chemical and metallurgical[7]	983	2,143	—	—
Other miscellaneous	—	—	—	—
Unspecified:				
Actual[8]	5,854	24,880	3,970	13,692
Estimated[9]	534	1,832	164	562
Total[10]	9,244	36,349	5,323	17,840

W Withheld to avoid disclosing company proprietary data; included with Other construction aggregate.
[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, and fine aggregate (screening-undesignated).
[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[5] Includes agricultural limestone.
[6] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[7] Includes crushed stone for cement manufacture.
[8] Includes production reported without a breakdown by end use.
[9] Includes estimates for nonrespondents.
[10] Data may not add to totals shown because of independent rounding.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Blue Circle Inc., a subsidiary of Blue Circle Industries Ltd.[1 2]	One Parkway Center 1850 Parkway Place Suite 1000 Marietta, GA 30067	Quarry and plant	Rogers.
Ideal Basic Industries Inc., Ideal Cement Co.[1 2]	Box 8789 Denver, CO 80201	do.	Pontotoc.
Lone Star Industries Inc.[1 2]	300 First Stamford Place Box 120014 Stamford, CT 06912-0014	do.	Mayes.
Clays:			
Acme Brick Co., a subsidiary of Justin Industries Inc.	Box 24012 Oklahoma City, OK 73124	Pits and plants	Oklahoma.
Chandler Materials Co.	5805 East 15th St. Tulsa, OK 74102	Pit and plant	Do.
Commercial Brick Corp.	Box 1382 Wewoka, OK 74884	do.	Seminole.
Oklahoma Brick Corp., a subsidiary of Merry Companies	Box 75368 4300 NW. 10th St. Oklahoma City, OK 73127	do.	Canadian and Muskogee.
Feldspar:			
Arkhola Sand and Gravel Co., a division of APAC-Arkansas Inc., a subsidiary of Ashland Oil Co.[2 3]	Box 1401 Muskogee, OK 74401	Dredge and plant	Muskogee.
Gallium and germanium:			
Eagle-Picher Industries Inc.	Box 737 Quapaw, OK 74363	Refinery	Ottawa.
Gypsum:			
Harrison Gypsum Co. Inc.	Box 69, Route 4 Lindsay, OK 73052	Quarry	Caddo.
Heartland Cement Co.	Box 428 Independence, KS 67301	do.	Blaine.
Republic Gypsum Co.	Drawer C Duke, OK 73532	Quarry and plant	Jackson.
Temple-Inland Forest Products Corp.	Box 1270 West Memphis, AR 72303	do.	Comanche.
United States Gypsum Co., a subsidiary of USG Corp.	Box 187 Southard, OK 73770	do.	Blaine.
Iodine:			
Iochem Corp.	6520 North Western Suite 200 Oklahoma City, OK 73116	Brine field and plant	Woodward.
North American Brine Resources	c/o Beard Oil Co. 2000 Classen Center Bldg. Oklahoma City, OK 73106	Oilfield brines and plant	Kingfisher.
Woodward Iodine Corp., a subsidiary of Asahi Glass Co. Ltd. and Ise Chemical Co.	Box 1245 Woodward, OK 73801	Brine field and plant	Woodward.
Lime:			
St. Clair Lime Co.	Box 894 Oklahoma City, OK 73101	Mine and plant	Sequoyah.
Pumice (volcanic ash):			
Axtell Mining Corp.	Box 92 Gate, OK 73844	Open pit	Beaver.
Salt:			
Cargill Inc.	Box 167 Freedom, OK 73842	Solar evaporation	Woods.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Construction:			
Boorhem-Fields Inc.[2]	8144 Walnut Hill Lane Suite 297 Lock Box #9 Dallas, TX 75231	Quarries	Bryan.
The Dolese Co.[2]	Box 677 Oklahoma City, OK 73101	Pits and plants	Canadian, Kingfisher, Logan, Oklahoma.
Gainesville Sand & Gravel Co.	Thackerville, OK 73459	Pit and plant	Love.
Lemon Haskell Construction Co. of General Materials Co. Inc.	Box 75608 Oklahoma City, OK 73147	Pits and plant	Cleveland.
Industrial:			
UNIMIN Corp.	258 Elm St. New Canaan, CT 06840	Pit and plant	Pontotoc.
U.S. Silica Co.	Box 187 Berkeley Spring, WV 25411	Pits and plant	Johnston.
Stone:			
Crushed:			
Amis Materials Co.	Box 417 Atoka, OK 74525	Quarry	Atoka.
Anchor Stone Co. and Tulsa Rock Co., subsidiaries of Anchor Industries	3300 North Mingo Valley Expressway Tulsa, OK 74116	do.	Rogers and Tulsa.
Bellco Materials Inc.[3]	Box 466 Nowata, OK 74048	Quarries	Nowata, Rogers, Washington.
Material Producers Inc.	Box 577 Norman, OK 73070	Quarry	Murray.
McNabb Stone Co., a division of McNabb Coal Co. Inc.	Drawer C Catoosa, OK 74015	Quarries	Rogers and Wagoner.
Meridian Aggregates Co., a subsidiary of Burlington Northern Railroad	Box 86 Mill Creek, OK 74856	Quarry	Johnston.
The Quapaw Co.	Box 72 Drumright, OK 74030	Quarries	Creek and Pawnee.
Sooner Rock & Sand Co., a subsidiary of Hallett Construction Co.	Box 1549 Norman, OK 73070	Quarry	Murray.
Standard Industries, a division of APAC-Oklahoma Inc.	Box 580670 Tulsa, OK 74158	Quarries	Cherokee, Kay, Mayes, Tulsa.
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.
Pontotoc Stone Co.	1434 NW 30th St. Oklahoma City, OK 73118	do.	Johnston.
Willis-Oklahoma Red Granite Inc.	Box 867 Granite, OK 73547	do.	Greer.
Tripoli:			
American Tripoli Co.	Box 489 Seneca, MO 64865	Mines	Ottawa.
Zinc:			
Zinc Corp. of America, a division of Horsehead Industries Inc.[4]	Box 579 Bartlesville, OK 74005	Electrolytic refinery	Washington.

[1] Also clays.
[2] Also stone.
[3] Also sand and gravel.
[4] Also sulfuric acid; copper, lead, and silver residues; and cadmium balls.

THE MINERAL INDUSTRY OF OREGON

By Rodney J. Minarik[1]

The value of nonfuel mineral production in Oregon in 1989 was $185.6 million, an increase of about 4% over that of 1988. Gains in the production value of portland cement, crushed stone, and nickel were largely responsible for the increase, offsetting declining values for construction sand and gravel and gold. Industrial minerals accounted for nearly all of the State's nonfuel mineral production value. Oregon ranked 37th in the Nation in that value, compared with 38th in 1988. Oregon was the only State to produce nickel. The State ranked first nationally in the quantity of pumice produced, fourth in the production of diatomite, and was a significant producer of processed natural zeolite.

TRENDS AND DEVELOPMENTS

Production value of Oregon's three most valuable minerals—portland cement, construction sand and gravel, and crushed stone—increased 4%. These construction materials accounted for the bulk of the State's total mineral production. Gold and nickel were the only metals produced in significant quantity. Gold exploration experienced a major shift away from the old producing regions in the northeastern and southwestern parts of the State to the Basin and Range Province in southeastern Oregon, especially northern Malheur County. The nickel plant formerly owned by Hanna Mining Co. near Riddle, Douglas County, was reactivated by Glenbrook Nickel Co.

EMPLOYMENT

According to the Oregon Employment Division, Department of Human Resources, the State's 1989 mining and quarrying employment was 1,400 workers, an increase from the 1,300 workers reported for 1988. Reflecting the continuing strength of the State's aluminum reduction industry, employment in the nonferrous metals segment of Oregon's primary metals industry increased to 5,300 workers from 5,100 in 1988. Blast furnace and iron and steel foundry employment rose to 5,600 in 1989, an increase of 500 over that of 1988. Weekly wages for primary metals industry workers averaged $503 for a 41.5-hour workweek.

REGULATORY ISSUES

Teledyne Wah Chang Albany Corp. (TWCA) was seeking Federal and State approval to ship thousands of truckloads of low-level radioactive sludge from near Albany to a licensed disposal site in northwestern Oregon. The semisolid sludge was left over from TWCA's zirconium manufacturing process in the late 1960's and 1970's. The radioactivity came from the naturally occurring elements contained in the Australian sand from which the zirconium metal was extracted.

A study was begun to determine the amount of contamination and possible options available to remove hazardous materials from the site of the former Bergsoe Metals Corp. secondary lead smelter in St. Helens, Columbia County. Bergsoe Metals began recycling batteries at the site in 1982 and closed it in 1986. An interim cleanup plan for consolidating and covering the contaminated material has been in place. Plans are to eventually remove the lead-contaminated materials from the site. Although it had a lease-financing agreement for the site, the Port of St. Helens was not an owner or manager of operations and, therefore, would not be required to assist in cleanup of the hazardous materials.

EXPLORATION ACTIVITIES

Gold exploration was concentrated in southeastern Oregon, especially in

TABLE 1

NONFUEL MINERAL PRODUCTION IN OREGON[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Clays	metric tons	242,966	$986	225,001	$1,049	210,893	$875
Gem stones		NA	350	NA	894	NA	1,304
Nickel (content of ores and concentrates)	short tons	—	—	—	—	382	2,600
Sand and gravel (construction)	thousand short tons	e13,000	e42,200	14,880	52,657	e14,400	e49,700
Stone (crushed)	do.	20,663	73,902	e22,200	e77,600	2 18,407	2 81,204
Talc and pyrophyllite	short tons	150	14	W	W	225	18
Combined value of cement, diatomite, gold, lime, pumice, silver, stone (crushed dolomite and quartzite, 1989), value indicated by symbol W		XX	43,544	XX	45,988	XX	49,854
Total		XX	160,996	XX	178,188	XX	185,555

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

northern Malheur County. In 1989, nearly 8,000 claims were located in the county, bringing the total to more than 21,000. Exploration drilling was done on at least 16 different properties.

Atlas Corp. continued drilling its Grassy Mountain project south of Vale, Malheur County. The company worked on the final feasibility study, and baseline environmental and water-quality data were collected. An operating plan calling for development of two open pits and heap-leach cyanidation was submitted to the Bureau of Land Management (BLM).

Chevron Resources Co. drilled and sampled extensively at its Hope Butte project. The property was first explored for mercury in the 1950's and 1960's, but was recently determined to have gold mineralization. Also, Chevron continued exploration of its Quartz Mountain (Jessie Page) prospect.

ASARCO Incorporated acquired a large land position in the State and conducted drilling programs at several properties, including Epithermal's Shell Rock Butte prospect, Manville Corp.'s Katey prospect, and a discovery in the Dry Creek area on the east side of Owyhee Reservoir. The Shell Rock lease was later dropped.

Manville explored at the Bannock and Hillside properties. American Copper & Nickel Co. continued drilling its prospect in Harper Basin, and Malheur Mining Co. drilled at its Kerby prospect near Farewell Bend. South of Farewell Bend, both Malheur Mining and Atlas located claims near Tub Mountain. Atlas did some drilling, while Malheur Mining leased its claims to Echo Bay Mines Ltd.

Ican Minerals Ltd. did extensive drilling and surface sampling at the Racey property near Malheur City in northern Malheur County. Billiton Exploration Inc. joined Ican in the project and initiated an extensive followup drilling program. In Baker County, Golconda Mining Inc. explored the Manville property near the Record Mine southeast of Unity. Hecla Mining Co. drilled near the old Flagstaff Mine east of Baker.

Quartz Mountain Gold Corp. announced that a feasibility study done by an independent engineering contractor found the Quartz Mountain gold prospect in Lake County to be "economic at current gold prices." Pegasus Gold Inc. signed a joint-venture agreement with Quartz Mountain to continue exploration, conduct feasibility studies, and develop a mine plan. Galactic Resources Ltd., which had a similar agreement with Quartz Mountain, stated it would no longer actively participate in the project and would limit its holdings to 20%. The low-grade heap-leach open pit project included both the Crone Hill and Quartz Butte deposits.

In Lake County, N. A. Degerstrom Inc. drilled at the base of Winter Rim on the west side of Summer Lake. Freeport-McMoRan Gold Co. drilled at a prospect near Bear Creek Butte south of Prineville, Crook County. In Grant County, Goldsearch Resources Inc. explored the Prairie Diggings property near John Day, and Asarco explored in the Spanish Peaks area south of Antone.

In Douglas County, Formosa Exploration Inc. continued to explore its Silver Peak project, a gold-containing massive copper-zinc sulfide ore body. Construction of the mill was being planned.

Aur Resources signed an agreement with Savanna Resources Ltd. giving it a 51% interest in Savanna's Turner-Albright massive sulfide property in southwest Josephine County. The property contains copper, gold, and zinc. Plexus Resources Corp. obtained development rights to the Bornite project in a property exchange with Cyprus Metals Exploration Co. The copper-gold-silver property is in the Cascade Mountains about 45 miles east of Salem in the North Santiam Mining District, Marion County.

LEGISLATION AND GOVERNMENT PROGRAMS

CooSand Corp., which held a sand mining claim on a 780-acre tract in the Oregon Dunes National Recreation Area, wanted to patent the land under provisions of the Mining Act of 1872. The U.S. Forest Service and the BLM agreed that it was legal, but several citizens' groups fought the action. By yearend, no decision had been made.

The BLM announced completion of an agreement between it, THC Inc., and Hecla regarding the proposed site of the National Historic Oregon Trail interpretation center near Baker. The agreement allows THC and Hecla to continue to explore for surface deposits of gold and silver on existing claims near the proposed center until March 1992. Exploration for deposits accessible by underground methods will be allowed until 1999. In return, THC and Hecla agreed not to surface mine near the proposed site for the center, not to damage wagon wheel ruts in the Oregon Trail, and to attempt to minimize adverse impacts on the site.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Cement production in Oregon increased more than 10% in tonnage and by about 21% in value from that of 1988. 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.

Most 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 portland cement produced in the State was used by ready-mixed companies (77%); concrete product manufacturers (9%); highway contractors (5%); and other contractors, building materials dealers, government agencies, and miscellaneous customers (9%).

Clays.—Oregon's 1989 clay production decreased by more than 6% in quantity and about 17% in value from that of 1988. Common clay, used chiefly in bricks, ceramic tile, and cement, was mined by three companies in Baker, Josephine, Klamath, Lane, and Multnomah Counties. Ash Grove Cement was the State's leading producer.

Three companies in two counties accounted for Oregon's bentonite production. Teague Mineral Products Co., south of Adrian, Malheur County, was the State's largest producer. The premium-grade sodium bentonite was mined in northern Malheur County and southwest Idaho. The material was sold for soil sealant at waste disposal sites, ditches, and ponds; drilling mud; and absorbent and binder for cattle food pellets. Central Oregon Bentonite Co. and Evergreen Bentonite Inc. produced bentonite from adjoining properties on Camp Creek, 40 miles southeast of Prineville, Crook County.

Diatomite.—Diatomite production in Oregon rose more than 3% in quantity, but value remained essentially the same as in 1988; the State again ranked fourth nationally for diatomite production. 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 company operated its Celatom diatomite processing facility west of Vale, Malheur County, for production of filter aids in water and food processing and for pharmaceuticals.

Oil-Dri Production Co. operated both an open pit and a processing facility in Christmas Valley, Lake County. The diatomite was packaged for use as pet litter and sold under several brand names.

Lime.—Lime production decreased by nearly 6% in quantity and 3% in value from that of 1988. Ash Grove Cement at Portland, Multnomah County, and Amalgamated Sugar Co. at Nyssa, Malheur County, produced lime throughout the year. Quicklime accounted for 81% of the total reported lime production in 1989. Ash Grove Cement produced all of the State's hydrated lime at a kiln the company operated in Portland. High-calcium limestone was barged in from the company's quarry on Texada Island near Vancouver, British Columbia, to be used as the plant's feedstock. Amalgamated Sugar purchased high-purity limestone from Ash Grove Cement's Durkee pit, Baker County, for use in sugar beet refining. At its plant in Nyssa, Amalgamated Sugar calcined the limestone to quicklime.

Perlite.—Expanded perlite was manufactured by Supreme Perlite Co. at Portland, Multnomah County; it was used for the production of cryogenic, horticultural, masonry, and construction products. The quantity produced and the value of the product were the same as in 1988. The company processed raw perlite from its mine on Dooley Mountain, Baker County.

Pumice.—Oregon pumice production again ranked first nationally for tonnage produced. Production increased more than 17% in quantity and almost 51% in value from that in 1988. Cascade Pumice Co. and Central Oregon Pumice Co. operated surface mines and crushing and screening plants in the Bend area, Deschutes County. Cascade Pumice mined pumice from two open pits and operated a quarry producing 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, and roofing.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

According to the Oregon Department of Geology and Mineral Industries, sand and gravel was produced in all but five counties. Clackamas, Lane, Multnomah, and Marion were major producing counties. Estimated quantity and value of 1989 production dropped about 3% and 6%, respectively, from the totals reported in 1988.

Industrial.—Silica sand was produced by CooSand Corp. from dune sands mined in the north shore of Coos Bay, Coos County. The sand was shipped by rail to a plant in Portland where most 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.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Although 1989 production dropped 17% from what was estimated for 1988, the value of Oregon crushed stone output increased nearly 5%. Reflecting the predominantly volcanic nature of the State's geology, most of Oregon's crushed stone was traprock (basalt), followed in order of quantity produced by limestone, sandstone, volcanic cinder, and granite.

Crushed stone production was reported in 28 of the State's 36 counties. Baker, Benton, Lane, Multnomah, and Washington Counties accounted for 41% of the total; Lane and Washington Counties were the leading producing counties. District 1, representing the northwest part of the State, accounted for 64% of the production.

The State's six leading crushed stone producers accounted for 52% of the quantity and 63% of the total value of reported production in 1989. The top four uses for crushed stone in Oregon during the year were graded road base, unpaved road surfacing, surface-treatment aggregate, and crusher run or fill.

Glenbrook Nickel Co. used crushed quartz from the Quartz Mountain Mine, Douglas County, for use in its nickel smelting operation at Riddle.

Bristol Silica and Limestone Co. produced crushed and screened quartz at its Jackson County quarry for a variety of uses, including poultry grit, sandblasting, and decorative stone. Other limestone production came from Jones Marble quarry, Josephine County, owned by Campman Calcite Co., and the D and D Ag Lime and Rock Co. quarry, Douglas County.

Talc (Soapstone).—Steatite of Southern Oregon Inc. produced high-grade soapstone from deposits on Elliott Creek Ridge in the Klamath Mountains at the southern edge of Jackson County. Production for 1989 decreased in quantity and value from the 1988 totals; however, output still remained 50% and value almost 29% above the 1987 reported levels. The principle product was asbestos-free sculpture stone in a variety of colors, which was marketed worldwide for art carving and other specialty uses.

Zeolite.—Although many Oregon zeolite deposits have been documented, Teague Mineral Products Co. was the only company to mine a natural zeolite product in 1989. Teague mined clinoptilolite from three distinct deposits in the Sucker Creek Formation in Malheur County. Each deposit has unique physical and chemical characteristics. The CH deposit, first mined in 1975, had a reserve estimated to be at least 20 million tons. The clinoptilolite is potassium-rich and is 80% to 85% pure. The primary zeolite mineral of the SC deposit, first mined in 1983, is heulandite. Heulandite has characteristics very similar to clinoptilolite and is primarily used for odor-control purposes. The XY deposit began production in 1987. It has low-bulk density with

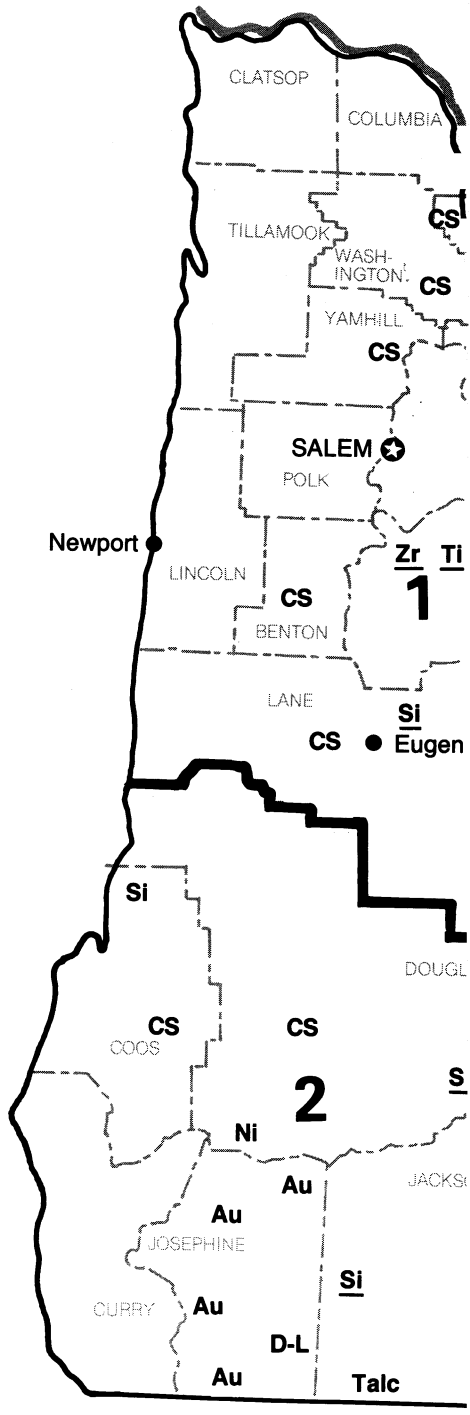
LEGEND

- 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

Principal Mineral-Producing Localities



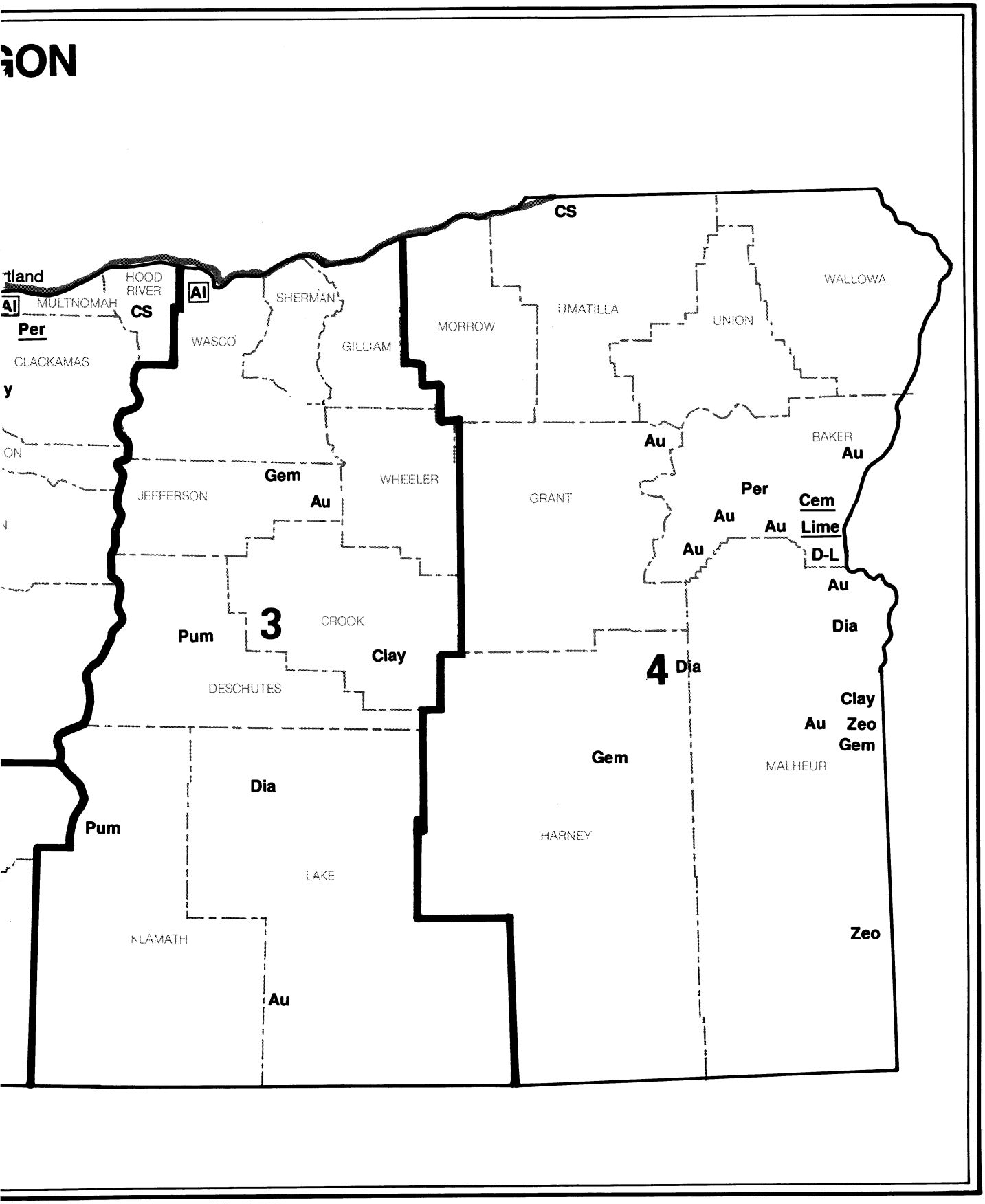

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TABLE 2

OREGON: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	157	278
Riprap and jetty stone	129	389
Filter stone	141	611
Coarse aggregate, graded:		
Concrete aggregate, coarse	55	230
Bituminous aggregate, coarse	548	2,362
Bituminous surface-treatment aggregate	805	3,160
Fine aggregate (-3/8 inch):		
Stone sand, bituminous mix or seal	134	584
Other fine aggregate[2]	100	416
Coarse and fine aggregates:		
Graded road base or subbase	3,732	12,894
Unpaved road surfacing	1,255	5,091
Crusher run or fill or waste	778	3,591
Other construction materials[3]	502	2,456
Other miscellaneous uses[4]	7,713	43,516
Unspecified:[5]		
Actual	2,359	5,625
Total[6]	18,407	81,204

[1]Includes traprock, limestone, sandstone, volcanic cinder and scoria, granite, and miscellaneous stone; dolomite and quartzite withheld to avoid disclosing company proprietary data.
[2]Includes stone used in stone sand (concrete) and fine screenings.
[3]Includes stone used in other coarse aggregate and railroad ballast.
[4]Includes stone used in cement manufacture, asphalt fillers or extenders, and estimates for nonrespondents.
[5]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[6]Data may not add to totals shown because of independent rounding.

excellent absorption qualities. With exceptional purity of more than 95%, the zeolite products were used primarily in value added applications. Ore from all three deposits was processed in Teague's mill near Adrian.

Metals

Aluminum.—Oregon's primary aluminum production increased nearly 9% in quantity, but owing to a significant drop in prices, total value declined by more than 13%.

The State's two aluminum producers—Reynolds Metals Co.'s Troutdale smelter, Multnomah County, and the Northwest Aluminum Co. tolling smelter at The Dalles, Wasco County—operated at near-rated ingot capacity. Reynolds Metals imported alumina from Australia and Jamaica; Northwest Aluminum obtained all its alumina from Australia. Aluminum prices, which averaged $1.10 per pound in 1988, dropped to below $0.88 per pound in 1989.

The Bonneville Power Administration (BPA) took the unusual step of freezing its base power rates for aluminum customers for the next 2 years. The announcement was welcomed by the industry because it made production planning easier from an energy-cost standpoint.

Alcan Aluminum Corp. announced plans to build an aluminum cable plant at Roseburg, Douglas County. The plant reportedly would be completed by 1991 and would manufacture transmission and distribution conductor cable.

Columbium, Hafnium, Tantalum, Titanium, and Zirconium.—TWCA, a major producer of columbium, produced high-quality columbium products 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, an extremely light and strong metal, was used principally in nuclear reactors and in superalloys for the aerospace and defense industries. As a byproduct of zirconium production, TWCA produced hafnium metal as sponge and crystal bar; major markets were for 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) completed the addition of an eighth reduction furnace at its Albany titanium plant in Linn County. The additional furnace, plus the seventh sponge reactor that was installed at the end of 1988, will raise OREMET's titanium sponge capacity to 5,400 tons per year. Titanium ingot also was produced by TWCA. The company continued to concentrate on new product lines, such as shaft tubing for golf clubs.

Gold.—Precious-metal production came mainly from small placer mines in southwestern and northeastern parts of the State. The major precious-metal producer in Oregon was the Bonnanza Mine, a placer gold operation on Pine Creek near Halfway, Baker County. Other small, seasonal lode gold mines included the Pyx Mine in Grant County and the Lower Grandview Mine, Baker County. Areas that had small, seasonal placer gold operations included Greenhorn, Elk Creek, and Pine Creek in Baker County; Canyon City, Galice, Josephine Creek, and Sucker Creek in Josephine County; and Canyon City Placers in Grant County.

Nickel.—The nickel smelter near Riddle, Douglas County, was reactivated by Glenbrook Nickel Co., a joint venture of Cominco American Resources Inc. and USA Investments. The plant was processing the screened low-grade laterite stockpile that was left at the site when Hanna Mining Co. closed the Nickel Mountain Mine and smelter in 1987. Glenbrook has sufficient stockpiled ore to operate for several years. The company was considering the possibility of blending additional ore into the stockpile by either reopening the mine or by obtaining

TABLE 3

OREGON:[1] CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(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 aggregate (+1 1/2 inch)[2]	225	913	201	406	W	W	—	—
Coarse aggregate, graded[3]	1,409	5,944	([4])	([4])	W	W	—	—
Fine aggregate (-3/8 inch)[5]	61	321	([4])	([4])	W	W	—	—
Coarse and fine aggregates[6]	3,733	12,792	1,261	4,398	W	W	W	W
Other construction aggregates	246	1,381	118	537	—	—	—	—
Chemical and metallurgical[7]	—	—	—	—	—	—	W	W
Special[8]	3	70	—	—	—	—	—	—
Unspecified:								
Actual[9]	1,952	5,000	—	—	—	—	407	625
Estimated[10]	1,602	5,469	55	177	472	1,698	—	—
Total[11]	9,230	31,891	1,634	5,518	W	W	W	W

W Withheld to avoid disclosing company proprietary data.
[1]Excludes 4,969,999 short tons valued at $34,787,886 not reported by county.
[2]Includes macadam, riprap and jetty stone, filter stone, and other coarse aggregates.
[3]Includes concrete aggregate (coarse), bituminous aggregate (coarse), bituminous surface-treatment aggregate, railroad ballast, and other graded coarse aggregates.
[4]Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[5]Includes stone sand (concrete), stone sand (bituminous mix or seal), fine aggregate (screening-undesignated), and other fine aggregates.
[6]Includes crushed stone for graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[7]Includes crushed stone for cement manufacture.
[8]Includes crushed stone for asphalt fillers or extenders.
[9]Includes production reported without a breakdown by end use.
[10]Includes estimates for nonrespondents.
[11]Data may not add to totals shown because of independent rounding.

ore from offshore resources, possibly New Caledonia or Indonesia. To reopen the mine, Glenbrook would have to purchase new equipment since all of the original equipment was removed by the former owners.

Silicon Metal, Polycrystalline Silicon, and Ferrosilicon.—Silicon metal was produced by Dow Corning Corp. at its facility in Springfield, Linn County. All of the product was used exclusively for the company's silicon-base chemical operation in Midland, MI. With a single 17.5-megawatt electric furnace, the Springfield plant is capable of producing 10,000 short tons of silicon metal annually. The plant's electric power was supplied by BPA, and all the raw materials are reportedly obtained domestically.

Glenbrook Nickel, purchaser of the former Hanna ferronickel operation at Riddle, Douglas County, began ferrosilicon production; the product was used on-site in the production of ferronickel. The BPA supplied power to the smelter after completing a major part of refurbishing an electrical power substation. Another transformer was due to be installed at the substation before yearend, after which the smelter should be able to produce at full capacity.

Steel.—Cascade Steel Rolling Mills Inc., operators of a minimill in McMinnville, Yamhill County, announced its decision to build a new melt shop. The company chose Italian equipment builder Danieli S.p.A. to construct the steel plant capable of producing more than 600,000 tons per year of steel billet. Reportedly, the increased billet production would correct a raw steel shortfall at the McMinnville plant, allow 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.

Standard Steel Co. of Portland, Multnomah County, was closed and many of its assets sold to a newly formed company, Northwest Steel Processing Inc. According to a newspaper report, the lumber industry was a major customer of Standard Steel, and when that industry experienced a downturn, Standard Steel encountered financial difficulties. Instead of warehousing a variety of steel shapes, a spokesperson for Northwest Steel said it planned to concentrate on "torch-cutting and other made-to-order steel shaping for a variety of manufacturers." Northwest Steel reportedly will retain many of Standard Steel's former employees.

Oregon Steel Mills Inc., a Portland steelplate and pipe producer, was in the process of purchasing and reopening the California Steel Industries' plate mill at Fontana, CA. The Fontana mill would eventually use slab from Oregon Steel's Portland plant. Oregon Steel reported that its output of higher quality plate increased; the company planned to enlarge its large diameter pipe business significantly. Late in the year, trading of Oregon Steel securities began on the New York Stock Exchange.

[1]State Mineral Officer, Bureau of Mines, Spokane, WA. He has covered the mineral activities in Oregon for 2 years. Assistance in the preparation of the chapter was given by W. A. Lyons, editorial assistant.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum:			
Northwest Aluminum Co.	3313 West 2nd 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.[1]	5550 SW. Macadam Ave. Suite 300 Portland, OR 97201	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.
Lime:			
Amalgamated Sugar Co.	Box 1766 Nyssa, OR 97913	Plant	Malheur.
Ash Grove Cement West Inc.	5550 SW. Macadam Ave. Suite 300 Portland, OR 97201	do.	Multnomah.
Perlite (expanded):			
Supreme Perlite Co.	4600 North Suttle Rd. Portland, OR 97217	do.	Do.
Pumice:			
Cascade Pumice Co.	Box 1087 Bend, OR 97701	Pit	Deschutes.
Central Oregon Pumice	5 NW. Greenwood Ave. Bend, OR 97701	Pit	Do.
Stone (crushed):			
Lone Star Industries Inc.	Box 1730 Seattle, WA 98111	Quarry	Washington.
Rogers Construction Co.	Box 730 Umatilla, OR 97882	Quarries	Multnomah and Washington.
U.S. Forest Service	319 SW. Pine St. Portland, OR 97208	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.
Zeolite:			
Teague Mineral Products Co.[2]	Box 35-C, Route 2 Adrian, OR 97901	Surface mine and plant	Malheur.
Zirconium:			
Teledyne Wah Chang Albany[3]	1600 NE. Old Salem Rd. Albany, OR 97321	Plant	Linn.

[1]Also clays, pumicite, and crushed stone.
[2]Also bentonite.
[3]Also columbium, hafnium, tantalum, and vanadium.

THE MINERAL INDUSTRY OF PENNSYLVANIA

This chapter has been prepared under a Memorandum of Understanding between the 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]

In 1989, the value of nonfuel mineral production in Pennsylvania was about $1 billion. Value exceeded 1 billion for the third year in a row. In the decade of the 1980's, Pennsylvania produced nonfuel minerals valued at nearly $8 billion. Crushed stone, the State's leading mineral commodity, accounted for $3.1 billion of that total. During the decade, crushed stone production surpassed that of coal for the first time in State history.

TRENDS AND DEVELOPMENTS

During the 1980's, Pennsylvania's minerals industry shifted from one noted for production of coal and steel to one that became the Nation's top producer of crushed stone. The change occurred primarily because of increased environmental regulations and international competition, which kept the price of coal and steel stagnant and depressed. In contrast, demand by the construction industry for mineral aggregates began to surge in the mid-1980's and continued at high levels through the end of the decade. Mineral aggregates were sold generally within a 50-mile radius of the mine site; thus, prices and competition were most influenced by local and regional conditions. A 10-year, $11.7 billion highway construction and repair program initiated by the State in 1985, along with a major expansion at the airport in the Pittsburgh area, provided a stable market for stone and sand and gravel producers.

This trend was expected to continue in the 1990's, particularly if Federal clean air legislation, proposed in 1989, were enacted. High-sulfur content coal produced in Pennsylvania and steel companies, particularly those with coke facilities, were expected to be adversely affected by the more stringent pollution control requirements included in the proposed legislation.

EMPLOYMENT

In 1989, Pennsylvania employed 28,000 workers in mining and 92,000 workers in primary metals, about the same as the year before.[3]

Compared with figures of 10 years ago, jobs in mining dropped by 46.2% and those in primary metals by 54.9%.

TABLE 1

NONFUEL MINERAL PRODUCTION IN PENNSYLVANIA[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Cement:							
Masonry	thousand short tons	397	$30,464	391	$28,713	349	$26,473
Portland	do.	6,325	334,709	6,309	329,634	5,757	301,980
Clays[2]	metric tons	1,094,176	4,751	1,248,139	5,843	1,049,973	4,936
Gem stones		NA	5	NA	5	NA	5
Lime	thousand short tons	1,574	93,430	1,641	91,214	1,660	92,139
Peat	do.	18	513	21	736	20	746
Sand and gravel (construction)	do.	e14,800	e72,900	19,826	91,966	e19,500	e94,600
Stone:							
Crushed	do.	97,213	458,676	e104,600	e470,700	3 93,123	3 455,004
Dimension	short tons	60,118	10,177	e59,022	e9,584	44,267	10,032
Combined value of clays (kaolin), mica (scrap), sand and gravel (industrial), stone (crushed granite, 1989), and tripoli (1987-88)		XX	10,872	XX	14,098	XX	14,754
Total		XX	1,016,497	XX	1,042,493	XX	1,000,669

e Estimated. 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.

In 1989, employment in the construction industry increased over that of 1988 by 4.3% to 241,000 workers. Construction industry employment in 1989 was about 18% higher than that in 1979.

LEGISLATION AND GOVERNMENT PROGRAMS

Environment-related legislation dominated the 1989 session of the Pennsylvania General Assembly. Bills signed into law included provisions to prevent spills and leaks from aboveground and underground petroleum product storage tanks, protect the Great Lakes from toxic substances, and study ways of sealing underground coal mines to prevent acid mine drainage. Other provisions signed banned laundry detergents with phosphates and created a new program for response to nuclear powerplant emergencies.

Legislation introduced in 1989 and carried over for action in 1990 included bills to fund a $2 million program for plugging abandoned and orphaned oil and gas wells, to create a $5 million Pennsylvania Remining Fund to encourage mine operators to remine and reclaim abandoned mine lands, and to help control ground-level ozone air pollution by setting standards on the evaporation rate of gasoline.

The Pennsylvania Bureau of Topographic and Geologic Survey was the primary State agency involved in mineral-related studies and research. In 1989, the Survey continued work on identifying sources of high-purity carbonates, as well as evaluating the potential use of mica, silica, and talc for mineral fillers. Initiated in 1989 was a feasibility study of the coalbed methane resources in the State. Data were obtained in Armstrong, Cambria, Somerset, and Greene Counties from premining degasification holes and from methane recovery test projects. A summary of these and other Survey projects was published.[4]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

The commodities of cement, lime, construction sand and gravel, and crushed stone again accounted for the vast majority of Pennsylvania's value of nonfuel mineral production. Production of these commodities declined with the exception of lime for which a small increase in output was reported. Despite the decline in 1989, production remained well above the pre-1986 levels and indicated demand from the construction industry, the primary consumer of industrial minerals, had remained strong in 1989.

Cement.—Production of portland cement declined by about 10% in 1989 compared with that of 1988. The State remained the Nation's third leading producer, accounting for 8% of the U.S. output. During the year, Coplay Cement Co. began a $20 million project to increase production capacity by 45% at its Nazareth plant in Northampton County.

Lime.—Pennsylvania ranked third nationally in lime production. Output of 1.6 million short tons was about the same as in 1988.

Corson Lime Co., Montgomery County, was denied permission to build a $3 million enclosed conveyor belt over a 1½-mile stretch of roadway.[5] Corson Lime had planned to convey crushed limestone from its quarry to the lime plant. Whitemarsh Township Planning Commission officials denied Corson's application for a zoning and building permit, calling the plan inconsistent with the fabric of the community.

Another lime producer, Bellefonte Lime Co., Centre County, sought permission to open a limestone quarry on a 50-acre site in Benner Township. In 1989, Bellefonte produced lime from limestone mined at a quarry in Pleasant Gap. Permission for the new quarry was sought because only an estimated 3 years of limestone reserves remain at the Pleasant Gap site. At yearend, the proposal remained pending before the local planning commission.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Estimated production of construction sand and gravel of about 19.5 million short tons was about the same as that reported in 1988.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Pennsylvania stone statistics are compiled by geographical districts as depicted in the State map. Table 4 presents end-use statistics for Pennsylvania's four districts.

TABLE 2

PENNSYLVANIA: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1988		1989	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Agriculture	17,876	$1,010	16,530	$1,109
Acid water neutrilization	80,534	4,595	56,704	2,706
Paper and pulp	31,025	1,483	26,371	1,230
Steel:				
Basic oxygen	490,873	24,555	450,862	22,737
Electric	213,556	10,152	220,397	10,813
Sewage treatment	74,348	4,284	109,852	4,109
Water purification	33,338	r1,853	54,657	2,562
Other[1]	699,588	r43,282	724,863	46,873
Total	1,641,138	91,214	1,660,236	92,139

r Revised.

[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.

Crushed.—In 1989, production of crushed stone accounted for approximately one-half of Pennsylvania's value of nonfuel mineral production. In 1980, stone had accounted for only about one-third of the State's value. Crushed stone output for the decade totaled 700 million short tons valued at about $3.1 billion.

Crushed stone production in Pennsylvania surged from the 50- to 60-million-ton level during the 1980–86 period to an average of about 98 million tons per year from 1987 through 1989. That surge in output reflected increasing highway construction and continuing economic development in Pennsylvania and its bordering States. It also illustrated the need for mineral aggregates as a basic requirement during periods of economic growth. Crushed stone produced in Pennsylvania, particularly from the southeastern part of the State, was used extensively in adjacent States. In 1989, about 8 tons of stone was produced for each person in Pennsylvania compared with the national average ratio of 5 tons per person. For the six States bordering Pennsylvania, the ratio was about 4 tons per person.

In 1989, 104 companies operated 206 quarries producing 93 million tons of crushed stone. The top 10 producing companies operated 71 quarries and accounted for 48% of the total output. Limestone was the major rock type mined; other types included dolomite, sandstone, and traprock.

Production from district 4 in southeastern Pennsylvania accounted for about 72% of the State total. The expanding economy in this district, which included Philadelphia and Harrisburg, created strong demand for construction aggregate. Of the 19 counties in district 4, a total of 14 reported production in excess of 1 million tons with 6 producing more than 6 million tons.

In a major transaction during the year, Broyhill & Associates Inc. sold limestone quarries in Adams and Lebanon Counties to Wimpey Minerals PA Inc., a subsidiary of George Wimpey PLC of the United Kingdom.

Other Industrial Minerals.—The mineral commodities discussed following accounted for about $60 million of Pennsylvania's nonfuel mineral production value as given in table 1.

TABLE 3

PENNSYLVANIA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	305	$1,158
Riprap and jetty stone	803	4,487
Filter stone	662	3,086
Other coarse aggregate	W	W
Coarse aggregate, graded:		
Concrete aggregate, coarse	5,323	24,763
Bituminous aggregate, coarse	6,299	26,505
Bituminous surface-treatment aggregate	2,702	13,692
Railroad ballast	971	4,458
Other graded coarse agggregate	W	W
Fine aggregate (−3/8 inch):		
Stone sand, concrete	1,272	6,112
Stone sand, bituminous mix or seal	3,758	15,207
Screening, undesignated	1,670	7,196
Other fine aggregate	W	W
Coarse and fine aggregates:		
Graded road base or subbase	12,683	52,156
Unpaved road surfacing	1,336	6,015
Crusher run or fill or waste	1,443	5,670
Other coarse and fine aggregates		
Other construction materials[2]	1,583	7,311
Agricultural:		
Agricultural limestone	1,005	8,694
Poultry grit and mineral food	121	1,654
Other agricultural uses	W	W
Chemical and metallurgical:		
Cement manufacture	8,594	40,228
Lime manufacture	1,443	6,963
Dead-burned dolomite manufacture	W	W
Flux stone	91	516
Glass manufacture	W	W
Sulfur oxide removal	57	625
Special:		
Mine dusting or acid water treatment	96	1,365
Asphalt fillers or extenders	279	2,716
Whiting or whiting substitute	W	W
Other fillers or extenders	272	4,369
Roofing granules	W	W
Other miscellaneous uses:[3]		
Waste material	W	W
Other uses not listed	1,561	12,744
Unspecified:[4]		
Actual	30,938	159,716
Estimated	7,857	37,597
Total	93,124	[5]455,003

[1] Includes dolomite, limestone, sandstone, traprock, and miscellaneous stone; granite withheld to avoid disclosing company proprietary data.
[2] Includes stone used in coarse aggregates-graded and large and fine aggregates.
[3] Includes stone used in dead-burned dolomite, whiting or whiting substitute, roofing granules, drain fields, glass manufacture, and waste material.
[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.

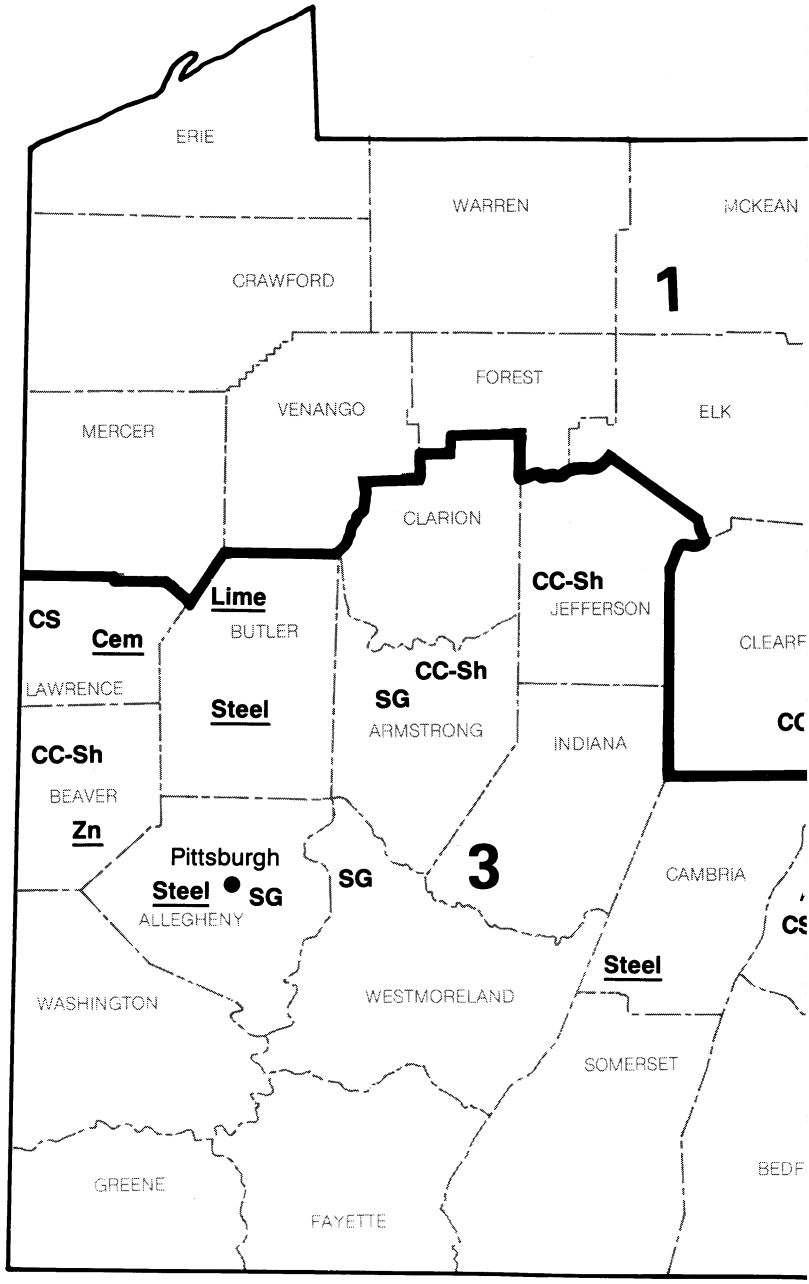
PENNS

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

MINERAL SYMBOLS

CC-Sh	Common Clay & Shale
Cem	Cement plant
CS	Crushed Stone
D-G	Dimension Granite
D-S	Dimension Sandstone
D-SL	Dimension Slate
IS	Industrial Sand
Lime	Lime plant
Mica	Mica
Peat	Peat
SG	Sand and Gravel
Steel	Iron and Steel plant
Zn	Zinc plant

Concentration of mineral operations



Principal Mineral-Producing Localities

VANIA

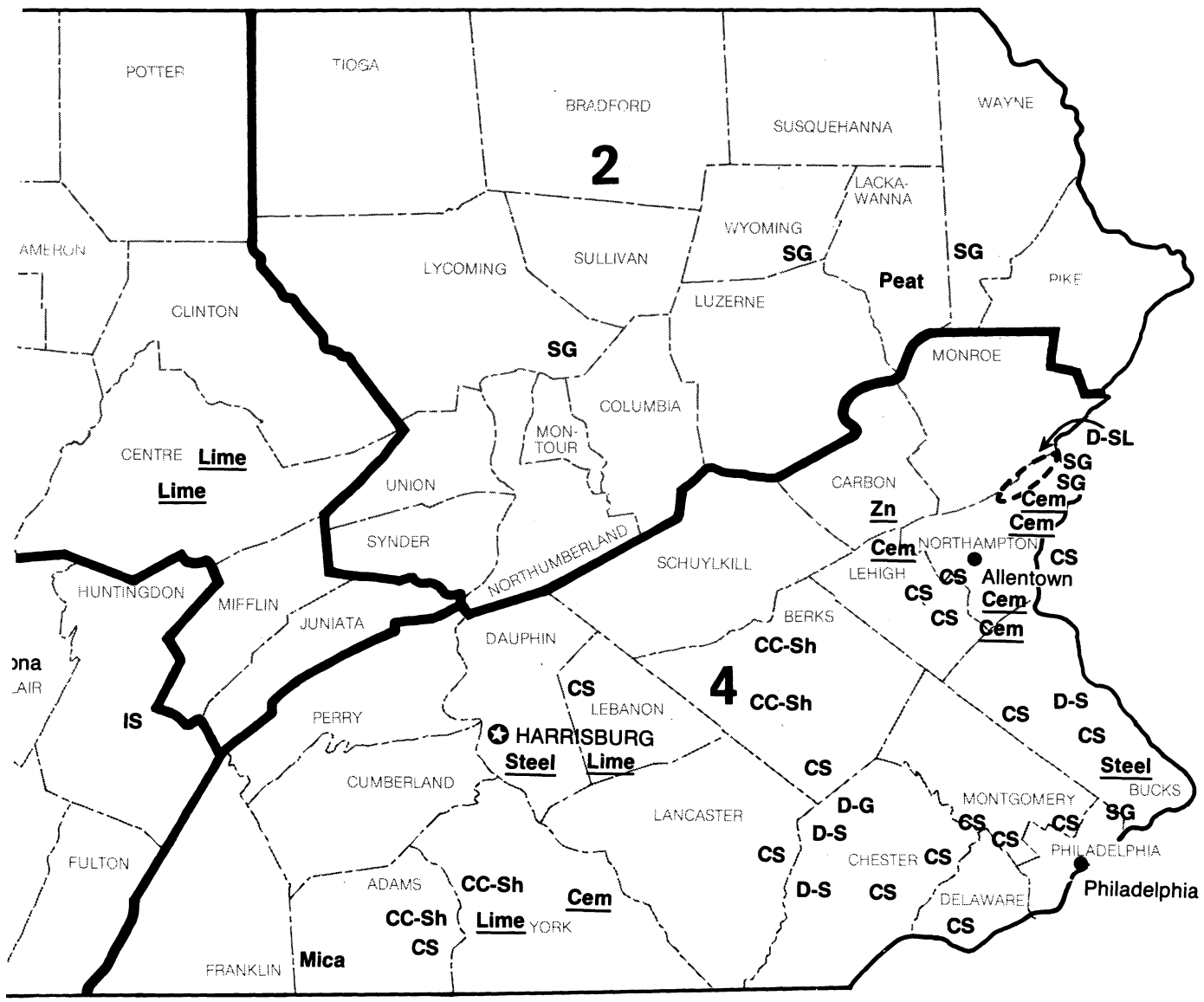

POTTER
TIOGA
BRADFORD
2
SUSQUEHANNA
WAYNE
LACKA-
WANNA
WYOMING
SG
SG
Peat
SG
PIKE
AMERON
LYCOMING
SULLIVAN
LUZERNE
CLINTON
SG
MONROE
COLUMBIA
MON-
TOUR
D-SL
SG
SG
Cem
Cem
CENTRE Lime
Lime
UNION
CARBON
Zn
SYNDER
NORTHUMBERLAND
SCHUYLKILL
Cem
NORTHAMPTON
CS
LEHIGH
CS
Allentown
CS
Cem
CS
Cem
HUNTINGDON
MIFFLIN
JUNIATA
DAUPHIN
BERKS
CC-Sh
4
CC-Sh
CS
LEBANON
CS
D-S
IS
PERRY
HARRISBURG
Steel
Lime
CS
CS
Steel
CUMBERLAND
BUCKS
D-G
MONTGOMERY
LANCASTER
CS
CS
SG
D-S
CS
CS
CS
PHILADELPHIA
FULTON
CHESTER
CS
ADAMS
CC-Sh
Cem
D-S
CS
DELAWARE
Philadelphia
CC-Sh
Lime
YORK
CS
CS
FRANKLIN
Mica

TABLE 4

PENNSYLVANIA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3		District 4	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Coarse aggregates:								
Coarse aggregate (+1 1/2 inch)[1]	302	$1,150	89	$391	536	$3,489	1,092	$4,951
Coarse aggregate, graded[2]	918	2,674	645	2,782	3,215	17,828	10,607	46,544
Fine aggregate (−3/8 inch)[3]	640	1,644	364	1,486	1,295	6,025	4,439	19,531
Coarse and fine aggregates[4]	936	2,867	1,091	4,274	2,467	11,905	11,079	45,346
Other construction aggregates	—	—	44	217	375	1,534	1,164	5,559
Agricultural[5]	W	W	W	W	57	676	1,062	9,575
Chemical and metallurgical[6]	W	W	W	W	2,399	14,914	6,857	31,419
Special[7]	W	W	W	W	123	1,430	918	10,353
Other miscellaneous	1,465	7,658	113	1,249	—	—	34	217
Unspecified:								
Actual[8]	318	1,382	1,755	8,291	3,660	17,115	25,204	132,928
Estimated[9]	168	1,067	552	2,483	2,375	12,024	4,761	22,023
Total[10]	4,748	18,442	4,653	21,174	16,502	86,941	67,219	328,447

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."

[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 graded coarse aggregates.

[3] Includes stone sand (concrete), stone sand (bituminous mix or seal), and fine aggregate (screening-undesignated).

[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, crusher run or fill or waste, and drain fields.

[5] Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.

[6] Includes crushed stone for cement manufacture, lime manufacture, dead-burned dolomite, flux stone, glass manufacture, and sulfur oxide removal.

[7] Includes crushed stone for asphalt fillers or extenders, whiting or whiting substitutes, other fillers or extenders, waste material, mining dusting and acid water treatment, and roofing granules.

[8] Includes production reported without a breakdown by end use.

[9] Includes estimates for nonrespondents.

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

Pennsylvania ranked third nationally in output of masonry cement. In 1989, production was reported from 10 operations. One plant at Nazareth was inactive. More than 1 million metric tons of common and fine clays was produced in Pennsylvania from 34 pits. It should be noted that the Bureau of Mines began reporting clay statistics in metric tons in 1989. Output of kaolin, which more than tripled in 1988 from that in 1987, declined by a similar margin in 1989. Scrap mica used as a filler, primarily by the automotive industry, was mined by one company in Fairfield, Adams County. Most of the peat mined in Pennsylvania came from a three-county area in the northeastern part of the State.

Industrial sand was produced by one company in Huntingdon County. No production was reported from a small sand mining operation in Allegheny County that had been active in 1988. Pennsylvania ranked first in the United States in production of slate, a dimension stone used as roofing material, blackboards, and in pool tables. Other types of dimension stone quarried in the State included bluestone, diabase, quartzite, and sandstone. A small quantity of tripoli, or rottenstone, was processed in Northumberland County and sold as filler and for use in polishing compounds.

Mineral commodities processed in Pennsylvania included those that were imported, shipped from domestic sources outside the State, or manufactured into higher value end products. Commodities surveyed by the Bureau of Mines were synthetic graphite, iodine, iron oxide materials, expanded perlite, sulfur (recovered), sulfuric acid, and exfoliated vermiculite. The combined valued of these commodities was about $85 million.

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.

Iron and Steel.—Steel production declined to about 11.9 million short tons, according to data published in the Pennsylvania Business Survey by The Pennsylvania State University.

Pig iron shipments were no longer reported to the Bureau of Mines beginning in 1988 because several of the Nation's major producers declined to respond to the Bureau survey. However, 6 years of data on steel production and pig iron shipments showed Pennsylvania produced steel at about a 2:1 ratio to pig iron. Based on that ratio, pig iron shipments in 1989 were estimated at 6 million tons, a decrease of 0.9 million tons compared with the 1988 total.

Pennsylvania's and the Nation's leading steel producer, USX Corp., began two major projects during the year. In September, USX broke ground at its Edgar Thomson Works for a $250 million modernization program. The firm planned to install a continuous caster capable of producing 2.6 million short tons of steel annually. Installation of the caster was part of a contract agreement with the United Steelworkers Union settled in 1987 after a 6-month strike. USX also began a 3-year, $89 million project

to upgrade environmental controls at its coke works in Clairton. About 4.5 million short tons of coke was produced at Clairton and sold to steelmaking operations in Michigan, Ohio, Pennsylvania, and West Virginia.[6]

Zinc.—Zinc Corp. of America (ZCA) operated a primary zinc refinery at Monaca, PA. ZCA was also involved in production of secondary zinc at a plant in Palmerton operated by Horsehead Resource Development Co. (HRD). HRD recovered cadmium, lead, and zinc from steelmaking waste dust generated in electric arc furnaces.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in Pennsylvania for 8 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 Admin., The Pennsylvania State Univ., University Park, PA, Feb. 1990, p. 4.

[4] Pennsylvania Geology. Bureau of Topographic and Geologic Survey. V. 20, No. 4, July 1989, 32 pp.

[5] Montgomery County Observer (Center Square, PA). Whitemarsh Denies Corson Proposal. Aug. 2, 1989, p. 2.

[6] Pittsburgh (PA) Post-Gazette. More Cash For Coke-Oven Controls. Dec. 15, 1989, pp. 21-22.

TABLE 5

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
Allentown Portland Cement Co.	Box 199 Blandon, PA 19510	Plant and quarry	Berks.
Coplay Cement Co.	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.	Wood and Prospect St. Box 270 Nazareth, PA 18064	Plant	Do.
Clays and shale:			
L. D. Baumgardner Coal Co. Inc.	Box 104, R.D. 3 Phillipsburg, PA 16866	Pit	Clearfield.
Glen-Gery Corp.	Box 1542 Reading, PA 19603	Pits and plant	Adams, Berks, York.
Medusa Corp.	Box 5668 Cleveland, OH 44101	Pit	Lawrence.
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	Do.
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 Pl. Pittsburgh, PA 15219	Plant	Butler.
Peat:			
Hyponex Corp.	2013 South Anthony Blvd. Fort Wayne, IN 46803	Bog and plant	Monroe.
Lake Benton Peat Moss Co. Inc.	R.D. 1 Dalton, PA 18414	Bog	Lackawanna.

See footnote at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Construction:			
Davison Sand & Gravel Co.	3d Ave. and 4th St. New Kensington, PA 15068	Dredge and pits	Armstrong and Westmoreland.
Dravo Corp.	4800 Grand Ave. Pittsburgh, PA 15222	Dredge, pit, plant	Allegheny and Beaver.
Glacial Sand & Gravel Co.	Box 1022 Kittanning, PA 16201	do.	Armstrong.
Stabler Co. Inc.[1]	Box 3188 Wescoville, PA 18106	Pits and plants	Bradford and Northampton.
Warner Co.	699 Bristol Pike Morrisville, PA 19067	Pit and plant	Bucks.
Wyoming Sand & Stone Co.	R.D. 1 Falls, PA 18615	do.	Wyoming.
Industrial:			
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	Quarries and plant	Huntingdon.
Stone:			
Crushed:			
Beazer Materials & Service Inc.	436 7th Ave. Easton, PA 18042	do.	Centre, Chester, Clinton, Columbia, Delaware, Lycoming, Monroe, Montour, Tioga, York.
Eureka Stone Quarry Inc.	Lower State and Pickerton Sts. Chalfont, PA 18914	do.	Bucks, Lackawanna, Monroe, Pike.
Glasgow Inc.	Box 248 Glenside, PA 19038	do.	Chester and Montgomery.
New Enterprise Stone & Lime Co. Inc.	R.D. 3 New Enterprise, PA 16664	do.	Adams, Bedford, Blair, Centre, Cumberland, Franklin, Huntingdon, Lancaster, Somerset.
Stabler Co. Inc.	R.D. #3, Box 150 Center Valley, PA 18034	do.	Berks, Carbon, Lancaster, Lehigh, Monroe, Northampton, Susquehanna.
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.

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 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

The value of nonfuel mineral commodities produced in Puerto Rico in 1989 (excluding construction sand and gravel) decreased slightly from that of 1988, from $167 million to $163.7 million. Overall, Puerto Rico ranked ahead of 12 of the 50 States in the value of minerals produced. Over 90% of the minerals produced in Puerto Rico were used locally by the construction industry. After starting slowly in 1989, the construction industry recovered in the second quarter but suffered a setback in September when Hurricane Hugo devastated much of the island. Construction was brought to a virtual stop for over 2 weeks due to power outages caused by the storm. However, the construction industry recovered very strongly in the last quarter of 1989 because structures damaged by the storm were repaired or rebuilt.

Trends and Developments

The slow start of the construction industry in 1989 was blamed on two factors. First, a plebiscite to determine whether Puerto Rico would remain a Commonwealth, become a State, or gain total independence was expected in 1992. As a Commonwealth, businesses in Puerto Rico receive considerable tax benefits. Foremost of these was not having to pay Federal income tax on profits earned in Puerto Rico. Not knowing whether these benefits would continue after the plebiscite, industry was hesitant to invest capital in new business or plant improvements. Second, the Government was accused[3] by construction industry representatives of a slowdown in approving pending construction projects and in putting out bids for the projects.

As a result of Hurricane Hugo, however, a sudden availability of money through emergency loans and credit extensions caused a miniboom in the construction and minerals industries. The Federal Government made available to Puerto Rico $448 million from a $1.1 billion appropriation to provide relief to victims of the hurricane. The Federal Emergency Management Agency was to make the money available to 56 towns that were declared disaster areas. Banco Popular de Puerto Rico, the island's largest bank, estimated[4] that businesses suffered $1.4 billion in losses from operations halted by the storm. Damage to factory buildings and equipment was placed at $400 million and losses in agriculture at $150 million.

Cement, which accounted for nearly 70% of Puerto Rico's reported mineral production, decreased by only 23,000 short tons after reaching record production levels in the 3 months following the storm. Commencement of construction of 5,000 new concrete homes for victims of Hugo accounted for much of the increased production in the final quarter. Analysts estimated[5] that 13,000 new concrete homes were needed for families left homeless by Hurricane Hugo. The largest manufacturer of prefabricated concrete homes in Puerto Rico predicted that its sales would more than double in 1990.

During the 1980's, Puerto Rico's mineral production fell from a record high of $212 million in 1980 to $113 million in 1983, then rose steadily through 1988 to reach a high of $167 million before dropping slightly to $164 million at the end of 1989.

TABLE 1

NONFUEL MINERAL PRODUCTION IN PUERTO RICO[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	1,296	$106,185	1,397	$113,966	1,374	$112,318
Clays	metric tons	134,290	318	148,218	365	136,873	311
Lime	thousand short tons	25	3,558	25	3,802	26	3,800
Salt	do.	40	900	40	900	—	—
Sand and gravel (industrial)	do.	67	W	31	624	30	600
Stone (crushed)	do.	8,480	41,299	e9,350	e47,400	8,389	46,648
Total[2]		XX	152,260	XX	167,057	XX	163,677

e Estimated. 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.

The decade of the 1980's was one of growing environmental awareness in the community and of stricter enforcement of laws protecting the environment by Federal and local agencies. The major environmental problems affecting Puerto Rico during 1989 were the pollution of drinking water supplies and the disposal of solid and hazardous waste. The Federal Environmental Protection Agency (EPA) reported[6] that 80% of drinking water supplies in remote areas were not within Federal standards. The Puerto Rico Aqueduct and Sewer Administration (PRASA) announced that it would spend $1.3 billion in the 4 fiscal years ending June 30, 1993, to convert to a regional sewage treatment system. This system would replace dozens of outdated, overburdened treatment plants with fewer larger plants.

In 1989, only 6 of 62 nontoxic landfills operated within Puerto Rico Environmental Quality Board (EQB) standards. The island generated over 200,000 tons of hazardous waste in 1989, but has only three commercial hazardous waste facilities. The only one of these capable of handling solid waste was under an EPA mandate that allows it to keep hazardous waste at the site for a maximum of 90 days. Until the leachate collection system is approved by the EPA, all solid hazardous waste shipped to this site for temporary storage must be shipped to approved disposal sites in Louisiana, Texas, or South Carolina for permanent disposal.

New operations or plant expansions announced or commenced in Puerto Rico in 1989 include conversions of both of the island's cement plants from wet to dry processing and the construction of a plant to process filler-grade calcium carbonate and cosmetic talc by a group of local and Venezuelan businessmen. Bayamon Steel Processors Inc. began producing stainless sheet steel during August 1989. E.I. du Pont de Nemours Co. Inc. announced that it was planning to spend $50 million expanding its facilities in Manati and Aguadilla over the next 3 years.

Employment

Puerto Rico's employment in the construction industry increased by 2,000 in 1989 to 53,000. In 1989, according to Mine Safety and Health Administration (MSHA) statistics, 1,961 people were employed in the minerals industry by 111 companies at 115 locations.

Regulatory Issues

During 1989, regulatory issues in Puerto Rico were concerned almost entirely with problems related to water pollution, solid waste disposal, and hazardous waste disposal.

Since 1985, industry growth has been hampered by a ban on new hookups to many of the island's wastewater plants. The original 1985 EPA order banned new hookups to 88 of PRASA's 106 water-treatment plants. At the end of 1989, only 14 plants remained arrested, a term signifying that new hookups could not be made. An EPA monitor's report issued earlier in the year indicated that PRASA expected to have two new and six improved water-treatment plants functioning by the end of 1989.

Only 14 of 62 solid waste disposal sites were in conformance with EPA regulations at the end of 1989. Under new regulations that have to be complied with by 1992, none of the sites would be in compliance. It has been estimated[7] that at least $1 billion would have to be spent to upgrade and construct new solid waste disposal facilities.

Solid waste sites containing hazardous waste found throughout the island were a major concern because of the threat they posed to ground water supplies. The EQB has forced the responsible parties to clean up the hazards occurring on many of these sites. The cleanup has been both time consuming and costly. The Upjohn Co. has spent about $13 million since 1983 to clean up its spill site at Barceloneta. On August 14, the municipality of Barceloneta notified businesses that the private sector could no longer use the town's landfill. The landfill was one of six local municipality landfills on EPA's Superfund Priority List. In all, 17 Puerto Rican landfills were on the Superfund list.

A study conducted by the Puerto Rico Manufacturers Association showed that, by 1993, 112,000 metric tons of hazardous waste will be generated annually on the island, compared with 50,000 tons generated in 1987. The EPA disputed these figures because they did not include recycled waste or waste disposed of locally. The EPA estimated that 200,000 tons of hazardous waste was being produced each year.

Many of Puerto Rico's liquid hazardous wastes were being recycled or incinerated. Contaminated fluids and nonrecyclable residues were converted into organic fuel at Safety-Kleen's Manati plant. The fuel was then transported to the San Juan Cement Co. Inc. (SJC) where it was combined with coal and burned to supply energy for the kilns. The organic fuel supplied the same energy value as coal but at a much lower cost. Hazardous waste contained in the fuel was reported to burn at a much higher temperature, 2,600°F. versus 1,800°F., and stay in the hottest region for a longer time in the cement kilns than in commercial incinerators. About 60% of Safety-Kleen's waste was burned at the SJC facility. Wastes Safety-Kleen could not handle were shipped to incinerators in Texas or Louisiana or to a secured landfill in South Carolina.

By the end of 1989, Eli Lilly had spent over $2 million upgrading hazardous waste incinerators installed in 1972 for $1.2 million. Lilly operated the facility at its Mayaguez plant at a rate of 4.5 gallons per minute. A second incinerator designed to handle a specific type of waste was installed at the plant in 1989 at a cost of $500,000.

Hazcon Caribbean Inc. announced that it had introduced into Puerto Rico a process that solidifies hazardous waste and converts it into inert material. The process developed by Hazcon's parent company in Katy, TX, had been approved by the EPA. The solidification process takes 24 hours and costs $90 to $200 per ton depending upon the toxicity of the original material. Before-and-after tests run on wastes containing toxic materials such as oil, mercury, and zinc showed that toxicity levels had been lowered below EPA specifications or essentially eliminated.

In other regulatory matters, the U.S. Court of Appeals denied the request of Puerto Rican Cement Co. Inc. (PRC) for an exemption from significant deterioration regulations under the Clean Air Act. PRC had appealed an EPA ruling that the new kiln it planned to install had to adhere to current air quality regulations even though the new kiln was expected to emit less pollution than the two kilns it would replace.

The U.S. Commerce Department made a preliminary determination that Venezuelan aluminum sulfate was being sold in Puerto Rico at below fair market value. Antidumping duties would be imposed to offset the unfair price if the

agency's final determination found that the company, Sulfatos del Orinoco S.A., was guilty. The investigation began as a result of a petition filed by General Chemical de Puerto Rico, whose parent company was forced to close the Puerto Rican plant because of the extremely low prices.

Exploration Activities

A Memorandum of Understanding (MOU) was drawn between Cominco American Resources Inc. and the retiring Secretary of Natural Resources after yearlong negotiations with the Commonwealth's Advisory Committee on Mining. Cominco felt it would be prudent to establish some economic conditions before investing in a costly subsurface drilling program that could lead to the discovery of minable gold deposits. Puerto Rico mining law allows prospecting permit holders to negotiate the terms and conditions of a possible subsequent lease at this early stage. However, the Secretary of Natural Resources can add terms and conditions that he may deem necessary at the time a lease is granted.

In deference to the incoming new Secretary of Natural Resources, the MOU was not signed but presented for approval. At this time, the document was made public and subsequently became a political issue. Political opposition that regarded terms of the MOU unfavorable to the Commonwealth has delayed exploration.

On August 23, 1989, the Puerto Rico Electric Power Authority spudded the first exploratory borehole for oil and gas since 1960. Named the Toa Baja No. 1, it was in the North Coast Basin some 10 kilometers west of San Juan. The hole was logged to 8,812 feet when it was plugged and abandoned on November 7 without any encouraging signs. No further exploratory holes were drilled.

Legislation and Government Programs

The EPA awarded $12,303,136 to the Commonwealth of Puerto Rico to underwrite a State Revolving Fund, created by the Commonwealth Act 44 of 1988 to finance construction of wastewater treatment facilities. The Puerto Rico Infrastructure Financing Authority was the recipient of the money and would administer the fund. PRASA would be the recipient of the initial round of low-interest loans for water-control projects. Upgrading the water-treatment facilities should have a positive effect on construction and related mineral industries by easing the ban on new water hookups.

The United States Geological Survey (USGS) continued work to evaluate the island's ground water supply and to update Puerto Rico's geologic map. The USGS had located 120 mineral occurrences on the island, and it planned to publish a mineral resource assessment of the island in 1990.

The Commonwealth government and the city of San Juan approved the construction of a waste-to-energy plant to be built in suburban San Juan. The $85 million plant would burn 1,040 tons of municipal garbage per day, providing electricity for 18,000 homes while relieving congestion on San Juan's overused landfills. The facility, to be built by Westinghouse Corp., was scheduled for completion by 1991. However, as of yearend 1989, neither the Puerto Rico Planning Board nor the Permits and Regulations Agency had granted construction permits.

Safety-Kleen, the only company offering commercial incinerating services, applied for a permit to expand its facilities.

Construction executives expressed strong disapproval of new, more stringent nonhazardous solid waste regulations. Puerto Rico, along with mainland States, will have 18 months beginning on January 1, 1990, to bring regulations on solid waste in compliance with the EPA. After the 18 months, the public and private sectors will be allowed 5 years to conform to the new regulations. It was estimated that Puerto Rico will need at least $1 billion to meet the regulations. Puerto Rico's tentative plan called for the rehabilitation of 43 landfills to extend their lifespan for an additional 5 to 10 years. By 1991, plans were to begin the construction of 10 regional landfills and various incinerators. Business leaders were not convinced this could be accomplished within established deadlines.

Review by Nonfuel Mineral Commodities

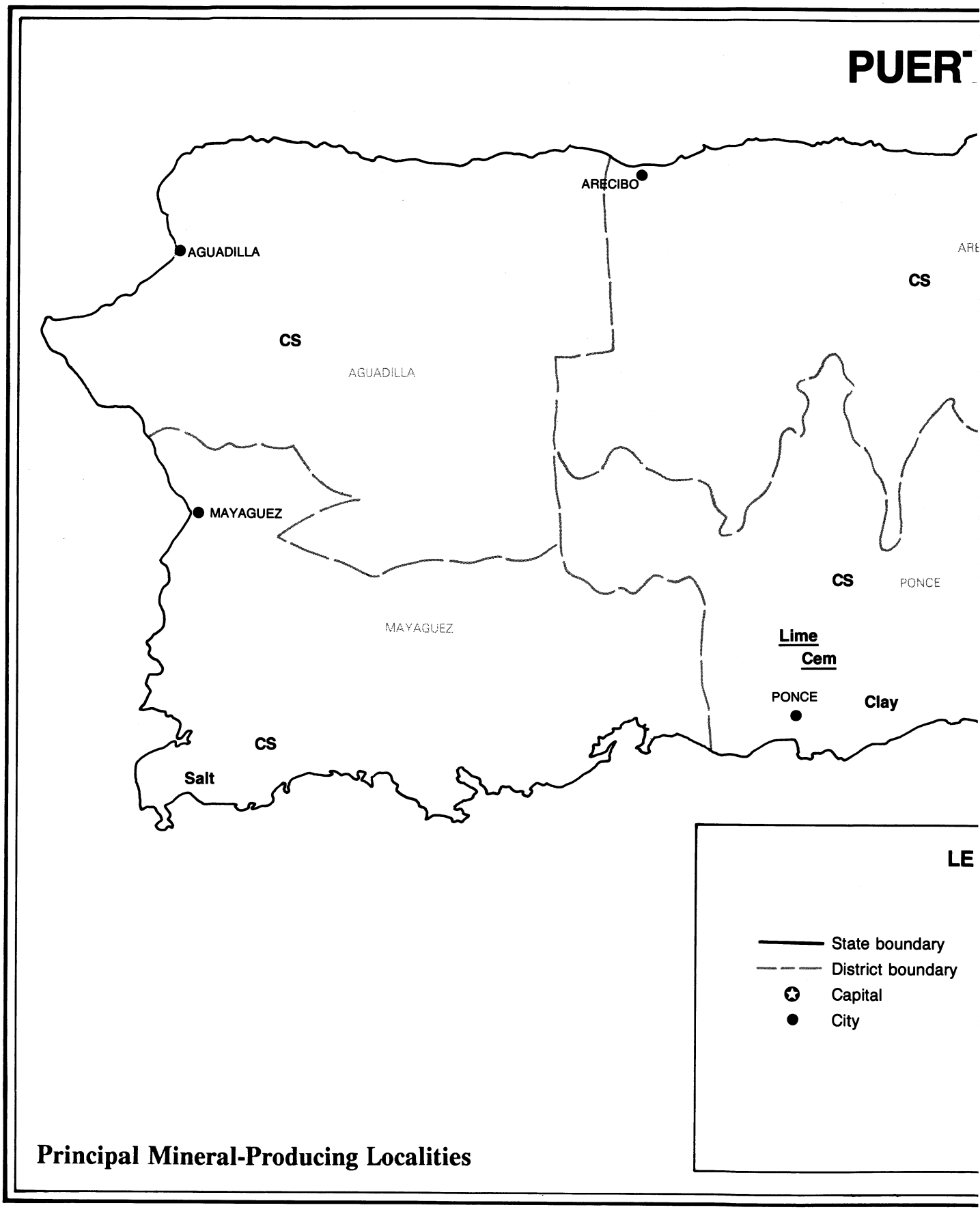
Industrial Minerals.—All of Puerto Rico's reported mineral production was derived from industrial minerals. Cement accounted for 68.6% of the total value of minerals produced, excluding construction sand and gravel. Seven other industrial minerals were reported to have been mined or produced in 1989.

Cement.—Puerto Rico did not export cement in 1989, and imported cement accounted for only 2.37% of the total domestic sales. Cement sales were distributed as follows: 46.8% to ready-mix concrete, 44.2% to building material dealers, 3.6% to highway contractors, and 2.3% to other contractors and government agencies. All of the cement produced was hydraulic portland cement.

Puerto Rico's largest cement company, PRC, was 1 of only 11 publicly traded companies operating in Puerto Rico. In April, PRC's board of directors voted unanimously to recommend amendments to the company's certificate of incorporation to their stockholders. The amendments were designed to discourage hostile takeover of the firm.

PRC began a $30 million conversion of its Ponce plant from wet to dry processing in 1989. The project was financed by a $10 million loan from Puerto Rico's largest bank, Banco Popular de Puerto Rico, and a $20 million financing package from various mainland insurance companies. The conversion would increase the manufacturing capacity of the plant's No. 6 kiln from 600,000 tons per year to 1 million tons per year. The company's engineering department designed and supervised the project. The conversion, which was expected to take 2 years to complete, created 400 construction jobs. PRC reported that sales during the fourth quarter of 1989 increased 7.64% over the same period in 1988. Despite the increase in sales, PRC's profit for the period decreased from $445 million in 1988 to $299 million in 1989.[8]

Puerto Rico's other cement company, San Juan Cement Co. Inc., also began conversion of its Dorado plant from a wet to a dry process. The plant was scheduled to go on-line in 1990 with a clinker output of 2,000 tons per day. Included in the conversion were a 680-ton-per-hour crushing plant, a roller mill with an integrated high-efficiency



Principal Mineral-Producing Localities

· RICO

ND

MINERAL SYMBOLS

Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Lime	Lime plant
Salt	Salt
St	Stone

separator, two homogenizing silos, a preheater, a calcining kiln, and a reciprocating grate cooler.

Clays.—Clay was mined for the production of brick and tile and for internal use by the Commonwealth's two cement companies. The bulk of the clay was mined by the cement companies; consequently, clay production was directly related to the production of cement clinker and showed a decline in volume from that of 1988.

Graphite (Synthetic).—Union Carbide operated its synthetic graphite plant at Yabucoa at reduced capacity during 1989. Speculation continued that the plant would be permanently closed because of economic conditions.

The plant, which had been larger than any on the U.S. mainland, used petroleum coke and pitch as raw material. These were mixed, extruded, and shaped into green forms, which were carbonized to drive off volatiles, and then graphitized to produce electrodes.

Sand and Gravel.—Because of very poor response to its questionnaires, the Bureau of Mines no longer compiles production data for construction sand and gravel mined in Puerto Rico.

Construction.—MSHA listed 57 construction sand and gravel operations in its statistical summary of mining operations inspected during the fourth quarter of 1989. Eight of these were shown as permanently closed, and five operated on an intermittent basis in 1989.

Industrial.—Industrial sand was produced by Owens-Illinois Inc. at its Vega Baja sand plant west of San Juan. The sand was used to produce bottles, some of which were exported to the mainland. The bottle manufacturing plant was in a 300,000-square-foot facility and employed 350 people.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Crushed stone, predominantly limestone, accounted for slightly more than 28.5% of the value of mineral production, excluding construction sand and gravel, in 1989. According to MSHA reports, 55 crushed stone operations owned by 50 companies were inspected in 1989. Two of the sites were operating on an intermittent basis, and one was shown as permanently closed. Forty-six companies operating 48 quarries returned surveys to the Bureau of Mines. Limestone was produced at 36 quarries, marble at 4, traprock at 3, granite and sandstone at 1 each, and the rock type was not specified for the 3 other quarries. Major uses of crushed stone included cement manufacturing, fine aggregate, and concrete aggregate, each of which accounted for over 1 million tons in 1989. Other major uses, each accounting for over 100,000 tons, included bituminous stone sand, concrete stone sand, graded road base, and abrasives.

Dimension.—Although no dimension stone production was reported to the Bureau of Mines, MSHA listed three dimension stone operations in 1989, one of which was shown as permanently closed.

Damage caused by Hurricane Hugo resulted in the increased use of rubblestone and riprap by the U.S. Army Corps of Engineers to repair breakwaters and jetties.

Other Industrial Minerals.—Puerto Rico Calcite Co., formed by a group of local and Venezuelan investors, announced plans to build a plant to process filler-grade calcium carbonate and cosmetic talc in Guanica. The group raised $6 million to finance construction of the plant. Work was scheduled to begin in December and be completed by June 1990. Plans called for the plant to have an annual capacity of 25,000 tons of calcium carbonate and 15,000 tons of talc. Company officials planned to import ore from the Dominican Republic because of the scarcity of high-brightness limestone or marble on the island. The domestic market was considered adequate to consume the bulk

TABLE 2

PUERTO RICO: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate, graded:		
Concrete aggregate, coarse	1,018	6,547
Bituminous aggregate, coarse	89	498
Bituminous surface-treatment aggregate	34	149
Fine aggregate (−3/8 inch):		
Stone sand, concrete	214	1,745
Stone sand, bituminous mix or seal	516	3,806
Coarse and fine aggregates:		
Graded road base or subbase	212	988
Terrazzo and exposed aggregate	36	267
Other construction materials[2]	1,885	10,200
Agricultural: Agricultural limestone	17	156
Chemical and metallurgical: Cement manufacture	1,798	7,258
Other miscellaneous uses[3]	179	1,165
Unspecified:[4]		
Actual	460	3,011
Estimated	1,931	10,857
Total	8,389	[5]46,648

[1] Includes limestone, dolomite, granite, marble, sandstone, traprock, and miscellaneous stone.
[2] Includes stone used in macadam, riprap and jetty stone, filter stone, other coarse aggregate, other fine aggregate, unpaved road surfacing, and crusher run or fill or waste.
[3] Includes stone used in whiting or whiting substitute, other fillers or extenders, and abrasives.
[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.

of production, although expansion may allow the company to export to the mainland.

PRC continued as the island's only lime producer. Production of the chemical-grade lime used primarily for water purification and by the construction industry continued at the same level as in 1988. Salt continued to be produced from the evaporation of seawater by two companies in southwestern Puerto Rico. Recovered elemental sulfur was produced by the Sun Co. Inc. at its Humacao oil refinery.

Metals.—Puerto Rico has potentially economic porphyry copper and gold deposits. However, a combination of current economic conditions, political wrangling, and infrastructure difficulties precluded development by either private companies or the government.

Metals production reported to the Bureau of Mines was restricted to extruded aluminum. Aluminum Extrusion Corp. produced aluminum extrusions from imported aluminum billets at Canovanas.

THE COMMONWEALTH OF THE NORTHERN MARIANAS

Only one territory other than Puerto Rico has commonwealth status. The Commonwealth of the Northern Mariana Islands was part of the Trust Territory of the Pacific until it voted to become a commonwealth in 1976. The Northern Mariana Islands were one of four territories that the United Nations designated the United States to oversee with the ultimate goal of helping them to attain self-government. The agreement granting the Northern Mariana Islands commonwealth status went into full effect in 1986. Unlike Puerto Rico, the U.S. Department of the Interior continued to play a large role in the administration of the Northern Mariana Islands.

The Commonwealth consisted of 16 islands covering 184 square miles in the western Pacific Ocean. Saipan (the capital), Tinian, and Rota were the three main islands. The only mineral commodity produced on the islands was crushed stone for the local construction industry.

CARIBBEAN ISLAND POSSESSIONS

The Caribbean Island Possessions consisted of the U.S. Virgin Islands, which include St. Croix, St. John, and St. Thomas; Navassa Island south of Guantanamo, Cuba; the Swan and Corn Islands off the Honduran and Nicaraguan coasts; and the Quito Sueno Banks, Roncador Banks, Serranilla Banks, and Serrana approximately 250 miles east of the Central American coast. The only mineral production reported was from the Virgin Islands.

The Virgin Islands are about 1,650 miles (St. Thomas, 1,635 miles) southeast of New York City and approximately 1,000 miles (St. Croix, 1,125 miles) southeast of Miami. Although more than 50 islands comprise the group, only St. Thomas, St. Croix, and St. John had populations of significant size. Of the 106,000 residents of the Virgin Islands, 52,400 lived on St. Croix, 50,860 on St. Thomas, and 2,740 on St. John. Approximately 2,400 were employed in construction and mining in 1989.

Trends and Developments

Hurricane Hugo was the dominant factor affecting the Caribbean Island Possessions mineral industry in 1989. Particularly hard hit was St. Thomas, which was devastated. Sulfur production at the Hess Oil Co. was curtailed for several weeks when the operation was completely shut down due to power outage and storm damage. As in Puerto Rico, rebuilding and repairing structures destroyed or damaged by the storm resulted in a strong demand for construction aggregate in the final quarter of 1989.

A referendum to decide the Virgin Islands future status was scheduled to be held in June 1991. The U.S. Virgin Islands Commission on Status and Federal Regulations was working to educate the general public on the options available. The commission combined seven status options into three categories: (1) status and incorporated territory, (2) independence and free association, and (3) status quo, commonwealth, and compact of Federal relations.

Martin Marietta completed the sale of its alumina refinery on St. Croix to Clarendon Ltd., a Swiss-based aluminum trading company. Clarendon's newly created subsidiary, Virgin Islands Alumina Inc., retained Ormet Corp. of Hannibal, OH, to serve as manager of the operation. Ormet was to oversee and guide all aspects of the restart and subsequent production of the plant, which has been idle since 1985. Shipments of alumina were expected to begin in 1990.

Review by Nonfuel Mineral Commodities

Industrial Minerals.—**Sand and Gravel.**—Approximately 30% of the construction sand and gravel used in the Virgin Islands was imported from Barbuda, approximately 100 miles east of St. Croix. Devcon International Corp. produced manufactured sand at its traprock quarry on St. Croix near Grove Place and at its Brookman limestone quarry on St. Thomas.

Stone.—Crushed stone was produced by Devcon at the two locations noted above and by St. Croix Stone and Sand Inc. at the Robes Hill Mine near Frederiksted from an unspecified rock type. Caribbean Material Supply Co. produced crushed stone from traprock at its Springfield, St. Croix, quarry. The stone was used as concrete aggregate, concrete sand manufactured from sandstone, crusher run fill, and riprap and jetty stone.

Other Minerals.—The only other industrial mineral produced in the Virgin Islands in 1989 was elemental sulfur recovered as a byproduct at the Hess oil refinery.

Metal production was scheduled to resume with the reopening of the Virgin Islands Alumina plant, which had been closed since 1986, but delays caused by Hurricane Hugo pushed back the opening to 1990. Ore for the plant was expected to be bauxite imported from Jamaica, but the mines there have been inactive, and officials estimated[9] that at least $18 million would be needed to rehabilitate the mines and that shipments of bauxite would not begin until 1991.

PACIFIC ISLAND POSSESSIONS

The Pacific Island Possessions comprise the following islands acquired between 1839 and 1967: American Samoa (1900), Baker (1839), Canton (1939), Enderberg (1939), Guam (1898), Howland (1934), Jarvis (1934), Johnston (1858), Kingman Reef (1922), Midway (1967), Palmyra (1898), and Wake (1898).

The only mineral production reported was construction aggregate quarried on American Samoa and Guam. Concrete products are manufactured locally using imported cement.

The major development in the Pacific Island Possessions was the completion of a $150 million, four-barreled, high-tech incinerator on Johnston Atoll. The incinerator is part of a $3.1 billion plan to store and destroy a huge stockpile of chemical weapons from West Germany. The plan has drawn considerable opposition from environmentalists, church leaders, and area politicians.

TRUST TERRITORY OF THE PACIFIC ISLANDS

After World War II, the United Nations designated four territories that the United States would oversee with the ultimate goal of helping them to develop self-government. The territories included the Northern Mariana Islands, Marshall Islands, Federated States of Micronesia, and the Republic of Palau.

In the 1970's, these territories voted on their future status. The Northern Mariana Islands opted for commonwealth status while the other three voted for "free association" with the United States. Free association denotes self-government with the United States providing defense responsibilities and economic aid. In return, the free association states allow the United States to maintain military bases on the islands. By 1986, compacts had been ratified, and the Marshall Islands and the Federated States of Micronesia became free States. The Republic of Palau has remained a trust territory of the United States because its compact has not yet been ratified. The obstacle delaying ratification is a clause in Palau's constitution declaring that Palau will be a nuclear-free country, which contradicts U. S. military requirements.

No mineral production was reported from the Trust Territories in 1989.

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[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL. He has 32 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. Construction Industry Ended Year That Began Slow in Miniboom. V. 17, No. 52, Dec. 28, 1989, p. S6.

[4] Latin American Economic Report. Puerto Rico/U.S. Aid. Jan. 6, 1990.

[5] Caribbean Business. Everybody Wants a Cement House Nowadays. V. 17, No. 40, Oct. 5, 1989, p.15.

[6] Caribbean Business. P.R.: No Longer a Tropical Paradise. V. 17, No. 48, Nov. 30, 1989, p. 28.

[7] Caribbean Business. Preventive Maintenance Is the Salvation of the Environment. V. 17, No. 37, Sept. 14, 1989, p. S4.

[8] Pit and Quarry. Financial Facts. V. 82, No. 5, May 1990, p. 14.

[9] Latin American Mining Letter. Jamaica Leads Way in Caribbean Bauxite Boom. V. 8, No. 22, Nov. 23, 1989.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
	PUERTO RICO		
Cement:			
Puerto Rican Cement Co.[1]	Box 1349 Ponce, PR 00936	Plant	Ponce.
San Juan Cement Co.[2]	GPO 2888 San Juan, PR 00936	do.	San Juan.
Graphite (synthetic):			
Union Carbide Corp.	39 Old Ridgeway Rd. Danbury, CT 06817	do.	Humacao.
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.
Cantera Perez Inc.	Box 789 Humacao, PR 00661	do.	Humacao.
Cantera Dorado Inc.	Box 4217, Bay Gardens Station Bayamon, PR 00620	do.	Arecibo.
Sulfur:			
Sun Co. Inc.	1801 Market St., 23d Floor Philadelphia, PA 19103	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.
Sulfur:			
Amerada Hess Corp.	1 Hess Plaza Woodbridge, NJ 07095	Plant	Do.
	GUAM		
Stone (crushed):			
Guam Government Public Works Department	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, crushed stone.
[2] Also clay, crushed stone.

THE MINERAL INDUSTRY OF RHODE ISLAND

This chapter has been prepared under a Memorandum of Understanding between the 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 1989 was $11 million, a decrease of $6 million from that of 1988. The primary reason for the decline was the decrease in production of crushed stone and construction sand and gravel, the principal minerals produced in the State. These decreases were largely the result of fewer housing starts in 1989; starts declined by 24% from 1988 levels. Mineral-related industrial activity in the State included glass manufacturing, wire manufacturing, refinishing of precious and specialty metals, and metalworking and fabrication.

TRENDS AND DEVELOPMENTS

Construction began on North America's first gypsum fiberboard plant in East Providence. Highland American Corp. planned to produce Gypsonite, a trade name for the gypsum fiberboard. Gypsum fiberboard is a new type of drywall construction board made from natural gypsum and cellulose fiber. The difference between Gypsonite and conventional wallboard is that Gypsonite is a solid material and looks like plaster in contrast to conventional wallboard, which is a paper-gypsum-paper sandwich. The new $30 million plant is designed for a capacity of 150 million square feet of Gypsonite annually. The plant was expected to be operating by mid-1990 and employ about 85 workers.

LEGISLATION AND GOVERNMENT PROGRAMS

During the 1989 legislative session, the Rhode Island General Assembly amended Section 23-18.9-9.1 of the General Laws by adding criteria for siting three types of solid waste management facilities, and also authorized the State Planning Council to adopt additional criteria for the same three types of facilities. The three types of solid waste management facilities were solid waste landfills, incinerators, and resource recovery facilities. The statute prohibited location or operation of solid waste landfills in five areas. These were watersheds of existing drinking water supplies, the watershed of Big River Reservoir, ground water recharge areas, 100-year flood plains, and areas within 20 feet of the coast and/or coastal high-hazard areas. Incinerators and resource recovery facilities were prohibited in coastal high-hazard areas, wellhead protection areas designated by the Director of Environmental Management, and National Estuarine Sanctuaries designated by the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce.

In June, the Rhode Island Office of State Planning, a division of the Department of Administration, adopted Land Use 2010: State Land Use Policies and Plan as Element 121 of the State Guide Plan. The plan updated and replaced the original land use element of the State Guide Plan, which was adopted in 1975. The updated plan established new goals and policies for land use, described the context for planning, and analyzed the capability of the State's land to support development. Topics in the plan included air quality, water resources, acid rain, energy resources, topography, geology, and minerals. Also in June, technical paper number 135, the Rhode Island Environmental Inventory: A Working Paper for Land Use 2010, was printed. It was the sixth of a series of working papers developed in conjunction with

TABLE 1

NONFUEL MINERAL PRODUCTION IN RHODE ISLAND[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	$1	NA	$1	NA	$2
Sand and gravel (construction)	thousand short tons	e2,700	e10,900	1,853	7,847	e1,100	e3,900
Stone (crushed)	do.	1,228	7,797	e1,500	e9,400	[2]1,208	7,170
Total[3]		XX	18,698	XX	17,248	XX	11,072

e Estimated. 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.

RHODE ISLAND

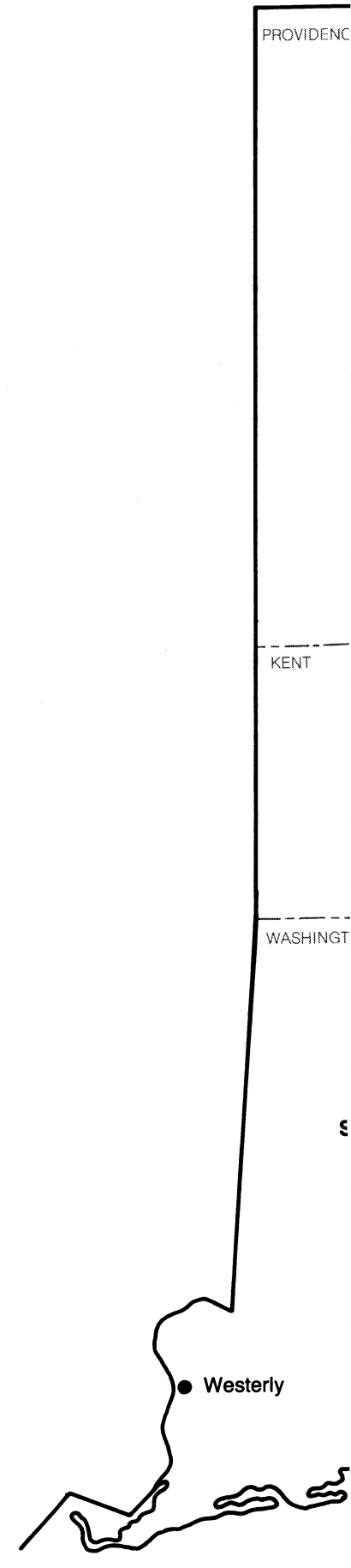
LEGEND

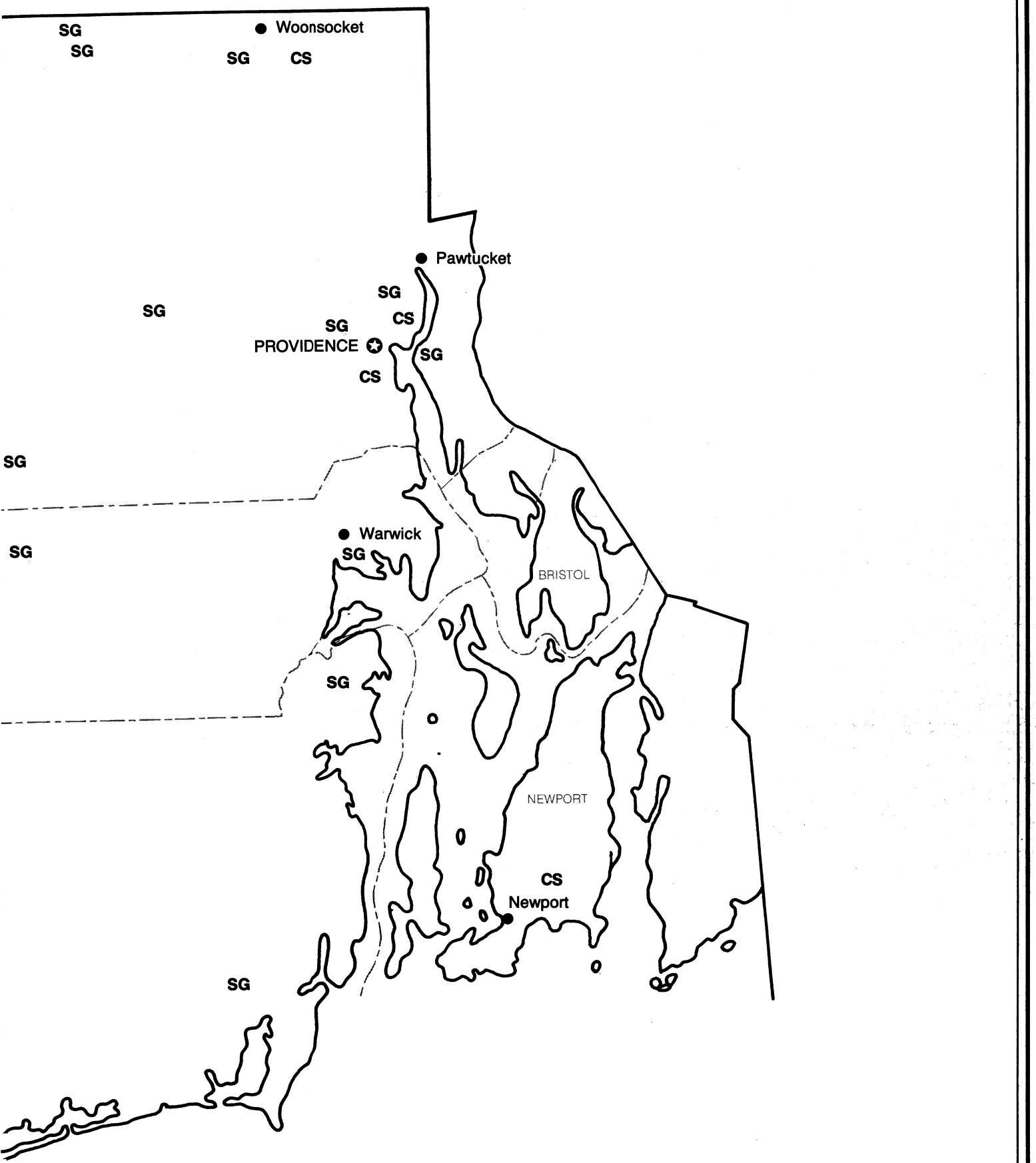
- State boundary
- County boundary
- Capital
- City

MINERAL SYMBOLS

- **CS** Crushed Stone
- **SG** Sand and Gravel

Principal Mineral-Producing Localities




SG
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Warwick
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NEWPORT
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Newport
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the update of the land use plan.

Element 781 of the State Guide Plan entitled, "Energy Facilities Siting Plan," was amended in December. The plan was designed to improve the energy facility siting process used by the State, forecast the likely types of energy-related activities the State may be asked to accommodate through the year 2000, and devise a means by which to evaluate the impacts of energy facility siting proposals. Policies were also established for review of electric power generating facilities.

The Office of the State Geologist at the University of Rhode Island continued work on surficial mapping and offshore sand and gravel mapping. Preliminary mapping of the State's bedrock geology was also completed. Work done over the past two decades on the petrology, geochronology, paleontology, and structural geology of pre-Mesozoic rocks of the State was used to revise earlier maps. Project support came from the U.S. Geological Survey (USGS) and the States of Rhode Island and Connecticut. As a result of this and previous work, a new bedrock geological map of Rhode Island was compiled at a scale of 1:100,000. The revised Rhode Island map would be incorporated into a combined Rhode Island-Connecticut map at a scale of 1:250,000, and it may be published by the USGS.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Based on these estimates, output and value of construction sand and gravel declined 40% and 50%, respectively. The primary reason for the production decline was lower demand from the construction industry. Value decreased because several producers lowered the selling price of the material. Construction sand and gravel was produced in three of the State's five counties. Leading counties, in order of output, were Kent, Washington, and Providence. The material was used primarily for concrete aggregate, asphaltic concrete aggregates, road base and coverings, and fill.

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.

TABLE 2

RHODE ISLAND: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Other miscellaneous uses [2]	547	2,982
Unspecified: [3]		
Actual	5	95
Estimated	655	4,092
Total [4]	1,208	7,170

[1] Includes limestone and granite; traprock quantity withheld to avoid disclosing company proprietary data.
[2] Includes stone used in riprap and jetty stone, filter stone, graded concrete aggregate, bituminous aggregate (coarse and surface treatment), stone sand bituminous mix or seal, graded road base or subbase, and agricultural limestone.
[3] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4] Data may not add to totals shown because of independent rounding.

***Stone.*—**Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed stone was the State's leading mineral commodity, accounting for nearly two-thirds of the total mineral production value. In 1989, output and value decreased 19% and 24%, respectively, from 1988 estimates. Five companies operated five quarries, four in Providence County and one in Newport County. Limestone was the leading type produced, followed by granite and traprock. Most of the stone was used for road base, filter stone, and bituminous and concrete aggregate.

[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in Rhode Island for 4 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sand and gravel:			
Construction (1988):			
A. Cardi Construction Co. Inc.	451 Arnold Rd. Coventry, RI 02816	Pits and plant	Kent.
Holliston Sand Co.[1]	Box 393 Slatersville, RI 02876	Pit and plant	Providence.
River Sand & Gravel Co. Inc.	101 Ferris St. Pawtucket, RI 02861	Pit	Kent.
South County Sand & Gravel Co.	North Rd. Peace Dale, RI 02878	Pit and plant	Washington.
TASCA Sand & Gravel Co.	Log Rd. Smithfield, RI 02917	Pit	Providence.
Industrial:			
Holliston Sand Co. Inc.	Box 97, 303 Lowland St. Holliston, MA 01746	Pit	Do.
Stone:			
The Conklin Limestone Co.	R.F.D. 1 Lincoln, RI 02865	Quarry	Do.
Forte Bros. Inc.	14 Whipple St. Berkley, RI 02864	do.	Do.
J. H. Lynch & Sons Inc.[2]	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.

[1] Also industrial sand.
[2] Also sand and gravel.

THE MINERAL INDUSTRY OF SOUTH CAROLINA

This chapter has been prepared under a Memorandum of Understanding between the 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] and Norman K. Olson[2]

The value of mineral commodities produced in South Carolina in 1989 increased 18.9% over that of 1988 to an alltime high of $425.3 million. The State's three leading commodities, cement, crushed stone, and gold, accounted for almost 75% of the total. The State led the Nation in vermiculite production, ranked 2d in kaolin output, and rose from 11th in 1988 to 6th in gold production. Overall, South Carolina's national ranking for the value of all minerals produced improved from 27th in 1988 to 25th. The State also ranked 22d in the value of industrial minerals and 18th in the value of metals.

TRENDS AND DEVELOPMENTS

South Carolina's mineral production increased in 1989 for the seventh consecutive year. The increase occurred although output of cement, the State's leading commodity in 1988, decreased significantly and fell to third place behind crushed stone and gold in 1989. The value of crushed stone increased by 5.5% to $111.7 million, accounting for more than 25% of the total value of all minerals produced. Cement value fell 16.5% to $99.1 million but still accounted for 22% of the total value. This loss was offset by a huge increase in the value of gold produced, along with a moderate increase in crushed stone production that was less than expected. Transportation industry officials had predicted[3] that the volume of crushed stone and sand and gravel would increase by a larger percentage because of South Carolina's 10-year, $13 billion program of transportation improvement. The program, which began in 1989, places a priority on road construction in rural areas and smaller cities.

Although the Bureau of Mines withholds data on the amount and value of gold produced, published reports[4] indicate that more than 220,000 ounces of gold was produced in the State in 1989.

During the decade of the 1980's, South Carolina's mineral growth increased steadily. The trend was interrupted in 1983 when a decline related to the national recession of the early 1980's was recorded. Growth increased sharply in 1984, but virtually no change occurred from 1985 to 1986. The value of mineral production increased from less than $150 million in 1980 to more than $400 million in 1989. The number of active mines increased from 405 to 525 between 1984 and 1989, an average of 5.9% per year.

On September 22, 1989, Hurricane Hugo caused heavy damage in South Carolina. Twenty-two counties were declared Federal disaster areas. Heaviest damage occurred in Charleston County, where structural damage was estimated at $2 billion, and 90% of the County's trees were destroyed.[5] The primary aluminum plant of Alumax Inc. in Mount Holly, Berkeley County, suffered

TABLE 1

NONFUEL MINERAL PRODUCTION IN SOUTH CAROLINA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement (portland)	thousand short tons	2,567	$117,878	2,533	$118,670	2,188	$99,083
Clays	metric tons	[2]1,989,948	[2]38,244	1,867,829	40,541	1,596,153	39,075
Gem stones		NA	10	NA	10	NA	10
Sand and gravel:							
Construction	thousand short tons	e7,500	e19,500	7,529	20,751	e7,500	e23,300
Industrial	do.	844	15,188	859	15,271	842	16,635
Stone:							
Crushed[3]	do.	24,278	105,387	e23,500	e105,800	24,429	111,656
Dimension	short tons	2,319	312	e353	e31	W	W
Combined value of cement (masonry), clays (fuller's earth, 1987), gold, manganiferous ore, mica (scrap), peat, silver, stone (crushed shell), vermiculite, and value indicated by symbol W		XX	44,806	XX	56,728	XX	135,538
Total		XX	341,325	XX	357,802	XX	425,297

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

major damage. Although structural damage was minor, a power outage caused by the hurricane allowed molten metal to harden in the pots. Full production was not restored until early December. Hurricane Hugo also damaged the slate roofs of more than 500 houses in Charleston's historic district. More than 800 tons of slate were shipped to Charleston from the Penrhym Quarry in Bethesda, Wales, to repair the damage.

On January 2, 1989, British Petroleum Minerals Corp. (BP) announced that it had sold its interest in the Ridgeway gold mine to The Rio Tinto-Zinc Corp. PLC (RTZ). The purchase was part of RTZ's acquisition of selected BP mineral properties in Australia, Canada, The Republic of South Africa, and the United States. RTZ subsequently renamed the operation Kennecott Ridgeway Mining Co. A company official explained that the change was made to take advantage of Kennecott's corporate name, which, he said, has been "synonymous with leadership in the United States mining industry for decades".[6] Galactic Resources Ltd. retained its 48% interest in the mining venture.

EMPLOYMENT

South Carolina's mining industry employed between 2,600 and 2,900[7] people directly involved with mineral extraction and beneficiation in 1989. The number of active mines increased to 525 from 483 in 1988.

REGULATORY ISSUES

The Division of Mining and Reclamation, South Carolina Land Resources Conservation Commission, submitted a wide range of amendments to South Carolina's Mining Act to the State Senate Agriculture and Natural Resources Committee. The amendments represented a consensus among various State government departments, the Mining Association of South Carolina, environmental groups, and interested citizens. Final action on the amendments is expected during the 1990 Legislative session.

During 1989, the Division of Mining and Reclamation also issued 49 new permits to mine and canceled 7 permits after reclamation had been completed. As of December 31, 1989, 525 mines operated by 262 mining companies were active; 69,630 total acres had been permitted with 18,896 acres actually affected; and 4,474 acres had been reclaimed. Twenty-six applications for new mining permits were pending at yearend.

In January, the Governor of South Carolina issued an executive order prohibiting hazardous waste disposal facilities in South Carolina from accepting waste from States that prohibit or limit waste disposal within their own boundaries. The legislature supported the Governor by enacting a law with similar intent in March. However, officials decided not to enforce the law pending the outcome of legal challenges to a similar law enacted by Alabama.

On October 13, 1989, South Carolina joined Alabama, Kentucky, and Tennessee in announcing an agreement in principle to cooperate in the treatment and disposal of hazardous wastes generated within their boundaries through the year 2010.

Martin Marietta Aggregates Corp. was forced to close temporarily a newly opened crushed stone quarry in September. Rains spawned by Hurricane Hugo caused runoff containing kaolin from the quarry's overburden to pollute a local stream and pond. The quarry had been allowed to open despite strong protests by local residents and environmentalists.

EXPLORATION ACTIVITIES

Piedmont Mining Co. financed an expanded exploration program at its Haile gold mine near Kershaw through the sale of 12.6% of its stock to the Corona Corp. By yearend, Piedmont announced that it had spent $733,000 on exploration and increased its reserves from 2.0 million tons averaging 0.043 ounce of gold per ton to 2.6 million tons averaging 0.045 ounce per ton.

Exploration for heavy minerals in ancient beach sand deposits extended into South Carolina from the primary center of activity in southern Virginia and northern North Carolina. Although several companies were known to be active in the exploration, no announcements related to major discoveries or planned mines in South Carolina were made during 1989.

LEGISLATION AND GOVERNMENT PROGRAMS

The South Carolina Legislature passed no bills affecting the mining industry in 1989. Bills to amend the Mining Act and to identify areas to be classified as wetlands were carried over to the 1990 session.

The Center for Science Education at the University of South Carolina received a $508,762 grant from the National Science Foundation. The money is to be used for a program to improve the teaching of earth science in the State's secondary schools. An additional $371,495 from a coalition of 25 State agencies brought total funding for the project to more than $880,000.

A professor at the University of South Carolina received a grant of $111,000 to study the chemical composition of rock core samples recovered during recent deep-sea drilling expeditions. Some of the samples contained very high concentrations of gold. It was hoped that the study would be able to relate the high gold concentrations to certain rock types. This information could help guide exploration for potential gold deposits.

The Aiken County Council passed an ordinance to allow the issuance of a $5 million industrial revenue bond to finance construction of a mining operation planned by the Bonsal Co. The bond will allow Bonsal to purchase the land and equipment needed to develop a sand and gravel deposit on the Savannah River floodplain east of Augusta, Georgia.

The South Carolina Department of Parks, Recreation, and Tourism awarded the Fairfield County Recreation Commission a $20,065 grant to develop a recreational park near the Kennecott Ridgeway Mining Co. gold mine. The company helped to clear the land and build structures in the park.

The Tuscaloosa Research Center (TURC) of the Bureau of Mines continued research on the environmental effects of cyanide-treated gold wastes. Monitoring and assessment of an abandoned tailings pond at Piedmont's Haile gold mine were initiated in 1989. TURC also identified two active mining operations to study the short-term effects of cyanide and heavy-metal contamination. The study of a heap-leach stack during washdown at Brewer's Jefferson Mine is scheduled to begin in 1990. Future

research will be initiated to develop mitigative measures for any ground water contamination that may be discovered by the current studies.

The Bureau's Intermountain Field Operations Center in Denver initiated property evaluations of the three South Carolina gold mines for the Minerals Availability System. The evaluations are scheduled to be completed during 1990.

The U.S. Department of Energy (DOE) continued work on the Defense Waste Processing Facility near Aiken. The operation planned to use a vitrification process in which radioactive liquid plutonium would be combined with borosilicate particles to form a glass. The glass would be poured into stainless steel canisters, sealed, and moved to the glass-waste storage building. Eventually, the canisters would be stored in DOE's permanent underground waste facility at Yucca Mountain, NV. Commencement of shipments to Nevada was scheduled for 1992, and shipments could continue for 20 years.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Ten industrial minerals were mined in South Carolina in 1989. Three additional industrial mineral commodities were produced from raw materials mined within the State, shipped from other States, or imported. These 13 commodities accounted for more than 75% of the value of minerals produced in 1989.

Cement.—Portland cement was the State's third leading mineral commodity with $99.1 million in sales accounting for 23.3% of South Carolina's 1989 industrial mineral value. These figures represent a decline of 16.5% from those of 1988 and reflect the softening of the economy in 1989, especially in housing starts. Production decreased from 2.5 million short tons in 1988 to 2.2 million short tons in 1989. Of the 38 States producing portland cement, South Carolina ranked 11th and 12th in volume and value, respectively. It ranked sixth in volume and fifth in value nationally in the production of masonry cement.

Cement was manufactured by three companies, Santee Portland Cement Co. in Orangeburg County and, in Dorchester County, Gifford-Hill Cement Co. and Giant Cement Co. Santee was a wholly owned subsidiary of the Dundee Cement Co., which in turn was owned by a Swiss firm, Holderbank Financire Glaris Ltd. The plant was founded in 1966 by two local families and sold in 1978 to Dundee. In 1989, it had a capacity of 6,000 tons per day (1.1 million tons per year) from its two wet-process kilns. The operation employed 190 people whose annual earnings were approximately $6.5 million.[8] Selected types of hazardous waste (principally dry-cleaning fluids and spent oil and grease from auto parts washers) were used to supplement coal as fuel for the plant. Santee also constructed a new 20,000-ton domed storage silo at its Georgetown terminal.

Gifford-Hill, a subsidiary of The Beazer Group, a United Kingdom conglomerate, had an annual capacity of 550,000 tons from one dry kiln. Giant Cement Co. had a capacity of 770,000 tons from four wet-process kilns.

Clays.—The volume of clay produced in South Carolina in 1989 declined almost 15%, although the value decreased less than 4% because the average unit value rose from $21.70 per ton to $24.48 per ton. A general softness in the economy, reflected in a slowdown in building construction, was believed to be the principal reason for the decline. Clay was mined by 21 companies from 38 pits in 18 counties. Approximately 58% of the clay mined was common clay, 41% was kaolin, and the remainder was montmorillonite, which is reported with fuller's earth by the Bureau of Mines. South Carolina ranked eighth in volume and fourth in value of the 38 States producing clay in 1989.

Common Clay and/or Shale.—Common clay, phyllite, and manganiferous schist (used as a coloring agent) were mined mainly for the production of brick in 1989. Common clay was mined by 14 companies from 25 mines in 13 counties. There was a slight increase in the value of common clay produced, although the volume decreased 8%.

Common clay was used in the manufacture of portland cement, common brick, face brick, structural tile, and terra cotta. Major producers were Boral Bricks Inc., Dundee Cement Co., Palmetto Brick Co., Richtex Corp., and Southern Brick Co.

Kaolin.—South Carolina ranked second nationally in the production of kaolin. Industrial kaolin was produced by five companies operating eight pits in Aiken County during 1989. Unprocessed kaolin was mined by four companies from five pits in five counties, down from five companies mining from seven pits in 1988. Production decreased, continuing a downward trend that started in 1987. This followed a period of steady growth that began in 1983. Although the volume of kaolin produced decreased more than 8%, total value increased 6.5%, reflecting a unit price increase of $7.75 per ton.

Hecla Mining Co. of Coeur d' Alene, ID, completed the purchase of Cyprus Industrial Minerals Co.'s (CIM) kaolin operations in the Aiken, SC, area. The sale was delayed by the Federal Trade Commission, which disallowed Hecla's purchase of CIM's ball clay operations in Tennessee and Mississippi. The purchase of kaolin operations in South Carolina and Georgia was allowed. Hecla operated the kaolin operations through its Kentucky-Tennessee Clay Co. (K-T Clays) subsidiary.

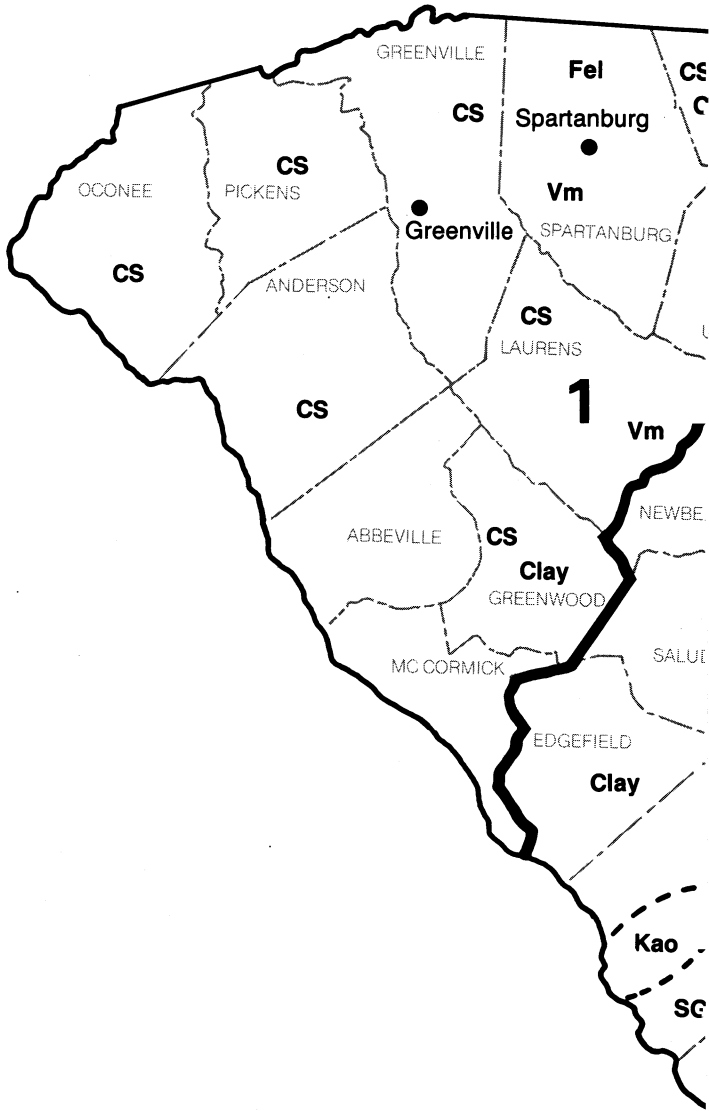
Major end uses of industrial kaolin were the manufacture of rubber, fiberglass, pesticides, paper, and adhesives and as a catalyst for oil refining. Each of the above accounted for more than 10,000 metric tons during 1989. Companies mining industrial kaolin, in addition to K-T Clays, were Dixie Clay Co., J. M. Huber Corp., National Kaolin Products Co., and Southeastern Clay Co.

Unprocessed kaolin was used in the manufacture of face brick, common brick, and miscellaneous refractories. Companies producing unprocessed kaolin were Richtex Corp., Palmetto Brick Co., Guignard Brick Works, and National Clay Products Co.

Mica.—Scrap mica was produced near Kershaw, SC, by MMC Holding Inc., formerly Mineral Mining Corp. MMC produced mineralite mica, a white, fine-grained mineral assemblage used in paint as a filler and in other industrial applications. Production decreased significantly from that of 1988, but South Carolina retained its ranking as the fourth leading State in the quantity of mica produced.

Peat.—Peat was mined by American Peat and Organics Inc. at Snuggedy Swamp near the Edisto River in Colleton County. The company employed 25 people and had mining rights to approximately 1,000 acres of the estimated 22,000 acres of peat in the swamp. Mining has

SOUTH CAROLINA



LEGEND

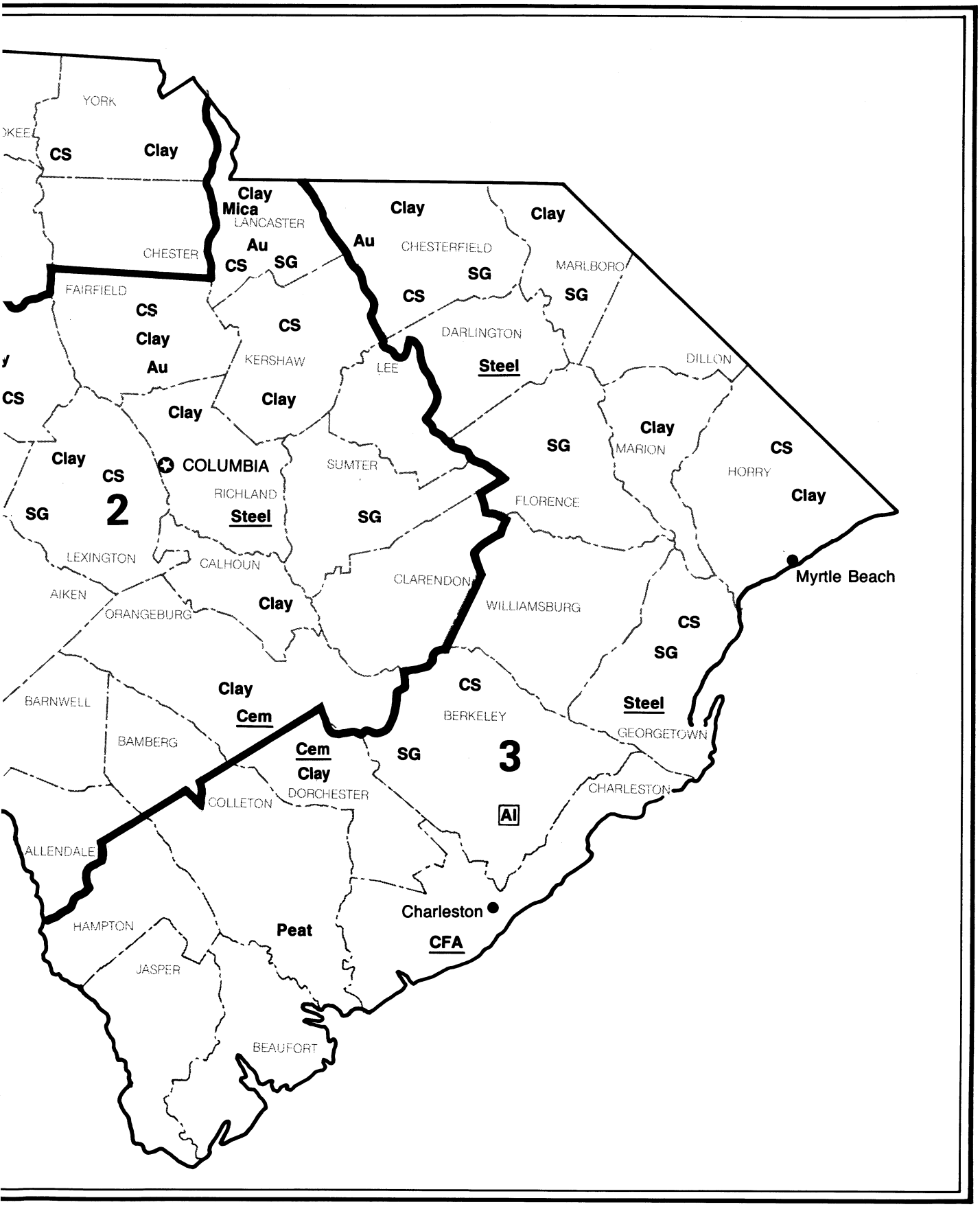
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

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


YORK
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FLORENCE
LEXINGTON
CALHOUN
CLARENDON
Myrtle Beach
AIKEN
ORANGEBURG
Clay
WILLIAMSBURG
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BERKELEY
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BARNWELL
BAMBERG
GEORGETOWN
Cem
Clay
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3
CHARLESTON
DORCHESTER
COLLETON
AI
ALLENDALE
Charleston
HAMPTON
Peat
CFA
JASPER
BEAUFORT

formed 15 to 20 ponds that provide fish and wildfowl habitat in the swamp. The peat has provided potting soil and related soil-conditioning materials for the horticultural market for the past 30 years. The quantity of peat mined decreased by one-third, while its value decreased by only one-fifteenth.

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the 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 estimates for 1987 and 1989.

Based on estimated construction sand and gravel production, the volume decreased slightly from that of 1988, although the value increased because of an increase in the average unit price from $2.76 per ton to $3.11 per ton. Fifty-five companies operating 65 mines in 22 counties produced sand and gravel mainly for road base, concrete aggregate, asphalt concrete, and fill. Districts 1 and 2 (see State map) accounted for more than 90% of the State's production.

W. R. Bonsal and Co. neared completion of its construction sand and gravel facilities on the Savannah River floodplain at the William E. Bell Mine near Beech Island, South Carolina. Property acquisition and mining equipment were financed in part by a $5 million industrial construction bond from Aiken County. The initial operation occupied 250 acres of Bonsal's 2,360-acre tract. The pit featured a German-designed airlift dredge capable of producing 400 short tons per hour. Air pumped down a 4-inch pipe forced a slurry of sand and gravel to the surface through the annulus of a 14-inch pipe and into a pump that transported the slurry to the sizing and processing operation.

Industrial.—Industrial sand production decreased slightly from that of 1988, but the value increased significantly because of an increase in the unit price. Five companies operated 53 pits in Lexington and Kershaw Counties, selling mainly to the fiberglass and glass container industries. Other uses included chemicals, blasting sand, and chemicals. South Carolina ranked 11th in volume and 10th in value with respect to the 38 States producing industrial sand and gravel.

W. R. Bonsal, one of the Nation's leading producers of industrial gravel for the production of silicon metal, was expected to produce industrial, as well as construction, sand and gravel at its Beech Island operation when it began production.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

South Carolina stone statistics are compiled by geographical districts as depicted in the State map. Table 3 presents end-use data for the State's three districts.

Crushed.—Crushed stone replaced cement as the most valuable commodity produced in South Carolina in 1989. Its value of approximately $112 million accounted for almost 35% of the value of industrial minerals produced and for more than 26% of the total value of all minerals mined. According to data supplied by the Mine Safety and Health Administration, crushed stone was produced by 19 companies from 38 quarries. Seventeen companies operating 34 quarries returned survey forms to the Bureau of Mines. Granite was produced by 20 of the quarries, limestone by 8, marl by 4, and shell by 2. Two new crushed stone quarries, one granite and one limestone, were permitted in South Carolina in 1989.

Georgia Marble Co. operated a filler-grade calcium carbonate quarry and plant at Campobello, Spartanburg County, SC. These facilities were included in the company's sale to First Chicago Corp. by its former owner, Kohlberg Kravis Roberts and Co. Seven companies, Bad Creek Constructors, Beazer USA, Dundee Cement, Martin-Marietta Aggregates, RMC Holdings USA, Tarmac America, and Vulcan Materials, each produced more than 1 million short tons of crushed stone during 1989.

Dimension.—A significant increase in the production of dimension stone occurred in 1989. According to survey data returned to the Bureau of Mines, three companies operating four quarries were active in 1989. Granite was the only rock quarried for dimension stone, and only rough monumental stone and rough blocks were produced.

Vermiculite.—South Carolina once again was the leading State in vermiculite production in 1989. Both production and value decreased slightly, continuing a slight downturn that began in 1988. Four companies mined vermiculite in Laurens and Spartanburg Counties.

Other Industrial Minerals.—Piedmont Mining Co., Charlotte, NC, acquired Mineral Mining Corp.'s (MMC) sericite operations near Kershaw when they purchased MMC in 1989. Lower quality sericite schist, used in brick manufacture, was mined by three other companies. Two companies, Boren Brick Co. and Boral Brick Co., mined a low-grade manganiferous schist for brick colorant. Boral produced from the Van Wyck Mine formerly operated by Ashe Brick Co., and Boren continued to operate the Fletcher Mine.

Spartan Minerals Corp., a subsidiary of Lithium Corp. of America, operated a feldspar grinding plant at Pacolet. The plant ground mica and a feldspar-silica concentrate obtained as a byproduct from Lithium Corp.'s operation at Cherryville, NC. The materials were sold to glass and whiteware manufacturers. M & T Chemicals Co. of Andrews, Georgetown County, SC, produced milled zircon from zircon concentrate imported from Australia and Florida for the ceramics, foundry, wall tile, and whiteware industries. The Bonsal Co. explored the possibility of producing byproduct rare-earth minerals for use in the paint, cosmetic, and semiconductor industries from their sand and gravel operation at Beech Island. The South Carolina Division of Mining and Reclamation indicated that this would not be possible under Bonsal's current permit, which restricts production to sand and gravel.

Other industrial minerals shipped from other States or imported into South Carolina for processing or manufacturing included ball clay, kaolin, and gypsum used by the Kohler Co. to manufacture bathroom and kitchen fixtures. Colemanite and ulexite mined in Turkey were processed by Industrial Minerals Inc. of Kings Creek for the fiberglass industry.

BASF Corp. announced a planned $30 million expansion of its carbon fiber precursor plant in Rock Hill. The plant's production was expected to increase from 300,000 pounds of polyacrylonitrile (PAN) precursor, the material from which carbon fibers are made, to more than 2 million pounds per year when the expansion is completed in the third quarter of 1991. This will give BASF the capacity to manufacture 3.3 million tons of carbon fiber annually.

TABLE 2

SOUTH CAROLINA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	2,057	10,157
Coarse aggregate, graded:		
Concrete aggregate, coarse	2,503	13,705
Bituminous aggregate, coarse	1,108	5,713
Bituminous surface-treatment aggregate	487	2,541
Fine aggregate (-3/8 inch):		
Screening, undesignated	2,515	12,077
Coarse and fine aggregates:		
Graded road base or subbase	2,094	8,799
Crusher run or fill or waste	2,860	13,999
Other construction materials[2]	2,207	11,210
Chemical and metallurgical:		
Cement manufacture	3,111	6,093
Other uses not listed[3]	504	2,338
Unspecified:[4]		
Actual	4,763	24,135
Estimated	219	890
Total[5]	24,429	111,656

[1]Includes limestone, granite, marl; a minor amount of shell withheld to avoid disclosing company proprietary data.
[2]Includes stone used in filter stone, railroad ballast, and stone sand (concrete and bituminous mix or seal).
[3]Includes stone used in agricultural limestone.
[4]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5]Data may not add to totals shown because of independent rounding.

Synthetic graphite was produced by Union Carbide Corp. at Greenville and by the Airco Carbon Div. of BOC in Ridgeville for electrodes in electric arc furnaces. South Carolina's four steel mills and the MacAlloy Corp.'s ferroalloy plant sold slag for aggregate, refractory material, and roofing shingle applications.

The Port of Charleston was the major shipping point for industrial minerals in South Carolina.

Metals

Gold and byproduct silver were the only metals of significant economic importance mined in South Carolina in 1989. Gold production increased dramatically owing to the first full year of operation of the Kennecott Ridgeway Mine, which opened in December 1988. South Carolina's national ranking in the production of gold rose from 11th to 6th. Three companies operated gold mines in 1989, and a fourth applied for an operating permit.

Gold.—Piedmont Mining Co. opened the modern age of gold mining in the southeastern United States when it reopened the Haile Mine near Kershaw in April 1985. The mine first produced in 1827 and operated intermittently until 1942. From its reopening in 1985 through 1989, the operation has been marginal, with the company reporting[9] losses in 1988 and 1989; however, a profit was reported in the fourth quarter of 1989. Piedmont sold 14% of its stock to Corona Corp. to finance an accelerated exploration program. As of December 31, 1989, reserves were reported to have increased from 86,000 ounces in 1988 to 117,000 ounces. Continued exploration was expected to lead to even greater increases in 1990. Piedmont employed 65 workers at the mine.

The Brewer Gold Co., owned by Costain PLC, London, opened the Jefferson Mine in Chesterfield County in July 1987. The company reported[10] production of 33,000 ounces of gold in 1989 at a cost of $290 per ounce. Brewer employed 120 at the mine. A major expansion of its heap-leaching facilities was begun in 1989 at a projected cost of $2.5 million.

The Ridgeway Mine in Fairfield County, a joint venture between BP Minerals Corp. and Galactic Resources Ltd. of Vancouver, British Columbia, Canada, was opened in December 1988. In its first full year of operation, the Ridgeway Mine became the 11th leading gold-producing mine in the country. In January 1989, RTZ Corp. announced that it had acquired BP's 52% interest in the Ridgeway Mine and renamed the operation the Kennecott Ridgeway Mine. Galactic Resources retained its 48% interest in the operation. Kennecott Ridgeway Mining Co. reported[11] production of 172,505 ounces of gold in 1989 with production cost averaging $140 per ounce. Reserves are estimated at 11 years. There were 200 employees at the operation in 1989.

The company tried various solutions to solve a major environmental problem in 1989 related to the deaths of birds and waterfowl from cyanide poisoning when they landed in the mine's 200-acre tailings pond. Although the deaths had become infrequent, Kennecott was not completely successful in solving the problem. Measures taken to prevent further deaths included fencing the pond and placing replicas of alligators, owls, and snakes in and around it. Kennecott reimbursed the State for two full-time South Carolina Fish and Wildlife workers employed to repel the birds with noise makers, sirens, shell crackers, special 12-gauge shotgun shells, and propane cannons.

The Kennecott Ridgeway Mining Co. also set up a wildlife trust that would donate $10,000 per year until the year 2000 to South Carolina's Harry Hampton Memorial Wildlife fund. The fund was operated by the South Carolina Wildlife and Marine Resources Department.

Gwalia (USA) Ltd., the Denver-based U.S. subsidiary of Australia's Gwalia Resources Ltd., applied in September for a permit to operate a gold mine in McCormick County. Gwalia obtained the property, which is about 3 miles from the Georgia line, from BP Minerals Corp.'s affiliate, Amselco Exploration, in 1988. Startup costs for the project, which will be called the Barite Hill Gold Mine, were estimated at $9 million;[12] construction was scheduled to begin in

TABLE 3

SOUTH CAROLINA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	W	W	W	W	—	—
Coarse aggregate, graded[2]	2,297	12,327	W	W	W	W
Fine aggregate (-3/8 inch)[3]	2,462	11,816	W	W	W	W
Coarse and fine aggregates[4]	2,505	11,782	W	W	W	W
Other construction aggregates	3,236	16,421	3,145	16,251	2,186	9,605
Agricultural[5]	(6)	(6)	—	—	—	—
Chemical and metallurgical[7]	—	—	(6)	(6)	(6)	(6)
Other miscellaneous	504	2,338	1,527	3,185	1,584	2,907
Unspecified:						
Actual[8]	771	3,987	2,078	12,097	1,914	8,052
Estimated[9]	—	—	—	—	219	890
Total[10]	11,775	58,670	6,750	31,532	5,904	21,454

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[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 screenings (undesignated).
[4]Includes crushed stone for graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[5]Includes agricultural limestone.
[6]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[7]Includes crushed stone for cement manufacture.
[8]Includes production reported without a breakdown by end use.
[9]Includes estimates for nonrespondents.
[10]Data may not add to totals shown because of independent rounding.

1990. Total reserves were estimated at 1.14 million metric tons averaging 1.58 grams per ton (less than 0.1 ounce per ton) gold and 6.2 grams per ton silver, with 80% recovery for gold and 60% for silver. Planned production was 17,000 to 18,000 ounces per year with 1.3 tons of waste being mined for each ton of ore. Dor bars, the molded finished product, were expected to contain approximately 75% silver and 25% gold.

Silver.—South Carolina's silver production was directly tied to its gold production. In 1989, silver recorded an even greater percentage increase in value than did gold. This was because the Ridgeway Mine, which accounted for the bulk of the gold increase, had a higher ratio of silver to gold than the two other gold mines. Despite the increase, South Carolina ranked only 14th of the 18 States producing silver.

Other Metals.—Aluminum and steel were the major metals produced but not mined in South Carolina. Primary aluminum was manufactured by Alumax Inc. at Mount Holly from more than 400,000 tons of alumina imported from Australia. Production of primary aluminum decreased significantly in 1989 owing primarily to a power outage caused by Hurricane Hugo that allowed molten metal to congeal in the melting pots. Although Alumax was able to restore full production almost twice as fast as the 20 weeks originally anticipated, the value of aluminum produced dropped almost 30% from 1988 rates.

In February, Kaiser Aluminum and Chemical Corp. announced plans to build an $11 million aluminum forgings plant in Greenwood. The forgings were to be used primarily by the automotive industry. Kaiser hoped to have the plant in operation by mid-1990 in time for the 1991 model year.

Ferrochrome was manufactured by MacAlloy Corp., the Nation's largest producer, from imported chrome ore at its Charleston facility.

The Bureau of Mines did not collect statistics on steel by State; therefore, steel statistics were not included in the text table on metal production. Steel was produced by Chatham Steel Corp., Columbia; Georgetown Steel Corp., Georgetown; Nucor Corp., Darlington; and Owen Electric Steel Co., Cayce. The Georgetown plant uses the Midrex DRI process, a direct-reduced iron method developed by Midrex Corp. of Charlotte, NC. This process produces a highly metalized iron product from lump iron ore or iron oxide pellets that can be used instead of scrap iron or as a diluent of scrap. The Georgetown operation is unique in that it uses virgin iron from a captive source.[13] Georgetown purchased Tree Island Industries, which has wire plants in the United States and Canada, and another 25,000-ton Canadian wire plant in 1989.

Nucor Corp. completed installation of a Danieli six-stand cantilevered rougher and an EMC ladle furnace in 1989. Owen Electric Steel Corp. completed a revamp of a bar mill in August.

Allvac Inc., a subsidiary of Teledyne Inc., broke ground in August for a $35 million continuous automated bar mill to produce high-temperature titanium alloys. The plant, which is on 664 acres in Chester County, would employ 300.

Advance Composite Materials Corp. of Greer was awarded a contract by the Air Force Systems Command to develop metal matrix composites. The company would work specifically on aluminum matrix composites with silicon fiber reinforcement.

[1]State Mineral Officer, Bureau of Mines, Tuscaloosa, AL. He has 32 years of 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]State geologist, South Carolina Geological Survey, Columbia, SC.

[3]Rock Products. Dec. 1988.

[4]The State (Columbia, SC). Is There Glitter in S.C.'s Mines? Mar. 19, 1990.

[5]_____. Hurricane Hugo, County by County Review. Sept. 30, 1989.

[6]Chronicle Independent (Camden, SC). Kennecott Senior Partner in Gold Mine. July 19, 1989.

[7]Annual Report, 1988–89. South Carolina Land Resources Conservation Commission. July 1, 1989, p. 25.

[8]Observer (Holly Hill, SC). Cement Plant, Orchard Toured. June 29, 1989.

[9]Work cited in footnote 4.

[10]Northern Miner. Piedmont Slips into Red on Weak Gold Prices, Higher Costs. Jan. 1, 1990.

[11]Work cited in footnote 4.

[12]Mining Activity Digest. South Carolina, Gwalia International Ltd. V. 16, No. 2, Feb. 28, 1989, p. 5.

[13]Iron Age. Growth Still Sparks the Minimills. Apr. 1990, p. 24.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aluminum (smelters):			
Alumax Inc.	Box 1000 Goose Creek, SC 29445	Plant	Berkeley.
Cement:			
Giant Cement Co.	Box 218 Harleyville, SC 29448	do.	Dorchester.
Gifford-Hill Cement Co. of South Carolina	Box 326 Harleyville, SC 29448	do.	Do.
Santee Portland Cement Co., a subsidiary of Dundee Cement Co.	Box 698 Holly Hill, SC 29059	do.	Orangeburg.
Clays:			
Common clay and shale:			
GSX Services of S.C., Inc.[1]	Rt. 1, Box 255 Pinewood, SC 29125	do.	Sumter.
Palmetto Brick Co.[2]	Box 430 Cheraw, SC 29520	do.	Kershaw and Marlboro.
Richtex Corp.[2]	Box 3307 Columbia, SC 29230	Mine and plant	Lexington and Richland.
Santee Portland Cement Co.	Box 698 Holly Hill, SC 29059	do.	Orangeburg.
Kaolin:			
J. M. Huber Corp.	Box 306 Langley, SC 29834	do.	Aiken.
Kentucky-Tennessee Clay Co.	Rt. 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.
Colemanite:			
Industrial Minerals Inc.	Box 459 York, SC 29745	Plant	York.
Feldspar:			
Spartan Minerals Corp., a subsidiary of FMC Corp., Lithium Division	Box 520 Pacolet, SC 29372	do.	Spartanburg.
Gold:			
Brewer Gold Co., a subsidiary of Westmont Mining Co.	Rt. 2, Box 57 Jefferson, SC 29718	do.	Chesterfield.
Kennecott Ridgeway Mining Co.	Rt. 2, Box 106 Ridgeway, SC 29130	Mine and plant	Fairfield.
Piedmont Mining Corp.	Box 505 Kershaw, SC 29067	do.	Lancaster.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Manganiferous ore:			
Boral Bricks Inc.	Box 4510 Augusta, GA 30909	Mine	Lancaster.
Boren Brick	Box 736 Blacksburg, SC 29702	do.	Do.
Mica (sericite):			
Mineral Mining Corp.	Box 458 Kershaw, SC 29067	Mine and plant	Do.
Sand and gravel:			
Becker Sand and Gravel Co. Inc.	Box 848 Cheraw, SC 29520	Pits and plants	Various.
W. R. Bonsal & Co.	Box 53 Beach Island, SC 29841	do.	Aiken.
Brewer Sand Co. Inc.	Box 267, Route 2 Lancaster, SC 29720	do.	Chesterfield and Lancaster.
Foster-Dixiana Sand Co.	Box 5447 Columbia, SC 29250	do.	Lexington.
Palmetto Sand Co.	Box 1893 Summerville, SC 29484	do.	Dorchester and Orangeburg.
Stone:			
Crushed:			
Martin Marietta Aggregates	Box 30013 Raleigh, NC 27612	do.	Do.
Tarmac America Inc.	Box 34527 Richmond, VA 23234	do.	Do.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	Quarries and plant	Various.
Dimension:			
Granite Panelwall Co., a division of Florida Crushed Stone Co.	Box 898 Elberton, GA 30635	do.	Lancaster.
Matthews International Corp.	Box 606 Kershaw, SC 29067	Quarry	Kershaw.
North Carolina Granite Co.	Box 151 Raleigh, NC 27612	do.	Kershaw.
Vermiculite:			
Enoree Minerals Corp.	Box 289 Lauren, SC 29360	Mines and plant	Spartanburg.
W. R. Grace & Co.	Rt. 1 Enoree, SC 29335	do.	Laurens.
Patterson Vermiculite Co.	Rt. 1 Enoree, SC 29335	do.	Do.
Strong-Lite products Corp., formerly Carolina Vermiculite Co. Inc.	Box 98 Woodruff, SC 29388	do.	Do.

[1]Fuller's earth.
[2]Also kaolin.

THE MINERAL INDUSTRY OF SOUTH DAKOTA

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

By Leon E. Esparza[1]

In 1989, the value of South Dakota's nonfuel mineral production was about $284 million, a slight decrease compared with the 1988 value. A 31% decrease in the value of crushed stone production offset increases recorded for other major commodities, including cement, gold, construction sand and gravel, and dimension stone. South Dakota ranked 32d in the value of nonfuel mineral production, accounting for about 1% of the U.S. total. Gold, the State's leading commodity, accounted for 70% of the total value of nonfuel minerals produced in the State in 1989, followed by portland cement and crushed stone.

Minerals used in construction accounted for about 30% of the nonfuel mineral production value. In 1989, the value of nonresidential construction permits increased nearly 23% compared with the 1988 value; the number of private and public residential units authorized increased by about 8%.[2] The value of State road contract awards increased by slightly more than 5%, to $122 million.[3] According to the South Dakota Department of Labor, mining employment totaled 2,610 jobs in 1989, about 5% fewer than in 1988. Average hourly earnings for mine production workers was $12.37 in 1989, a slight increase over the 1988 wage rate.

Mineral taxes in South Dakota are levied only on gold and silver production. Collections for the fiscal year ending June 30, 1989, totaled slightly more than $8 million, up 14% from the previous fiscal year, according to the South Dakota Department of Revenue, Severance Tax Unit.

REGULATORY ISSUES

The State Board of Minerals and Environment (SBME) issued two life-of-mine permits in 1989. One was to the South Dakota Cement Commission for a gypsum operation in Meade County. The other was for a small gold mine to be operated on the C & W No. 4 Claim in Pennington County by Mr. Franklin Wolbaum of Custer.

The South Dakota Department of Water and Natural Resources (DWNR) concluded deliberations reported in the 1988 South Dakota Minerals Yearbook

TABLE 1

NONFUEL MINERAL PRODUCTION IN SOUTH DAKOTA[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Cement:							
Masonry	thousand short tons	4	W	4	W	W	W
Portland	do.	519	W	490	W	W	W
Gem stones		NA	$100	NA	$100	NA	$150
Gold[2]	kilograms	W	W	13,981	197,026	16,123	198,318
Lead[2]	metric tons	—	—	—	—	4	3
Sand and gravel (construction)	thousand short tons	e9,600	e19,100	7,929	18,681	e6,400	e20,800
Silver[2]	metric tons	W	W	3	552	4	705
Stone:							
Crushed	thousand short tons	5,070	18,515	e5,500	e20,600	3,833	14,303
Dimension	short tons	50,718	18,209	e43,297	e16,472	54,623	17,738
Combined value of beryllium concentrates (1987), clays (common), feldspar, gypsum, iron ore (1988–89), lime, mica (scrap), and values indicated by symbol W		XX	206,968	XX	32,288	XX	32,341
Total		XX	262,892	XX	285,719	XX	284,358

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

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

[2] Recoverable content of ores, etc.

chapter[4] concerning disposal of incinerated sewage ash stored at Edgemont by Consolidated Management Corp. (CMC). Early in 1989, the DWNR decided to spend CMC's bond money to bury the ash. In November, a contractor for the State completed burial of the material. CMC initially planned to use "proprietary reactor technology" to extract gold and other products from the ash.

EXPLORATION ACTIVITIES

During 1989, gold exploration continued in the Black Hills but at significantly reduced levels from the feverish pace of recent years. According to the DWNR, 16 exploration permits were issued in 1989, down from 24 permits issued in 1988. Of the permits issued in 1989, 14 were for gold and 2 were for industrial minerals. Although most of the gold exploration was in Lawrence County, some also was in Custer and Pennington Counties. New exploration permits were issued to seven companies. A total of 1,858 test holes was permitted for drilled depths ranging from 60 to 12,000 feet. The State also permitted collection of 390 bulk samples and construction of 38 trenches and 18 miles of access road. Gold exploration targets included Precambrian iron formations, Cambrian Deadwood Formation, Mississippian Pahasapa (Madison) Limestone, and Tertiary igneous intrusive rocks.

Companies with State exploration permits included Bond Gold-Richmond Hill Inc., a wholly owned subsidiary of Bond International Gold Inc.; Goldstake Explorations (SD) Inc.; Homestake Mining Co.; Noranda Exploration Inc. (in part through a joint venture with Crown Butte Mines Inc.); Oakmont Resources Inc.; South Dakota Cement Commission; and Wharf Resources (U.S.A.) Inc. Crown Butte announced in June that it had optioned two Noranda gold properties in the Rochford Mining District, about 17 miles south of Lead. In 1987, Noranda was reported to have identified geology and mineralization similar to that at the Homestake Mine at Lead. Crown Butte announced intentions to spend $1.5 million to expand reserves reported to be 2.3 million short tons or 2.1 million metric tons (MMmt), grading 0.11 ounce of gold per ton or 3.77 grams per metric ton (mt), 0.45 ounce of silver per short ton (15.43 grams per mt), and 0.72% copper.[5]

LEGISLATION AND GOVERNMENT PROGRAMS

In November, the Surface Mining Initiative Fund, a coalition of environmental activists, began circulating a petition seeking a November 1990 ballot initiative that would impose a 3,100-acre limit on surface mining in the Black Hills. Earlier in the year, the State Legislature passed, and the Governor signed into law, House Bill 1291, commonly known as the Centennial Environmental Act. Part of the act requires an industry-funded comprehensive environmental evaluation (CEE) when total affected lands under mining permits exceed 3,500 acres. Also enacted was a new law specifying certain lands unsuitable for mining. Originally identified as House Bill 1289, the law denies mining permits for lands that cannot be physically or economically reclaimed. Other provisions of the new law deny mining permits if water pollution cannot feasibly be prevented or if probable adverse socioeconomic impacts of a proposed mining operation outweigh its probable benefits.

The DWNR was involved heavily with mining-related oversight activities in 1989. As a result of the enactment of House Bill 1291, the department supervised the contractor selection and initiation of the CEE study of the Black Hills. Brown, Bortz and Coddington Inc. of Denver, CO, was selected as the contractor, and the report is scheduled for completion by December 1990. The study will address the social, economic, and environmental effects of large-scale gold mining in the Black Hills.

An allotment grant of $138,000 from the 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, 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. Fourteen graduate fellowships were supported by the allotment grant.

Projects undertaken included an investigation of problems associated with the permitting process for new gold mines in South Dakota. The investigation's purpose was to provide technical assistance to South Dakota mining companies and the DWNR. Technical assistance included a study for Wharf Resources comparing sound-level intensity of routine mining operations with those of nonmining sounds in the surrounding inhabited area, including chain saws, jet airplanes flying overhead, traffic noises, and barking dogs. The study concluded that the sound levels emanating from the mine operations were generally of lower intensity than those normally found in an inhabited area.

Another study sought a method to recover efficiently, through the use of centrifugation, the heavy and finely divided mineral particles from light gangue minerals. Success in the research would benefit the mineral processing industry by reducing current losses due to insufficient technology available to recover consistently material finer than minus 325 mesh. The study demonstrated that finely divided heavy and hydrophobic particles could be separated by centrifugal force in a two immiscible liquids system. Further study will be needed to understand the mechanisms of the separation process and to identify important parameters affecting the efficient separation of mixtures of many different types of minerals.[6]

The Bureau of Mines conducted several research projects to improve mine safety and economics at the Homestake Mine. Research results should benefit other deep underground mining operations worldwide. A study to determine the effect of nearby underground mining operations on a major shaft access-way continued. Another project sought ways to safely and economically improve blasting procedures or designs to preserve the integrity of rock surrounding mine workings. A third project involved designing methods to improve underground fire warning alarm systems. Researchers on this project developed a compact, lightweight antenna and an ultra-low-frequency electromagnetic alarm system that allows communication of a mine emergency through short pulsating interruptions in underground lighting systems. The Bureau also began an appraisal of selected mineral resources in

the Black Hills National Forest to determine their potential for development. The commodities specifically targeted for study included beryllium, columbium-tantalum, feldspar, gold, lithium, mica, quartz, silver, and tin. The study was scheduled for completion by late 1990.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Gold and Silver.—The State ranked fourth of 14 States in gold production value and hosted the second largest gold mine in the United States. Production in 1989 totaled 16,123 kilograms (kg) (518,371 troy ounces), valued at $198.3 million, which was a 15% increase in production but a less than 1% increase in value compared with 1988 figures. Gold accounted for 70% of the State's nonfuel mineral production value. The South Dakota Mining Association, of which all the States's major gold producers are members, reported 1989 gold production of 558,600 troy ounces (17,400 kg) at an average cash cost per ounce produced of $274.46.[7] This cash cost did not include startup capital, exploration, administrative overhead, and certain unspecified taxes.[8] Average gold price was $382.58 per ounce. Silver, produced as a coproduct of gold mining, increased significantly in both quantity and value. Precious metals production continued to increase, as in recent years, because of improved efficiency and the full-scale startup of two operations. All of the active major gold operations were in the northern Black Hills of Lawrence County within about a 7-mile radius of Lead, and most produced silver as a coproduct.

South Dakota's five major gold producers in 1989 had nearly $5.7 million invested in reclamation bonding with the State. The total area permitted for disturbance was 2,482 acres, with 1,874 acres disturbed and 190 acres reclaimed during the year. The gold producers had 1,816 employees, for a total annual payroll of nearly $55 million and an average hourly wage, including benefits, of $17.26. The average annual salary for mining-related jobs was $33,683. The industry's supply purchases totaled approximately $67 million. Taxes paid by the gold producers totaled nearly $7.6 million for State severance taxes, almost $4 million in State sales taxes, and $3 million for property taxes.[9]

Homestake Mining Co. was the State's largest gold producer. According to the Homestake 1989 annual report,[10] gold production from the Homestake and Open Cut Mines at Lead totaled 381,788 ounces (11,875 kg), a 2% decrease from the 16-year record production reported in 1988. Open Cut gold production totaled 68,539 ounces (2,132 kg) from 997,050 short tons of ore mined.[11] Overall recovery rate was about 95%. Homestake also reported 4.4 short tons (4 mt) of lead production.

Ore reserves for the Homestake underground mine totaled about 19.8 million short tons grading 0.229 ounce of gold per short ton (7.85 grams per mt), containing about 4.5 million ounces (140,000 kg) of gold, and at the Open Cut about 9.0 million short tons grading 0.122 ounce of gold per short ton (4.18 grams per mt) containing about 1.1 million ounces (34,200 kg) of gold. Total ore reserves for the Lead operations as of yearend 1989 were about 28.8 million short tons, with a weighted average grade of 0.196 ounce of gold per short ton (6.72 grams per mt) and containing about 5.6 million ounces (174,200 kg) of gold. Full production costs at the Lead operations in 1989 totaled $322 per ounce, an increase of $8 per ounce over the previous year. In 1989, exploration expenditures in South Dakota totaled $3.8 million.[12] Homestake's environmental operating expenses totaled nearly $2.6 million, or $6.76 per ounce of gold produced at the Lead operations.[13]

In 1989, Homestake continued exploration from platforms on the 8,000-foot, the deepest, level of the underground mine. Drilling targets included downplunge extensions of historically productive ledges and new ore ledges below the 8,000-foot level. Exploration successfully identified new ore bodies on the 15-ledge structure within the mine.

Underground mining in 1989 was mostly between the 1,400-foot and 7,850-foot levels, with about 25% of all underground production coming from below the 6,800-foot level. The Homestake mill has an annual production capacity of about 2.5 million short tons (2.3 MMmt). Some of the mine tailings were used as backfill in mine operations, and the remainder was deposited in the Grizzly Gulch tailings impoundment. In 1989, an additional lift for the impoundment, begun in 1987, was completed. The new lift was expected to extend the impoundment life until 2003. Construction of a carbon strip regeneration plant was completed and the carbon adsorption facility enlarged to process tailings decant water that could allow annual recovery of an additional 7,000 ounces (218 kg). Additionally, a regrind mill circuit was commissioned in 1989 to process tailings from the gravity circuit and was expected to yield another 4,000 ounces (124 kg) annually.

In August, Homestake announced a planned $30 million expansion of its Open Cut project. The expansion area would include a 26-acre tract mostly south and west of the current open pit and within part of the city of Lead. Also included would be a 92-acre waste disposal area near Central City, north of the current open pit. About 170 private and commercial structures within Lead could be relocated. The expansion would not begin until 1997, assuming all required county and State permitting requirements were completed. The Open Cut mine life would be extended about 5 years, to 2005, and at least an additional 375,000 ounces (11,664 kg) of gold would be added to its yield.

In May, Homestake was named "Business of the Century" by the Industry and Commerce Association of South Dakota. Homestake, formed in 1876 and employing nearly 1,300 South Dakotans, received the award for impacting the State's economy more than any other century-old business.

Wharf Resources increased gold production by 29%, to a record 77,000 ounces (2,395 kg) in 1989 compared with 1988 production.[14] Production increased as a result of completing construction of a new $4 million crushing and treating plant in late 1988. Wharf operated its open pit and cyanide heap-leach project all year and employed 147 people. The operation was north of Terry Peak in the Bald Mountain Mining District of Lawrence County, about 5 miles west of Lead. On-load and offload heap-leach methods extract precious metals from ore by spraying a

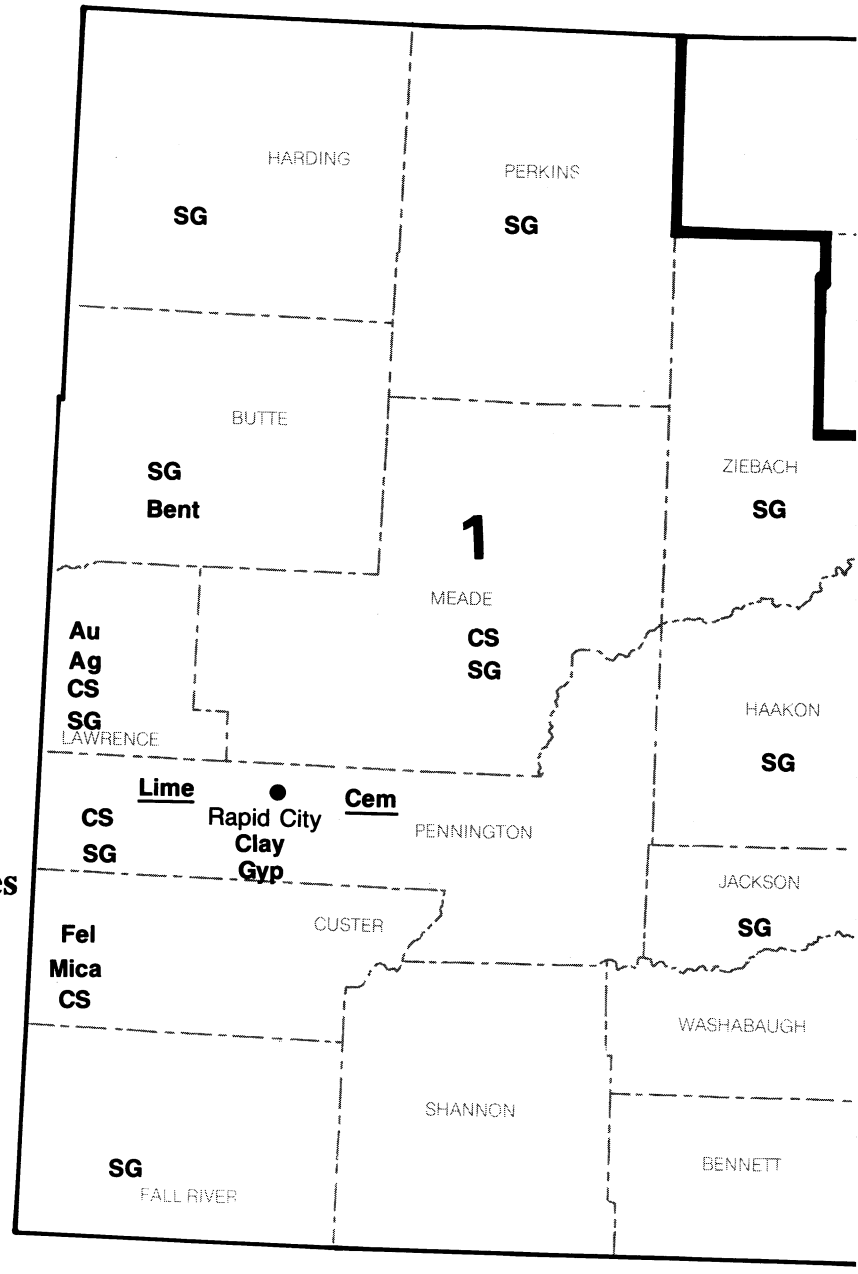
SOUTH

LEGEND

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

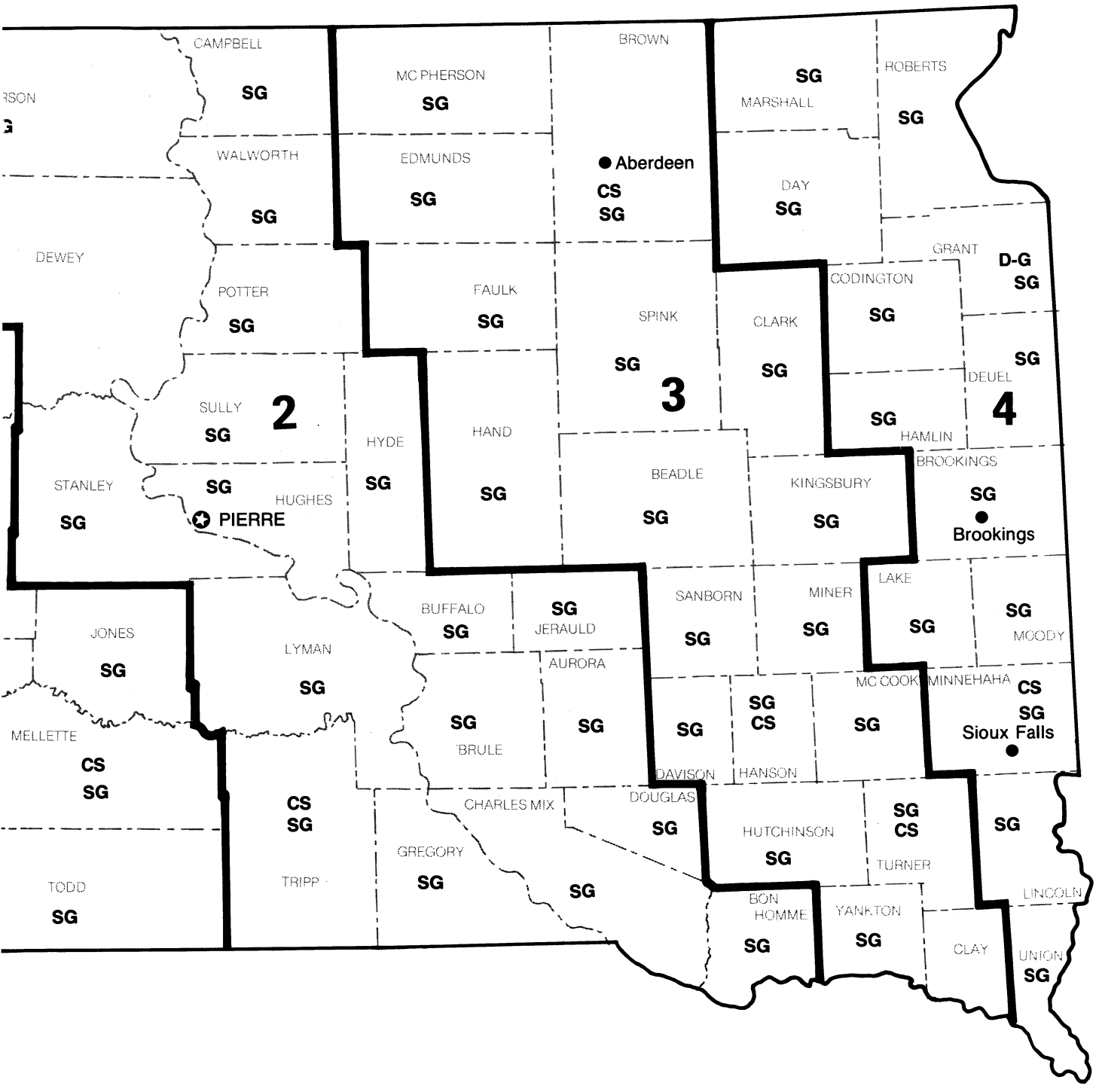
MINERAL SYMBOLS

Ag	Silver
Au	Gold
Bent	Bentonite
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
D-G	Dimension Granite
Fel	Feldspar
Gyp	Gypsum
Lime	Lime plant
Mica	Mica
SG	Sand and Gravel



Principal Mineral-Producing Localities

DAKOTA


CAMPBELL
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MC PHERSON
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BROWN
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MARSHALL
ROBERTS
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WALWORTH
SG
EDMUNDS
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Aberdeen
CS
SG
DAY
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DEWEY
POTTER
SG
FAULK
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SPINK
SG
3
CLARK
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GRANT
D-G
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CODINGTON
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DEUEL
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SULLY
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HYDE
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HAND
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HAMLIN
BROOKINGS
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Brookings
STANLEY
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HUGHES
PIERRE
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BEADLE
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KINGSBURY
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LAKE
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MOODY
BUFFALO
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SG
JERAULD
SANBORN
SG
MINER
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JONES
SG
LYMAN
SG
AURORA
SG
SG
SG
MC COOK
MINNEHAHA
CS
SG
Sioux Falls
MELLETTE
CS
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BRULE
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CS
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DAVISON
HANSON
CS
SG
CHARLES MIX
DOUGLAS
SG
HUTCHINSON
SG
SG
CS
SG
TODD
SG
TRIPP
GREGORY
SG
SG
TURNER
LINCOLN
BON HOMME
SG
YANKTON
SG
CLAY
UNION
SG

diluted solution of sodium cyanide over crushed ore heaped on an impervious pad; the metals dissolved by the solution are then recovered. Operating capacity was 2.3 million short tons of ore per year, but this was expected to be gradually increased by 1991 to 3.1 million short tons. Total ore mined in 1989 was about 2.2 million short tons, at a grade of 0.043 ounce of gold per short ton (1.47 grams per mt). The average direct production cost of sales per ounce of gold in 1989 was $180, down slightly from 1988.[15] Proven and probable ore reserves increased to 26.9 million short tons, at a minable grade of 0.035 ounce of gold per short ton (1.19 grams per mt) for about 936,000 ounces (29,110 kg) of gold.[16] The reserve was based on a 1.42:1 waste-to-ore ratio at $400 per ounce of gold and a cutoff grade of 0.0155 ounce of gold per ton.[17] Wharf was a runner-up in the open pit category for the prestigious Sentinels of Safety Award competition cosponsored by the Mine Safety and Health Administration and the American Mining Congress. Eligibility for the award required at least 30,000 injury-free work hours. Wharf received a certificate of award from the South Dakota Water and Wastewater Association and the DWNR for its management of a public water system.

Brohm Mining Corp., a wholly owned subsidiary of MinVen Gold Corp. produced gold from its Gilt Edge open pit mine and sodium cyanide heap-leach operation at lower than expected levels for much of 1989, its first full year of production. The low production rate was due to an ongoing repair of cell liners on the heap-leach pads. Repair work was hampered by adverse winter weather. In late October 1988, the company determined that the rate of seepage of processing solution through the upper layer of the leach pad into the leak detection system exceeded the amount allowed under the mine's various operating permits, although no leakage occurred into the surrounding environment. Repairs and testing carried over into 1989.

In March, Brohm submitted a plan to the U.S. Forest Service that, if approved, could quadruple the size of its Gilt Edge operation. The proposed $100 million expansion would allow the company to mine sulfide gold deposits adjacent to, and deeper than, the oxide gold ore bodies presently being mined. Announcement of the proposal encountered immediate negative responses from mining opponents because part of the expansion would, for the first time in the Black Hills, involve public lands. Also at issue was the mine operation's need for water resources made scarce in recent years because of drought, and general public concerns about land reclamation and potential damage to recreation areas and wildlife habitat. The company proposed to convert its sodium cyanide heap-leach gold recovery system to a vat-leach system and to construct a 22,000-square-foot milling facility. Employment would triple to 300 jobs. Brohm envisioned having the operation on-line by late 1991.

Production at the Gilt Edge in 1989 totaled 17,161 ounces (534 kg) of gold and 11,862 ounces (369 kg) of silver.[18] MinVen reported that 701,364 short tons of ore were processed, with an average grade of 0.036 ounce of gold per short ton (1.23 grams per mt). Minable proven and probable ore reserves at an average grade of 0.041 ounce of gold per short ton (1.40 grams per mt) were reported by MinVen to be nearly 53.5 million short tons containing almost 2.2 million ounces (68,430 kg) of gold.[19] The on-load and offload sodium cyanide heap-leach operation averaged a 98-day cycle time from pad loading to unloading, with an approximate 67% rate of gold recovery. Cash cost per ounce of gold produced was $407.

Bond Gold-Richmond Hill Inc. (BIG) began mine production at its Richmond Hill project in December 1988. The open pit mine and sodium cyanide heap-leach operation produced 44,603 troy ounces (1,387 kg) of gold in 1989[20] from 1.1 million short tons of ore, with an average grade of 0.040 ounce of gold per short ton (1.36 grams per mt). The company reported proven and probable ore reserves at a cutoff grade of 0.015 ounce per short ton (0.51 grams per mt) of gold of about 2.8 million short tons, at an average grade of 0.050 ounce of gold per short ton (1.71 grams per mt), for a total of 136,000 ounces (4,230 kg) of gold.[21]

In May, BIG battled a weather-related water runoff problem that caused red oxidized fine sediments from the mine site and vicinity to discolor waters feeding into scenic Spearfish Canyon and Bridal Veil Falls. The problem was quickly and voluntarily remedied by the company. In September, LAC Minerals Ltd., of Toronto, Ontario, Canada, acquired a 65% interest in BIG for $373.8 million.

Golden Reward Mining Co. began production at its surface Golden Reward Mine and on-load and offload sodium cyanide heap-leach, Merrill-Crowe zinc precipitation operation in October. The company poured its first doré bar on December 14, 1989. The operation is 3 miles southwest of Lead. Production for 1989 totaled 129 ounces (4.0 kg) of gold and 412 ounces (12.8 kg) of silver. Estimated operating costs for mining and processing, exclusive of royalties and severance taxes, were $178 per ounce of gold.[22] The company reported minable ore reserves of about 13.1 million short tons grading 0.042 ounce of gold per short ton (1.44 grams per mt), at a cutoff grade of 0.015 ounces (0.51 grams). A more detailed description of the operation was provided in the 1988 South Dakota Minerals Yearbook chapter.[23]

The Whitewood Creek joint venture involving Whitewood Creek Development Corp., a subsidiary of Homestake, and Goldstake Explorations (SD) Inc. continued its wait at yearend for a U.S. Environmental Protection Agency (EPA) decision on proposed optional remedies for cleanup of Whitewood Creek. Under guidelines of the Comprehensive Environmental Response, Compensation, and Liability Act, the EPA could allow the joint venture to recover gold from relict mine tailings along an 18-mile stretch of Whitewood Creek. The tailings occur in Butte, Meade, and Lawrence Counties along the Whitewood Creek from just north of the town of Whitewood northward to the confluence of the creek and the Belle Fourche River.

Minerva Exploration Inc., a subsidiary of Naneco Resources Ltd. of Calgary, Alberta, Canada, continued its efforts to secure State approval to begin surface mining operations at its Johnson Gulch project west of Lead. In July, the SBME decided it would not grant transfer of a mining permit to Minerva for the property previously held by Homestake. Minerva acquired the property from Homestake in 1986 with the understanding from the DWNR that the permit would also be transferred. Homestake acquired the permit in 1984 and posted a $661,800

reclamation bond but never mined the property. In April, Homestake was granted return of the bond by the SBME, as no land had been disturbed, with the understanding that the permit would remain active. When Minerva sought a permit transfer in July, SBME members voted that, because mining previously had not occurred and the bond was returned, there was no permit to transfer. At yearend, the issue was under court litigation.

Iron Ore.—Pete Lien & Sons Inc. intermittently produced iron ore from its mining property near Nemo. The material was sold for use in cement production at the South Dakota Cement Plant in Rapid City.

Industrial Minerals

Cement.—The South Dakota cement plant set a sales record in 1989, reversing a 3-year decline. Total sales for the year were reported by the company to have been about 677,000 short tons.[24] The sales increase resulted from taking advantage of spot shortages in some West Coast markets and increased road construction activity in Minnesota and North Dakota. The plant was the State's only cement operation and was owned by the State of South Dakota and governed by a seven-person commission appointed by the Governor. A large percentage of the plant's earnings have been remitted to the State's general fund each year.

Feldspar and Mica.—Contract miners for Pacer Corp. continued to produce feldspar and mica from small pegmatite deposits, mostly near Custer in the southern Black Hills. Producers included Good Faith Mining Co., Pacer Corp., and Rose Quartz Enterprises, all of Custer, and Dakota Gold & Quartz Co. of Rapid City. In 1989, feldspar production and value decreased about 13% and 31%, respectively, compared with 1988 figures. During the same period, scrap mica decreased about 14% in quantity and value. South Dakota ranked second of seven producing States.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988. Construction sand and gravel production was estimated to have decreased 19%; however, value was estimated to have increased 11%.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Crushed stone was produced from 13 quarries in 7 counties by 13 operators. Production and value in 1989 decreased about 30% and 31%, respectively, compared with estimates for 1988. Counties leading in production were Minnehaha, Pennington, and Hanson. Leading uses for crushed stone were in concrete aggregate, cement manufacturing, railroad ballast, and lime manufacturing. Unit values for all crushed stone ranged from $6.50 per short ton for terrazzo and exposed aggregate to $1.38 per ton for cement manufacturing. Average unit value was $3.73. The leading uses for crushed limestone and dolomite were in cement manufacturing, concrete aggregate, and lime manufacturing. Unit values for limestone and dolomite averaged $2.87, but ranged from $4.78 per ton for riprap and jetty stone to $1.38 for cement manufacturing.

Dimension.—South Dakota ranked ninth of 34 States in dimension stone production. Grant County hosted five granite dimension stone operations, all near Milbank. Production and value of dimension stone increased 26% and 8%, respectively, in 1989. In May, Dakota Granite Co. commissioned its new 14-foot-diameter slab-cutting saw, believed to be the world's largest.

Other Industrial Minerals.—Common clay and shale increased in production and value about 29% and 22%, respectively, during 1989. Crude gypsum decreased about 9%, and value decreased about 10%. All of the gypsum was used in cement manufacturing by the State's plant at Rapid City. Hydrated lime and quicklime production and value decreased 8% and 7%, respectively.

TABLE 2

SOUTH DAKOTA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch): Riprap and jetty stone	75	336
Coarse aggregate, graded:		
Concrete and bituminous aggregate (coarse)	598	2,864
Bituminous surface-treatment aggregate	99	506
Fine aggregate (−3/8 inch): Stone sand, concrete and bituminous mix or seal	166	515
Coarse and fine aggregate:		
Graded road base or subbase	186	701
Crusher run or fill or waste	13	39
Other construction materials[2]	307	1,278
Other miscellaneous uses[3]	1,064	2,023
Unspecified:[4]		
Actual	773	4,258
Estimated	552	1,783
Total	3,833	14,303

[1]Includes limestone, quartzite, sandstone, and miscellaneous stone.
[2]Includes stone used in railroad ballast, screenings (fine), unpaved road surfacing, and terrazzo and exposed aggregate.
[3]Includes stone used in cement manufacture, lime manufacture, and abrasives.
[4]Includes production reported without a breakdown by end use and estimates for nonrespondents.

[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN. Assistance in the preparation of the chapter was given by Wanda J. West, editorial assistant.

[2] U.S. Department of Commerce written communication.

[3] Highway and Heavy Construction. Market Update: Battle Lines Form Over Gridlock, Gas Tax. V. 132, No. 3, Mar. 1989, p. 34.

[4] Esparza, L. E. South Dakota. Ch. in BuMines Minerals Yearbook 1988, v. II, p. 448.

[5] The Northern Miner. Crown Butte Options Noranda Properties. V. 75, No. 16, June 26, 1989, p. 13.

[6] South Dakota Mining and Mineral Resources Research Institute. Annual Status and Final Report 1989. South Dakota School of Mines and Technology, Rapid City, SD. 81 pp.

[7] Internationally, gold price quotes use ounces and dollars as units of measure.

[8] South Dakota Mining Association (Sioux Falls, SD), 1990 Industry Status Report. 5 pp.

[9] Work cited in footnote 8.

[10] Homestake Mining Co. (San Francisco, CA). 1989 Annual Report to Stockholders. 40 pp.

[11] Homestake Gold Mine Employee Newsletter. V. 9, No. 1, Feb. 1990, p. 1.

[12] Homestake Mining Co. (San Francisco, CA). 1989 Form 10-K Report. 38 pp.

[13] Work cited in footnote 12.

[14] Wharf Resources Ltd. (Toronto, Ontario, Canada). 1989 Annual Report to Stockholders. 24 pp.

[15] Work cited in footnote 14.

[16] Dickenson Mines Ltd. (Toronto, Ontario, Canada). Annual Report to Stockholders, p. 11.

[17] Dickenson Mines Ltd. (Toronto, Ontario, Canada). 1989 Form 10-K Report, p. 11.

[18] MinVen Gold Corp. (Lakewood, CO). 1989 Annual Report to Stockholders, pp. 4–5.

[19] Work cited in footnote 18.

[20] LAC Minerals Ltd. (Toronto, Ontario, Canada). 1989 Annual Report to Stockholders, p. 27.

[21] Bond International Gold Inc. (Denver, CO). Financial Report, July 1–Dec. 31, 1989, pp. 6–7.

[22] MinVen Gold Corp. (Lakewood, CO). 1989 Form 10-K Report, 120 pp.

[23] Esparza, L. E. South Dakota. Ch. in BuMines Minerals Yearbook 1988, v. II, pp. 450–451.

[24] The Rapid City Journal. Cement Plant Sets Record. Jan. 19, 1990, p. A6.

TABLE 3

SOUTH DAKOTA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(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 aggregate (+1 1/2 inch)[1]	(2)	(2)	—	—	W	W	W	W
Coarse aggregate, graded[3]	(2)	(2)	—	—	W	W	W	W
Fine aggregate (−3/8 inch)[4]	(2)	(2)	—	—	W	W	W	W
Coarse and fine aggregates[5]	(2)	(2)	—	—	W	W	W	W
Other construction aggregates	676	2,776	—	—	—	—	—	—
Chemical and metallurgical[6]	(7)	(7)	—	—	—	—	—	—
Special[8]	—	—	—	—	—	—	W	W
Other miscellaneous	1,049	1,985	—	—	—	—	—	—
Unspecified:								
Actual[9]	—	—	—	—	—	—	W	W
Estimated[10]	552	1,783	—	—	—	—	—	—
Total	[11]2,276	6,544	—	—	W	W	W	W

W Withheld to avoid disclosing company proprietary data.

[1] Includes riprap and jetty stone and filter stone.

[2] Withheld to avoid disclosing company proprietary data; included with "Other construction 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 fine aggregate (screening-undesignated).

[5] Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run or fill or waste.

[6] Includes crushed stone for cement manufacture and lime manufacture.

[7] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."

[8] Includes crushed stone for abrasives.

[9] Includes production reported without a breakdown by end use.

[10] Includes estimates for nonrespondents.

[11] Data do not add to total shown because of independent rounding.

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 Bond International Gold Inc.[1]	601 West Main St. 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.[1]	Box 888 Lead, SD 57754	do.	Do.
Homestake Mining Co.[1 2]	Box 875 Lead, SD 57754	Underground mine and open pit, cyanidation mill, gravity separation, refinery	Do.
Wharf Resources (U.S.A.) Inc.	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	Pennington.
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, 1988):			
Bob Bak Construction Co.	Box 256 White River, SD 57579	Pits and plant	Corson.
Birdsall Sand & Gravel Co.	Box 767 Rapid City, SD 57709	Pits and plants	Fall River, Pennington, Sully.
Brownlee Construction Co.	Route 3 Watertown, SD 57201	do.	Codington.
Tom Luke Construction Co.	Box 169 Kimball, SD 57355	do.	Brule and Sanborn.
Bernard Mahrer Construction Inc.	Main St. Rutland, ND 58067	do.	Marshall.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Stone:			
Crushed:			
Limestone:			
Pete Lien & Sons Inc.	Box 440 Rapid City, SD 57709	Quarry and plant	Pennington.
Northwestern Engineering Co. (Hills Materials Co.)	Box 2320 Rapid City, SD 57709	Quarries and plants	Do.
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 57101	do.	Minnehaha.
Spencer Quarries Inc.	Box 25 Spencer, SD 57374	do.	Hanson.
Sweetman Construction Co.	Box 809 Sioux Falls, SD 57101	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.
[2] Also lead.

THE MINERAL INDUSTRY OF TENNESSEE

This chapter has been prepared under a Memorandum of Understanding between the 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] Gregory A. Upham,[2] and Robert E. Fulweiler[3]

The value of nonfuel mineral commodities produced in Tennessee in 1989 increased approximately 9% over that of 1988 to an alltime high of $638.4 million. The State's three leading nonfuel commodities, cement, crushed stone, and zinc, accounted for more than 80% of the total. Tennessee led the Nation in the value of zinc produced for the 29th time in the past 32 years. The State also ranked first in the value of ball clay and gem stones produced. Overall, Tennessee's national ranking for the value of all nonfuel minerals produced improved from 17th in 1988 to 16th.

TRENDS AND DEVELOPMENTS

For the fourth consecutive year, the value of Tennessee's nonfuel mineral production achieved a record high, primarily as a result of increases in the value of crushed stone and zinc. A review of the past decade shows that the value of the State's mineral production grew in 1980 and 1981, but dropped in 1982, reflecting the recession that affected most of the Nation. After a sharp rise in 1983 and 1984, the value of mineral production remained relatively stable until 1987. The past 3 years have shown a significant increase each year.

Major transactions affecting the zinc industry included the purchase by Union Zinc Inc. of USX Corp.'s zinc operations and King Hill Mines Inc.'s inactive Idol Mine in eastern Tennessee. Union Zinc also expanded its mining operations in middle Tennessee by opening a new ore body at its Elmwood-Gordonsville Mine.

Watts Blake Bearne & Co. PLC (WBB) acquired Cyprus Minerals Co.'s ball clay assets in Tennessee and Mississippi.

American Limestone Co., a wholly owned subsidiary of ASARCO Incorporated, acquired Acme Stone Co., Porter Brown Limestone Co. Inc., and Robco Materials Co.

Luck Stone Co. of Richmond, VA, entered the Tennessee dimension stone industry by purchasing a dimension stone fabrication plant in Knoxville and a quarry and plant in Blount County from the Marble Shop Inc.

Baroid Corp., formerly NL Baroid, sold its barite properties and reserves in the Sweetwater District, McMinn and Monroe Counties, to New Riverside Ochre Co. of Cartersville, GA.

At yearend, Federal Bankruptcy Court auditors were reviewing proposals from three prospective buyers of the Tennessee Chemical Co. (TCC), a Copperhill sulfuric acid producer. TCC filed for Chapter 11 bankruptcy protection in June.

EMPLOYMENT

Tennessee's mining industry employed

TABLE 1

NONFUEL MINERAL PRODUCTION IN TENNESSEE[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Clays[2]	metric tons	1,143,846	$25,480	1,165,736	$27,696	1,137,152	$26,292
Sand and gravel (construction)	thousand short tons	e7,900	e28,900	6,836	23,343	e6,100	e21,900
Stone:							
Crushed	do.	51,406	227,263	e52,200	e235,000	52,917	252,785
Dimension	short tons	3,360	573	e3,942	e567	4,888	437
Zinc[3]	metric tons	115,699	106,926	119,954	159,201	W	W
Combined value of barite, cement, clays (bentonite 1988, common 1989, fuller's earth), copper, gem stones, lead, lime, phosphate rock, pyrites, (1987), sand and gravel (industrial), silver, and value indicated by symbol W		XX	138,670	XX	139,842	XX	336,993
Total		XX	527,812	XX	585,649	XX	638,407

e Estimated. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

6,300 of the 2.2 million people working in the nonagriculture sector. Although total nonagricultural employment increased by 2.7% over that of 1988, mining employment decreased 4.5%.

REGULATORY ISSUES

Tennessee Department of Health and Environment (TDHE) officials began developing tighter regulations on water quality standards to comply with U.S. Environmental Protection Agency (EPA) rules. In June, EPA released a list of 600 waterways in the United States considered to be polluted by one or more of 126 toxins. Seventeen are in Tennessee, including three being polluted by municipal water sewage treatment plants, three by the U.S. Department of Energy weapons plants at Oak Ridge, three by the Oak Ridge National Laboratory, and eight by private industry. TDHE had until February 1990 to develop the regulations, and affected operations would have until mid-1992 to comply.

The EPA also ordered Jersey Miniére Zinc Co. (JMZ), a division of Union Zinc Inc., to either install filtering equipment or pipe wastewater from its Clarksville refinery directly to the Cumberland River. For the past 10 years, JMZ has discharged the water into a settling area that has formed a wetland containing fish and aquatic life. Filtering equipment that the EPA required before allowing continued discharge into the settling area would be more costly than the $200,000 to $300,000 JMZ estimates it will cost to build the pipeline to the river. JMZ officials indicated[4] the company would build the pipeline, although both they and TDHE personnel disagree with the EPA ruling because it would cause the wetland to dry up, killing the fish and aquatic life.

JMZ received the Tennessee Association of Business' highest corporate environmental award for overall environmental excellence at its Clarksville refining operation. JMZ was selected for its projects to recover metals from wastewater sludge, to reduce sulfur dioxide emissions to one-half EPA standards, to install equipment to further reduce emissions, and to store solid waste on-site in anticipation of future technology that will allow additional recovery of metals. In addition, the company has developed a 550-acre site surrounding its plant as a wildlife and bird sanctuary and a hiking area.

A formidable reclamation program is slowly transforming the barren lifeless landscape of the Copper Basin. So far the effort has taken more than 50 years and involved the planting of 15.2 million trees. Biologists estimate[5] it will be another 100 years before a layman will not be able to detect the difference between the basin and surrounding forests. Officials plan to keep a small part of the basin denuded as a reminder of what can result from deforestation and other ecological travesties. The 100-square-mile region is punctuated with bare craggy hills, collapsed mine shafts, and countless gullies.

Devastation began shortly after the discovery of rich seams of copper ore in the 1830's. Several mining companies began melting copper from the rock by building huge open fires. Trees were cut from miles around to fuel the fires that emitted massive amounts of sulfur dioxide. This killed much of the remaining vegetation and turned the soil even more acidic, making it unable to support most native plants. By 1878, about 50 square miles were mostly denuded.

The effort to reclaim the area began in the mid-1930's, and large-scale replanting by the Tennessee Copper Co. and the Tennessee Valley Authority (TVA) began in 1939. Efforts did not reach intensive proportions until the 1970's and 1980's when an average of 500,000 seedlings were planted each year, and reclamation costs averaged $225,000 per year. TVA now lists less than 11,000 acres as lacking vegetative cover, about one-third the original damaged area. About 1,200 acres remain classified as denuded.

EXPLORATION ACTIVITIES

Union Zinc Co. began an exploration drilling program at its newly acquired Idol zinc mine. If the drilling proves sufficient additional reserves, Union Zinc plans to reopen the mine during 1990.

LEGISLATION AND GOVERNMENT PROGRAMS

Only two laws affecting mineral activity were enacted during 1989. The first was a bill allowing phosphate rock-carrying trucks a margin of error for purposes of weight restriction enforcement. The second extended Tennessee's participation in the Interstate Mining Compact to June 30, 1990. The Surface Mining Section (SMS) of the Division of Water Pollution Control discontinued inspecting gravel operations in accordance with an amendment to the Mineral Surface Mining Law of 1972. The amendment exempted from State mine inspections gravel operations in counties having a population of less than 600,000. This brought the mining status of gravel into conformance with sand, which was exempted in the original law. Shelby County, with Memphis as its major city, was the only county in which sand and gravel operations continued to be inspected.

SMS conducted more than 1,200 noncoal mine inspections using three full-time inspectors. There were 128 operations with a permitted area of more than 3,780 acres active during the year. SMS also completed 10 Abandoned Mine Land (AML) restoration projects covering 117 acres at a total cost of $253,000. Two of the sites, comprising 14 acres, were reclaimed by a community college to serve as outdoor laboratories. Students gained hands-on experience developing the reclamation plans and operating the heavy equipment used to reclaim the areas. SMS also began its first noncoal AML reclamation project restoring abandoned barite mines in the Sweetwater area.

The Tuscaloosa Research Center of the Bureau of Mines released a report identifying mining and beneficiation waste characteristics, generation rates, and waste storage facilities for active phosphate operations in Tennessee.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Eight industrial minerals were mined in Tennessee in 1989. Four additional industrial mineral commodities were produced from raw materials mined within the State, shipped from other States, or imported. Of the latter four commodities, the values of cement and lime are included in table 1. The values

of synthetic graphite and expanded perlite are not included. The value of the industrial mineral commodities included in table 1 accounted for 68% of the total mineral value produced in 1989.

Barite.—Tennessee was one of the six States producing barite. The State's only producer, A. J. Smith, Jr., operated a mine and jigging plant on his own property in Loudon County. Smith also received a permit to mine barite 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. earlier in the year. The properties comprise approximately 1,100 acres of fee-simple and 1,200 acres of mineral-rights-only that Baroid acquired from L. A. Woods in the mid-1950's. Woods had worked the properties since the 1920's, producing barite for the drilling-mud and filler markets in the eastern and northern United States. Baroid had produced from 5,000 to 10,000 tons per month from several open pits to supply drilling mud to the Gulf of Mexico. Although reserves were adequate and quality was high, Baroid was forced to close its Tennessee operations in the mid-1970's because of a decline in the U.S. oil industry. Additionally, because of transportation costs from the inland source to consuming markets, Tennessee barite was not competitive with low-cost overseas exports.

Cement.—Portland cement production decreased slightly more than 5% in both volume and value, countering the national trend that showed a slight increase. Masonry cement production decreased more than 9%. Cement was produced by Signal Mountain Cement Co., a subsidiary of IFI International, at Chattanooga and by Dixie Cement Co., a subsidiary of Southdown Inc. since 1988, at Knoxville. Signal Mountain operated a two-kiln, 450,000-short-ton-per-year wet-process clinker capacity facility. Dixie operated a two-kiln, 550,000-short-ton-per-year dry-process plant.

Clays.—Ball clay, common clay, and fuller's earth were produced in Tennessee. The volume of clay production decreased 2.5%, and the value decreased 5.1% from that of 1988. Tennessee ranked 10th in volume and 4th in value with respect to the 38 States that produced clay in 1989. Nine companies mined clay from 22 pits in 12 counties.

Tennessee produced 71% of the ball clay mined in the United States, an increase over the 66% produced in 1988. Ball clay was produced by 4 companies operating 13 pits in 4 counties. Approximately two-thirds of the ball clay was mined in Weakley County.

The types of ball clay sold or used by producers in 1989 were: air-float (54%), water-slurried (16%), and unprocessed (30%). Ball clay production was 641,000 metric tons, 3% less than that produced in 1988.

The major end uses of ball clay, in order of amount sold or used by producers, were sanitaryware, dinnerware, floor and wall tile, exports, ceramics, fillers, extenders and binders, and refractories.

The purchase of the ball clay operations of Cyprus Industrial Minerals by WBB was made through its wholly owned subsidiary, United Clays Inc., for $7.32 million.[6] The purchase included extensive fee-simple and mineral-rights-only properties, as well as long-term leases in Tennessee and Mississippi. Also included were a mobile plant, storage facilities, processing plant, and other equipment used in extraction and processing operations. As a result of the acquisition, United Clays became the third largest ball clay producer in the United States.

Cyprus had previously announced the sale of its ball clay and kaolin operations to another Tennessee company, Kentucky-Tennessee Clay Co. (K-T Clay), a subsidiary of Hecla Mining Co., but the Federal Trade Commission disallowed the sale of the ball clay portion. K-T Clay was allowed to purchase Cyprus' kaolin operations in Georgia and South Carolina, however.

Common clay production was reported by only two companies from six pits in five counties. It accounted for 37% of the total volume of clay produced, but for only 3% of the value.

Principal end uses of common clay were for extruded brick, which accounted for more than 75% of the total usage, and for cement. General Shale Products Corp., a Johnson City brick manufacturer, was the State's leading producer of common clay. It permitted 9 pits comprising 295 acres and had an application to permit an additional 12 acres pending at yearend. General Shale produced face brick, under-concrete blocks, ready-mixed concrete, sand, and aggregate from plants in nine eastern and middle Tennessee locations and in four other States.

Montmorillonite fuller's earth was mined by Moltan Minerals Co. from two pits and processed at its plant near Middleton in Hardeman County. Southern Clay Inc., a subsidiary of Lowe's Inc., produced fuller's earth from one pit and a plant near Paris, Henry County. Production decreased by 1% while the value increased 6% over that of 1988. Major end uses of the fuller's earth were for pet waste and industrial absorbents and as a fungicide carrier.

Gem Stones.—Tennessee once again led the Nation in the value of natural gem stones produced, although their value was down more than 37% from that of 1988. Gem stone production consisted almost entirely of cultured freshwater pearls and, to a much lesser extent, mother-of-pearl. Two companies, American Pearl Farms and American Shell Co. Inc., operated cultured pearl farms in the western portion of the Tennessee River System. The largest producer, American Pearl Farms, completed its third major harvest from the five farms that it operated. Development of a sixth farm, planned to be nine times larger than the existing farms, was postponed to 1991 after originally being scheduled to be in operation by 1989. An associate company of American Pearl Farms, Tennessee Shell Co., continued as the major producer of mother-of-pearl.

Lime.—Lime produced in Tennessee was another commodity that dropped in volume but showed a significant increase in value over that of 1988. The volume decreased 5.9% while the value increased 8.2%. Tennessee ranked 15th in volume and 17th in value with respect to the 32 States producing lime. 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. Limestone was quarried for the manufacture of lime by Tenn-Luttrell and the Stoneman Co., a subsidiary of Beazer

USA Inc., at McMinnville, Warren County, and Shelbyville, respectively.

Phosphate Rock.—Production of phosphate rock increased 1.8% in quantity and 7.0% in value over that of 1988. The phosphate rock had an average P_2O_5 content of approximately 26%. The phosphate mined occurs as a residual deposit in the Ordovician Bigby Limestone. As is typical in residual deposits, concentrations of ore tend to be irregularly distributed. This resulted in the opening of numerous relatively small pits within the individual phosphate mining districts. The State's largest producer, Occidental Chemical Corp., had 6 sites permitted in Giles County, 3 in Hickman County, and 28 in Maury County. The ore was processed in its plant at Columbia, Maury County. Its active mining was concentrated in Giles County on 2,700 acres purchased from TVA. The purchase marked the second major sale of TVA phosphate properties and represented the last of the phosphate properties that TVA controlled in middle Tennessee. Stauffer Chemical Co., now Rhone-Poulenc Basic Chemicals Co., previously purchased approximately 2,000 acres of mineral rights in Williamson County. Officials from both companies indicated the purchases had significantly increased their reserves and extended the effective life of their operations. Rhone-Poulenc Basic had 6 sites permitted in Giles County, 14 in Maury County, and 6 in Williamson County. Its major production was from Williamson County, also on property acquired from TVA. The ore was processed at its Mount Pleasant plant in Maury County.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the 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 estimates for 1987 and 1989.

Based on estimated construction sand and gravel production, the volume decreased 11%, and the value decreased 6% from that of 1988. Sixty-seven companies operating 139 pits in 36 counties were permitted to mine sand and gravel when the State discontinued inspecting such operations at the beginning of 1989. The major uses of construction sand and gravel, each consuming more than 200,000 short tons, were concrete aggregates, road base and cover, asphalt concrete, and concrete products.

Industrial.—Industrial sand production showed significant increases in volume and in value over that of 1988. Industrial sand was produced by the Morie Co. Inc. near Camden, Benton County, and at Bruceton, Carroll County, and by Short Mountain Silica Co. (SMS) near Mooresburg, Hawkins County. No industrial gravel production was reported. The Morie Co. produced sand from Quaternary alluvial terraces of the Tennessee River in Benton County and the Big Sandy River in Carroll County. The sand was used mainly for automotive glass by the Ford Motor Co. glass plant at Nashville, with lesser amounts sold to the container glass, molding and core facings, golf course sand, blasting sand, and filtration sand markets.

SMS produced from the Silurian Clinch Sandstone. Its major production has been for the flat glass market, with approximately one-third going to the molding and core facings and specialty sand markets. During the year, SMS expanded its operations and entered the concrete mortar, sandblasting, and golf course sand markets.

Tennessee Electrominerals, a subsidiary of C-E Minerals Inc., produced fused silica, an amorphous glass form with high-purity, low-thermal conductivity and high resistance to thermal shock, at its plant at Greeneville, Greene County. Fused silica is produced by fusing high-purity silica sand in electric arc furnaces at temperatures exceeding 1,700° C. Its major uses are as inert extenders and fillers for resins used in the electronics industry and as a heat insulator in the form of tiles and foam brick.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Tennessee stone statistics are compiled by geographical districts as depicted on the State map. Table 3 presents end-use statistics for Tennessee's three districts.

Crushed.—Crushed stone was Tennessee's leading mineral commodity, accounting for 58% of the total value of industrial minerals and 40% of the total mineral production. Tennessee ranked seventh in volume and eighth in value nationally with respect to the 37 other States producing crushed stone. The volume increased 1.4% and the value increased 7.6% over those estimated for 1988. Limestone was the major rock type quarried, accounting for 93% of total production.

Seventy-one companies with 124 operations and 125 quarries in 60 of Tennessee's 95 counties reported crushed stone production. The three largest companies were Vulcan Materials Co. (26 quarries), American Limestone Co. (10 quarries), and Rogers Group Inc. (14 quarries). Major uses of crushed stone, in order of quantity produced, were 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 Limestone at Crab Orchard, Cumberland County, and at Anderson, Franklin County. The Anderson operation was purchased from Cowan Stone Co. during the first quarter of the year.

American Limestone Co.'s acquisition of Acme Stone Co. for $2.1 million[7] was part of Asarco's overall plan to grow in industries, such as construction aggregates, away from its traditional nonferrous metals business. Acme's limestone operations, just north of the Tennessee border, 130 miles northeast of American Limestone's Knoxville headquarters, provided access to markets in the middle eastern part of the United States. The acquisition of Porter Brown Limestone Co. Inc. and Robco Materials Co., both of Springfield, Robertson County, coupled with the Acme acquisition, increased American Limestone's production capacity by approximately 1 million short tons per year. This made American Limestone 1 of the 50 largest crushed stone producers in the Nation.

Another crushed stone producer, Crossville Limestone Inc., was sold at bankruptcy auction for $380,000 to Sugar Creek Clay and Limestone Inc. of Ohio. Sugar Creek plans to continue operating the plant with the present workers.

TABLE 2

TENNESSEE: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	171	734
Riprap and jetty stone	946	3,636
Filter stone	539	2,486
Other coarse aggregate	33	160
Coarse aggregate, graded:		
Concrete aggregate, coarse	7,996	33,605
Bituminous aggregate, coarse	7,006	30,736
Bituminous surface treatment aggregate	1,165	6,517
Railroad ballast	364	1,408
Fine aggregate (−3/8 inch):		
Stone sand,concrete	874	5,208
Stone sand, bituminous mix or seal	488	1,815
Screening, undesignated	2,857	12,779
Coarse and fine aggregates:		
Graded road base or subbase	4,782	19,763
Unpaved road surfacing	704	3,046
Crusher run or fill or waste	8,586	34,958
Other construction materials:	792	3,451
Agricultural:		
Agricultural limestone	744	3,028
Poultry grit and mineral food	341	2,119
Chemical and metallurgical: Lime manufacture	969	15,469
Special: Mine dusting or acid water treatment	20	254
Other miscellaneous uses:[2]	3,100	14,399
Unspecified:[3]		
Actual	9,238	47,248
Estimated	1,202	9,965
Total	52,917	[4]252,785

[1]Includes limestone, dolomite, sandstone, and miscellaneous stone.
[2]Includes stone used in cement manufacture, flux stone, sulfur oxide removal, asphalt and other fillers or extenders, whiting or whiting substitutes, roofing granules, and waste materials.
[3]Includes production reported without a breakdown by end use and estimates for nonrespondents.
[4]Data do not add to total shown because of independent rounding.

Luck Stone created a new group, Tennessee Marble Div., to manage the operations acquired from the Marble Shop. (See Trends and Developments section of this report.) Luck Stone now operates 13 crushed and dimension stone quarries and 5 fabrication shops, most of which are in Virginia. At another foreclosure auction, no one bid for the Candora Marble and Granite Co., a once-thriving 93-year-old dimension stone producer in south Knoxville. Candora supplied much of the Tennessee marble used to construct the East Building of the National Gallery of Arts in Washington, DC, in 1978. The company also had a $1.75 million contract to supply granite for the John J. Duncan Federal Building in Knoxville, but did not complete the job.

Dimension.—The quantity of dimension stone produced increased 24% while the value decreased 23% from values reported in 1988. The incongruity appears to be attributable largely to a reported decrease in the unit value of several types of monumental stone. Dimension stone was produced by the Crab Orchard Stone Co., Ross L. Brown Cut Stone Co., Luck Stone Co., Imperial Black Marble Corp., Turner Brothers Stone, and the Houston Co. Luck Stone's quarry was in Blount County, Imperial's quarry was in Grainger County, and all of the others were in Cumberland County.

Other Industrial Minerals.—Several industrial minerals were shipped into Tennessee where they were used to manufacture higher value products. The value of these added value products is not included in the value of minerals commodities produced or mined in the State. Tennessee ranked first nationally in the production of synthetic graphite. The quantity increased 60% over that reported in 1988, while the value increased by 64%. Union Carbide Corp. produced anodes, electrodes, unmachined shapes, and graphite powder at plants in Clarksville and Columbia. The Fortafil Fibers Div. of Akzo-Enka America Inc. produced high-modulus fibers at its Rockwood, Roane County, plant.

Byproduct gypsum was produced during the zinc refining process at JMZ's Clarksville operation and the phosphate processing operations in Maury County. JMZ was attempting to develop markets for the gypsum.

Cyprus Foote Mineral Co. announced plans to expand production of butyllithium at its plant at New Johnsonville, Humphreys County. The plant produced a full line of downstream organolithium compounds and lithium metal from lithium ore mined at its Chilean, Nevada, and North Carolina operations. Butyllithium was used in synthetic rubber and pharmaceutical products and was produced using lithium metal as the raw material.

Expanded perlite was processed by Chemrock Corp. in Nashville. Finished products included horticultural aggregate, fillers, cavity fill insulation, oil-water absorbents, and plaster and concrete aggregate. C-E Minerals Inc. produced fused magnesia at its Tennessee Electrominerals' fused-silica plant in Greeneville for use in electrical insulation applications. Typical applications include insulation in domestic appliances, water-heater elements, kilns, welding machines, and general heating systems.

Tennessee Chemical Co., while under Chapter 11 bankruptcy protection, continued to produce sulfuric acid at its plant in Copperhill. The company declared bankruptcy shortly after em-

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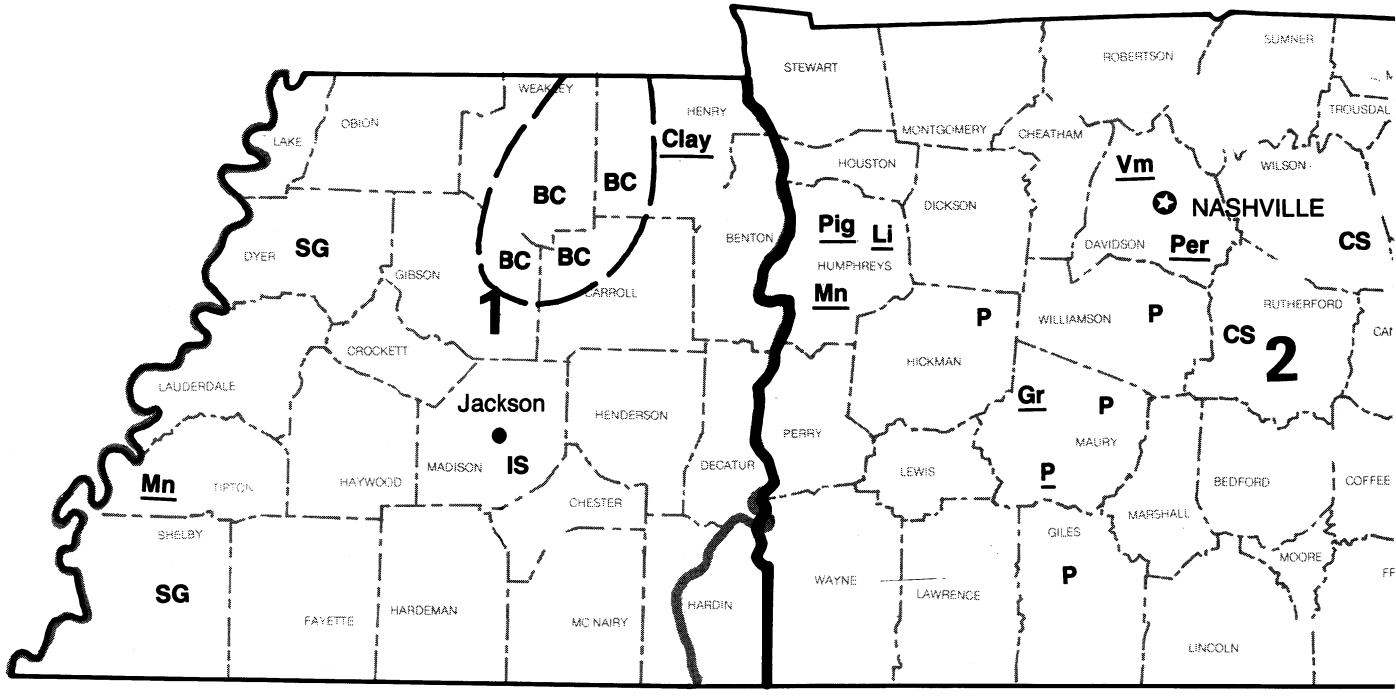


LE

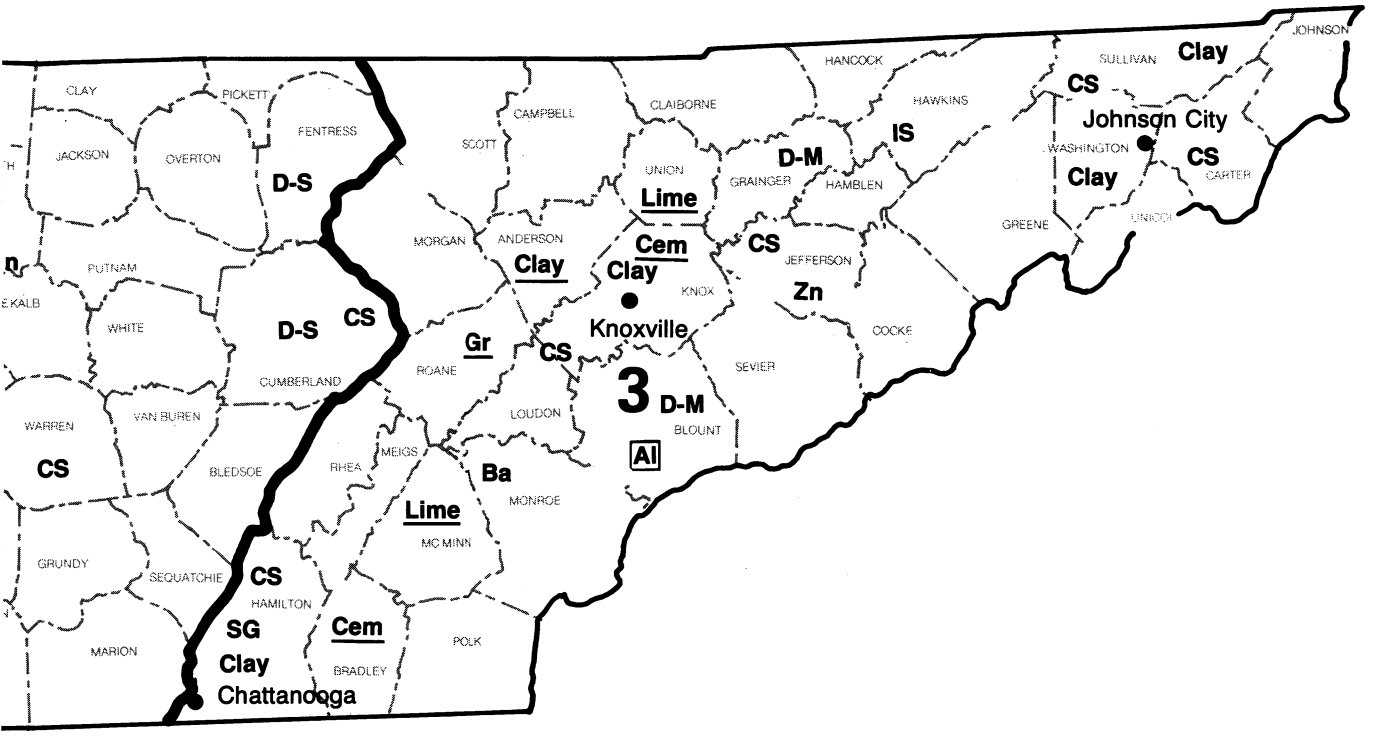
State boundary
County boundary
Capital
City
Waterway
Crushed stone/sand & gravel districts

MINERAL

Al Aluminur
Ba Barite
BC Ball Clay
Cem Cement
Clay Clay
CS Crushed
D-M Dimensic
D-S Dimensic
Gr Graphite
IS Industria
Li Lithium p

Principal Minera

SSEE



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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

roducing Localities

TABLE 3

TENNESSEE: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	W	W	825	2,801	W	W
Coarse aggregate, graded[2]	W	W	6,591	28,066	W	W
Fine aggregate (−3/8 inch)[3]	W	W	1,746	6,832	W	W
Coarse and fine aggregates[4]	W	W	9,026	34,045	W	W
Other construction aggregates	—	—	791	3,445	W	W
Agricultural[5]	W	W	334	1,634	W	W
Chemical and metallurgical[6]	—	—	890	3,264	W	W
Special[7]	—	—	([8])	([8])	W	W
Other miscellaneous	—	—	1,091	5,496	W	W
Unspecified:						
Actual[9]	W	W	5,802	30,504	W	W
Estimated[10]	—	—	998	8,976	W	W
Total	W	W	28,094	[11]125,064	W	W

W Withheld to avoid disclosing company proprietary data.
[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), and fine aggregate (screening-undesignated).
[4] Includes crushed stone for graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[5] Includes agricultural limestone and poultry grit and mineral food.
[6] Includes crushed stone for cement manufacture, lime manufacture, flux stone, and sulfur oxide removal.
[7] Includes crushed stone for mine dusting or acid water treatment, asphalt fillers or extenders, whiting or whiting substitutes, other fillers or extenders, roofing granules, and waste material.
[8] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[9] Includes production reported without a breakdown by end use.
[10] Includes estimates for nonrespondents.
[11] Data do not add to total shown because of independent rounding.

ployees represented by the International Chemical Workers Union voted to strike if their demands were not met when a 1-year extension to their contract expired on April 15.[8] TCC employed 436 workers at the plant, 250 hourly and the rest salaried. In its bankruptcy petition, TCC stated that current economic conditions made it impossible to operate unless employees made concessions, including wage reductions, changes in work rules, and reductions in fringe benefits.

E.I. du Pont de Nemours & Co. Inc. produced titanium dioxide at its 280,000-metric-ton-per-year capacity plant at New Johnsonville using the chloride process. In Du Pont's chloride process, the TiO_2 content of rutile, high-grade ilmenite, or high-TiO_2 slag is converted to titanium tetrachloride by chlorination at 850° to 950° C in the presence of petroleum coke using a fluid-bed chlorinator. To make the TiO_2 pigment, the prepared tetrachloride is oxidized with air or oxygen at 1,000° C, and the resulting TiO_2 is calcined at 500° to 600° C to remove residual chlorine.

W.R. Grace and Co.'s vermiculite exfoliation plant in Nashville was inactive during the year.

Metals

More than 40% of the zinc produced in the United States was mined in Tennessee. Several other metal commodities were manufactured into higher value products either from the metals mined within the State or shipped in from outside. Chief among these were aluminum, ferroalloys, and zinc oxide.

Zinc.—The value of zinc produced in Tennessee increased over that of 1988, although the volume produced decreased slightly. Union Zinc's acquisition of the USX operations, coupled with Asarco's acquisition of Inspiration Resources Corp.'s zinc operations in 1988, reduced the number of zinc producers in Tennessee to two. Union Zinc owned the Nation's largest and eighth largest zinc mines, the Elmwood-Gordonsville Mine in central Tennessee and the Davis Mine in the Jefferson City-Mascot mining district in eastern Tennessee. Asarco operated the Young, New Market, Immel, and Coy Mines, all in eastern Tennessee. Nationally these mines ranked 3d, 9th, 10th, and 13th, respectively, in order of zinc output. The reduction in the number of companies mining zinc has resulted in the withholding of production and value data in table 1 to avoid disclosing proprietary company data. However, figures published in Asarco's annual report[9] indicated that the company's four Tennessee mines achieved record production of 2.7 million short tons of ore mined, which was slightly higher than in 1988. The ore yielded 63,200 tons of zinc in concentrate in 1989 and 67,900 tons in 1988. Zinc recovery from the ore averaged 93% in 1989. At yearend, reserves at the four mines were 5.7 million tons averaging 3.3% zinc, about the same grade and tonnage reported in 1988.

Union Zinc Inc., a subsidiary of Belgium's Union Miniére SA, formed a

new division, Jefferson City Zinc Co., to operate the Davis zinc mine and mill at Jefferson City. The operation was expected to furnish an additional 22,000 metric tons of zinc concentrate each year to another division of Union Zinc, JMZ, for its refinery at Clarksville, Montgomery County.

Union Zinc's acquisition, in late November, of the inactive Idol Mine in the Copper Ridge zinc district included the zinc mine, concentrating facilities, and mineral rights. The Idol Mine was initially developed in the mid-1960's by the New Jersey Zinc Co., which was later acquired by Gulf + Western Industries Inc., but did not become fully operational until 1977. It closed in 1980, reportedly because of high labor costs, diminishing reserves, and the cost of meeting environmental regulations. Union Zinc formed another division, Clinch Valley Mining Co., to evaluate the Idol Mine and operate it if it is reopened.

In middle Tennessee, JMZ began mining the Stonewall ore body at its Elmwood-Gordonsville operation.

Zinc concentrates were processed at JMZ's refinery at Clarksville, one of four primary zinc refineries operating in the United States. Approximately one-half of the ore refined at Clarksville was trucked from the Elmwood-Gordonsville Mine. Most of the rest was barged via the Tennessee and Cumberland Rivers from east Tennessee. In addition to zinc metal, the refinery produced cadmium metal and sulfuric acid as byproducts.[10] The cadmium metal was used primarily to manufacture nickel-cadmium batteries, and the sulfuric acid was used mainly to produce fertilizer.

Zinc metal was produced from steelmaking electric arc furnace (EAF) dust by Florida Steel Co. at its Jackson, Madison County, plant. The plant had a capacity of 1,400 tons of zinc metal per year utilizing plasma furnace technology developed by Tetronic Research and Development Co. and Bethlehem Steel Co. EAF dust was also scheduled to be processed by Horsehead Resource Development Co., Palmerton, PA, beginning in January 1990. Horsehead purchased a 60,000-ton-per-year plant from Reserve Carbon Inc. in Rockwood.

The EPA required that furnace dust be chemically altered or stabilized before being disposed. Horsehead Resource, an environmental services subsidiary of Horsehead Industries Inc., New York, NY, specializes in the recycling of inorganic hazardous waste. The kiln process used entails removing cadmium, lead, and zinc from EAF dust by combining it with carbon at high temperatures in a rotary kiln. A cadmium- lead-, and zinc-enriched concentrate will then be sold to a sister company, Zinc Corp. of America, which will recover the zinc metal. The slag will be sold for aggregate for road construction and cement and as a sand substitute for use on icy roads.

A newly formed company, North American Oxide Inc., planned to French-process zinc oxide production by mid-1990 at a new plant on a 15-acre site in Clarksville. The plant was to have a production capacity of 20,000 tons per year of zinc oxide. Zinc metal for conversion to zinc oxide was expected to be supplied by the JMZ refinery, which is also in Clarksville. North American Oxide is an affiliate of the Rogers Group of Nashville, which has been active in mining and construction in eight midwestern States for more than 80 years.

The Montreal-based company, Pigment and Chemical Inc., announced it was modernizing the zinc oxide plant in Memphis that it purchased from Pasco Zinc Products Co. in 1988.

Zinc oxide's principal market was the rubber tire industry, which used approximately one-third pound of zinc oxide in every tire produced and consumed almost one-half of the zinc oxide used domestically.

Zinc Products Div. of the Ball Corp. was reportedly the largest manufacturer of rolled zinc products in the world. The plant at Greeneville produced penny blanks, zinc battery cans, and rolled strip zinc from zinc metal.

Other Metals.—A 200,000-metric-ton-per-year primary aluminum smelter using 328 smelting pots was operated by Aluminum Co. of America (ALCOA) at Alcoa, Blount County. Alcan Aluminum Corp. announced the purchase of Jarl Extrusions Inc., a maker of custom aluminum extrusions at Elizabethton. Jarl reportedly operated five presses and a remelt, billet casting center.

Phoenix Zinc Co. was denied permission to ship aluminum cans into its Millington, Shelby County, plant by the local Board of Zoning Appeals. Phoenix had planned to recycle the cans into notch bars and ingots. Southern Alloys Co. opened and closed its secondary aluminum plant at Shelbyville.

Secondary Aluminum Smelters Inc. (SAS), a joint venture of Metal Shippers Inc. and London Iron and Metal Co., both of Atlanta, GA, and Southern Foundry Supply Co. of Chattanooga, completed a $3 million, 36-million-pound-per-year secondary smelter in Chattanooga. The first pouring of commercial-grade low-copper-remelt-specification ingot (RSI) occurred in June. The smelter used scrap grades of sheet aluminum, painted siding, mixed low-copper chips, shredded scrap, and irony aluminum as raw material. Tentative plans called for using the smelter for tolling and conversion of scrap supplied by aluminum rolling mills and extrusion plants.

A secondary aluminum smelter that opened in February closed in September. Company officials attributed the closing to a lack of operating capital and a slide in the market. The plant, in Shelbyville, Bedford County, 60 miles south of Nashville and 27 miles from the new Saturn automobile plant, was built by Southern Alloys Co., a newly formed subchapter S corporation. The plant was designed to manufacture 6 million pounds per month of secondary ingot. One 160,000-pound furnace producing 3 million pounds per month was operating when production ceased. A second 160,000-pound furnace had been ordered. Fifteen potential buyers expressed an interest in the plant, which was listed for sale at its asset value of $6 million.

Ferroalloys were produced by Applied Industrial Minerals Corp., which manufactured ferrosilicon from high-grade silica mined in North Carolina at its Kimball, Marion County, plant. Two companies in Maury County, Occidental Chemical Corp., Columbia, and Rhone-Poulenc Co., Mount Pleasant, produced ferrophosphorus.

A sludge containing germanium continued to be reported as being recovered from the middle Tennessee zinc concentrate refined by JMZ at Clarksville. The sludge was sent to Union Miniére in Belgium for refining. Germanium was principally used in fiber optics and infrared lenses.

Refined Metals Corp. temporarily halted production of secondary lead at

its Memphis smelter early in the year. Company officials indicated the shutdown was prompted by a need for inventory adjustment and did not result from environmental concerns. Shelby County Health Department personnel confirmed that the plant was not being investigated. Lead was recovered from scrap by General Smelting and Refining Co., College Grove, Williamson County; Refined Metals Corp., Memphis; and Ross Metals Inc., Rossville, Fayette County.

Electrolytic manganese dioxide (EMD) producers were aided by antidumping duties assessed on U.S. imports from Greece and Japan. The duties were a result of Government findings that less-than-fair-value sales were materially hurting the domestic industry. Approximate duty margins ranged from 72% to 77% for EMD from Japan to 37% for that from Greece. Tennessee manufacturers aided by the decision were Chemetals Inc. of New Johnsonville and Rayovac Corp. and ESB Materials Corp., both in Covington, Tipton County. EMD was primarily used in alkaline dry cell batteries.

Secondary steel was produced by two companies, Florida Steel Co. with plants in Jackson and Knoxville, and Tennessee Valley Steel Corp. in Harriman, Louden County. The former began production during the year in a refurbished plant that had been closed in 1981 by the Tennessee Forging Steel Co.

The U.S. Department of Energy produced U^{235} from uranium using a gaseous diffusion process at its Oak Ridge facilities in Anderson and Roane Counties. Nuclear Fuels Services Inc. manufactured uranium and thorium metal alloys at its Erwin, Unicoi County, plant.

[1] State Mineral Officer, Bureau of Mines, Tuscaloosa, AL. He has 32 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] Minerals geologist, Tennessee Division of Geology, Nashville, TN.

[3] Chief geologist, Tennessee Division of Geology, Knoxville, TN.

[4] Leaf-Chronicle (Clarksville). EPA to JMZ: Pipe Effluent Directly Into River. June 16, 1989.

[5] Star Tribune (Chattanooga). Copper Basin Begins Recovery. Sept. 18, 1989.

[6] Industrial Minerals (London). WBB Will Buy Cyprus Ball Clay. No. 260, May 1989, p. 15.

[7] ——. American Limestone Acquires Acme Stone. No. 257, Mar. 1989, p. 21.

[8] News-Free Press (Chattanooga). 3 Tenn. Chemical Sale Plans, Pensions Status Get Review. Nov. 29, 1989.

[9] ASARCO Incorporated 1989 Annual Report.

[10] Leaf-Chronical (Clarksville). JMZ Top Producer Of High-Grade Zinc. Jan. 29, 1989.

TABLE 4

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.
Southern Clay Div. Edward Lowe Industries Inc.	Box 819 Paris, TN 38242	do.	Henry.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
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.	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]	Box 591 Columbia, TN 38401	Pits and plant	Giles, Hickman, Maury, Williamson.
Rhone-Poulenc Basic Chemicals Co. Inc.[3]	Box 89 Mount Pleasant, TN 38474	do.	Do.
Sand and gravel:			
Construction:			
Dixie Sand & Gravel Co.	515 River St. Chattanooga, TN 37402	Pits	Hamilton, Marion, Meigs, Rhea.
Memphis Stone & Gravel Co.	Box 1683 Memphis, TN 38101	do.	Dyer, Obion, Shelby.
Rogers Group Inc.[2]	Box 25250 Nashville, TN 37202	do.	Various.
Industrial:			
Short Mountain Silica Co.	Box 208 Mooresburg, TN 37811	Pit and plant	Hawkins.
Tennessee Silica Div. Morie Co. Inc.	Bruceton, TN 38317	Pits and plants	Benton and Carroll.
Stone:			
Crushed:			
American Limestone Co., a subsidiary of ASARCO Incorporated	2209 Blount Ave. Knoxville, TN 37901	do.	Various.
Franklin Limestone Inc.	Box 23082 Nashville, TN 37202	do.	Do.
Vulcan Materials Co., Midsouth Division	Box 7 Knoxville, TN 37901	Quarries and plants	Do.
Dimension:			
Ross L. Brown Cut Stone Co. Inc.	Box 398 Crab Orchard, TN 37723	do.	Cumberland.
Crab Orchard Stone Co. Inc.	Drawer J Crossville, TN 38555	Quarry and plant	Do.
Luck Stone Co.	629 Pellissippi Pkwy. Knoxville, TN 37932	do.	Knox and Blount.
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	Montgomery and Smith.

[1] Also clays.
[2] Also stone.
[3] Also ferroalloys.

THE MINERAL INDUSTRY OF TEXAS

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Bureau of Economic Geology, The University of Texas at Austin, for collection of information on all nonfuel minerals.

By Jane P. Ohl[1] and L. Edwin Garner[2]

The value of nonfuel minerals produced in Texas in 1989 was $1.46 billion, compared with $1.47 billion in 1988. The State ranked sixth in the Nation and accounted for 4.52% of the total value of nonfuel mineral production. Texas ranked 10th of 25 metal-producing States, accounting for nearly 2.5% of the Nation's total metals value.

Portland cement output continued to be the leading nonfuel mineral product in Texas, worth more than $286 million in 1989. In decreasing order of value, other nonfuel minerals produced were magnesium metal, crushed stone, Frasch sulfur, construction sand and gravel, salt, and lime. Twelve other nonfuel mineral commodities were produced.

EMPLOYMENT

In September 1989, 6.8 million persons were employed in nonagricultural jobs in Texas, nearly 2% more than in September 1988. The unemployment rate in Texas in September 1989 was 6.3%, compared with the U.S. unemployment rate of 5.5%.[3]

According to the Texas Employment Commission, about 9,700 workers were employed in mining nonfuel mineral commodities in 1989. And, according to a Dallas Business Journal supplement, Taking Stock, published in 1989, the Dallas-Fort Worth area had about 53,000 persons engaged in extracting and processing nonfuel mineral commodities, both metallic and nonmetallic.

REGULATORY ISSUES

Aluminum Co. of America's (Alcoa) Point Comfort plant headed the National Wildlife Federation's "Toxic 500" list as the Nation's single biggest releaser of

TABLE 1

NONFUEL MINERAL PRODUCTION IN TEXAS[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement:							
Masonry	thousand short tons	172	$11,283	136	$10,800	133	$10,735
Portland	do.	7,318	319,996	7,000	292,256	7,200	286,236
Clays[2]	metric tons	3,007,706	14,825	2,714,451	17,468	2,276,629	15,962
Gem stones		NA	345	NA	340	NA	W
Gypsum	thousand short tons	1,874	14,254	1,943	15,790	1,993	17,044
Lime	do.	1,140	59,027	1,192	55,935	1,304	60,829
Salt	do.	7,810	60,857	7,802	62,925	7,856	69,934
Sand and gravel:							
Construction	do.	e48,200	e178,600	50,370	171,167	e43,900	e155,800
Industrial	do.	1,509	22,843	1,631	26,645	1,661	29,107
Stone:							
Crushed	do.	84,347	276,477	e82,000	e271,300	76,823	252,982
Dimension	short tons	75,426	10,030	e66,354	e8,310	81,268	12,449
Sulfur (Frasch)	thousand metric tons	2,152	W	2,622	W	2,446	W
Talc and pyrophyllite	short tons	255,039	4,380	260,950	4,466	266,513	4,564
Combined value of clays [ball clay, fuller's earth (1987), kaolin], helium (crude and Grade-A), iron ore, magnesium compounds, magnesium metal, sodium sulfate (natural), and values indicated by symbol W		XX	457,814	XX	531,416	XX	546,812
Total		XX	1,430,731	XX	1,468,818	XX	1,462,454

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

toxic pollution, with emissions of 465.3 million pounds of unnamed pollutants. The company's Rockdale plant ranked third with 329 million pounds of unnamed pollutants. The federation's list was based on a U.S. Environmental Protection Agency (EPA) report on 1987 emissions data that EPA released to the public in June 1989. An Alcoa company spokesman protested that because the list was based on 1987 data, it included substances, such as aluminum oxide, that EPA has either found not to be toxic or has proposed reclassifying as nontoxic.[4]

EXPLORATION ACTIVITIES

Placer Dome (US) Inc. entered into an agreement with Gold and Mineral Exploration NL and Laverton Gold NL (both of Australia) to explore and develop its Mustang Draw sulfur reserves in Glasscock County, western Texas. Earlier, in 1988, exploratory tests at Mustang Draw showed the deposit contained 10 million to 15 million metric tons of elemental sulfur reserves. The first two phases of the development program, to start in early 1990, involve drilling; the third and final phase would consist of a $3 million pilot-testing program and feasibility study, which would take place during a 12-month period. The Mustang Draw sulfur deposit was first discovered in 1982 during the drilling of an oil exploration well.

Some exploration work at the Shafter Mine, Presidio County, was done by Gold Fields Mining Corp. in 1989. The Shafter is in a known silver district, although some gold also was recovered until the mine closed in 1942 after 50 years in operation.

LEGISLATION AND GOVERNMENT PROGRAMS

The Department of Energy's High Energy Physics Advisory Panel agreed with a subcommittee's findings that reducing the size or power of the super collider particle accelerator to contain costs would significantly and unacceptably increase the risk of missing important new physics. A proposal at yearend suggested that building the super collider to original specifications at the present cost and inflation rates could raise the $5.9 billion price tag by 20% to 30%. Reducing expenditures and building a smaller super collider would possibly compromise the scientific capacity and value of the machine. A decision on collider spending recommendations was expected from the Department of Energy Secretary in January 1990. The super collider is to be built in Ellis County, south of Dallas. Large quantities of crushed stone, sand and gravel, and clays, as well as a variety of metal products, will be used in constructing the super collider and auxiliary buildings. The influx of new workers during construction and for the life of the project will also require additional housing and roadways, both of which will raise the demand for mineral materials.

Total royalties derived from Federal mineral leases in and offshore Texas amounted to $750,210, down from $932,032 in 1988. Operators paid royalties on oil and gas. The Federal Government (Minerals Management Service and the Bureau of Land Management) distributed $5,000 to the State of Texas as its share of revenues collected.

On September 26, 1989, Southdown Inc. was one of seven domestic cement manufacturers to petition the U.S. International Trade Commission (ITC) and the U.S. Department of Commerce requesting that the Government impose antidumping duties on imports of portland cement from Mexico in an amount sufficient to eliminate the unfair pricing in the United States. On November 8, 1989, ITC issued a preliminary determination in favor of the petitioners. The Commerce Department was expected to determine that the dumping margins on imports from Mexico ranged from 52% to 57% and that importers would be required to post a bond to cover the amount of the dumping margin on virtually all imported cement after April 12, 1990. The Commerce Department's final determination was expected by late August 1990.[5]

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Portland cement output rose slightly over that of 1988 to 7.2 million short tons; however, total value declined 2% to $286 million. Historically, the State's portland cement output has accounted for about 10% of annual U.S. production, and Texas usually has been ranked first or second among 38 producing States; in 1989, Texas ranked second after California. Masonry cement, used for stucco and mortar, continued a 5-year downtrend, and output was estimated to be only 46% of that of 1984. Because of declines in Texas construction industries, demand for portland cement, although up 200,000 short tons from that of 1988, remained at a low 1975 level. The demand for masonry cement has fallen every year since a record-high level of 291,000 short tons in 1984.

Eleven plants produced cement in 20 kilns: 9 wet-process and 11 dry-process. Raw materials consumed in the making of cement were principally limestone and also included anhydrite, cement rock, chalk, clay, fly ash, gypsum, iron ore, marl, mill scale, sand, shale, and both imported and domestic clinker. Imported clinker was less than 3% of the total amount of clinker used. In addition, some acids and other chemicals were consumed at some plants. Pollution control equipment included 8 glassbags and 13 electric precipitators.

Portland cement was sold to ready-mix companies (63% of production), followed, in decreasing amounts, by other contractors, concrete products manufacturers, and other users. Finished portland cement was transported by rail, truck, and barge.

The average value of portland cement was $39.75, although some white cements classified as Type II general moderate heat, Type III high early strength, and waterproof portland sold for more than $80 per ton.

Holderbank Financiere Glaris Ltd. of Switzerland announced in May that it had agreed in principle to enter a 10-year takeover option agreement to acquire BoxCrow Cement Co. of Dallas. The acquisition would be made through the company's North American holding organization, HOLNAM. Technical, operating, and marketing expertise, as well as day-to-day management of BoxCrow's cement plant at Midlothian, would be provided by Ideal Basic Industries Inc. personnel.

Clays.—Texas was the third leading State in clay production in 1989. Texas clay pits were the source of ball clays, bentonite, common clay and shale, fire

clay, fuller's earth, and kaolin. The combined output of all clay types from Texas dropped 23% from that of 1988.

Only two clay types reported increased output. Ball clay production increased slightly—less than 3%—but its value soared 28%; fuller's earth production was up 5% to 30,327 metric tons. Texas was one of only five States to report ball clay production and one of only nine to report fuller's earth production.

Decreased output was reported for: bentonite, down nearly 5%; common clay and shale, down nearly 17%; fire clay, down 54%; and kaolin, down 6%. Southern Clay Products Inc. produced nonswelling and swelling bentonite from Cherokee County.

Gypsum.—Crude gypsum output increased slightly, and total value rose nearly 8%. Calcined gypsum production and total value both rose about 20%, and byproduct gypsum output and value soared about 48%.

The State ranked fourth nationally in production of crude gypsum and second, after California, in output of the calcined product. The average price of crude gypsum was $8.55 per short ton, 42 cents higher than that of 1988.

Texas ranked first of only seven States that produced byproduct gypsum. Byproduct gypsum, from the Texas Utilities Co. powerplant at Tatum, was used exclusively as feed to Standard Gypsum Co.'s plant in Rusk County. The plant was formerly owned by Windsor Gypsum Co. of McQueeney.

Helium.—Crude helium output and total value fell 31%, reversing the upward thrust from 1987 to 1988. Output and value of Grade-A helium, however, continued to increase, rising 26% in 1988 and 10% in 1989. Plants in Hansford and Moore Counties produced crude helium. The major end uses of helium were cryogenics, welding, and pressurizing and purging.

Iodine.—Crude and elemental iodines were produced by Texas Alkyls Inc. and Hoechst Celanese Chemical Group, both in Harris County. No iodine was recovered from brines, as was the case in Oklahoma.

Lime.—Lime production increased 9%, and total value rose more than 8% to $60.8 million. Plants in Bexar, Bosque, Comal, Hill, Johnson, and Travis Counties produced both quicklime and hyrated lime. Two other plants produced only quicklime. Chemical Lime Southwest Inc. at Clifton was the leading producer. Texas Lime Co., a subsidiary of Rangaire Corp. of Cleburne, purchased the 1,200-acre Round Rock limestone quarry and lime plant near Blum that had belonged to Dravo Lime Co. Dravo Lime was a subsidiary of Dravo Corp.

Magnesium Compounds.—Output of magnesium chloride extracted from seawater declined one-quarter from that of 1988. Hydrous magnesium chloride has been priced at $290 per short ton in recent years. Magnesium chloride was used for the electrolytic production of magnesium metal. It had several other applications, including its use in ceramics.

Perlite (Expanded).—Six plants expanded perlite in 1989. The plants sold 24,700 short tons, 58% more than in 1988. Average price per short ton fell, however, from $263.33 to $219.60.

Salt.—The Dow Chemical Co. was the largest producer of salt in Texas. Its production came from Brazoria County. Seven other firms produced salt in Chambers, Duval, Ector, Fort Bend, Harris, Jefferson, Matagorda, and Van Zandt Counties. Some of the salt was extracted from brines, some from rock salt. Price averaged $8.90 per short ton.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Although Texas was planning for highway construction and repairs and other State-funded activities that would consume large quantities of aggregates, no project of significance was completed in 1989. The $11.7 billion, 54-mile-long, oval super collider was planned for construction in Ellis County beginning in early 1991. In late 1989, consideration had been given to reducing the size of the collider but, instead, it was proposed to lengthen the oval by 1 mile.

Industrial.—Eleven counties, all but one in eastern Texas, were the source of the State's industrial sand production. Nine companies operated 14 pits; the top 4 companies accounted for nearly three-quarters of the output. The largest proportion of industrial sand (376,143 short tons) was sold as abrasive sand for sandblasting and averaged $19.45 per short ton. In decreasing order of amount used, industrial sand also was used as hydraulic fracturing sand, in the manufacture of glass containers, to produce molding and core sand, and for 10 other purposes. The average unit price for all uses was $17.53 per short ton. More than 80% of industrial sand was transported by truck.

Sodium Sulfate.—Texas was the second ranking of the three States that produced sodium sulfate. At its Seagraves facility in Gaines County, Ozark-Mahoning Co. extracted sodium sulfate from subterranean brines. Production declined slightly from that of 1988. Sodium sulfate was used in pulp and paper manufacturing and powdered detergents.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Texas stone statistics are compiled by geographical districts as depicted in the

TABLE 2

TEXAS: LIME SOLD OR USED BY PRODUCERS, BY USE

Use	1988		1989	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Road stabilization	576,396	28,883	425,432	20,825
Other[1]	615,614	27,052	878,874	40,004
Total	1,192,010	55,935	1,304,306	60,829

[1]Includes acid water neutralization, agriculture, aluminum and bauxite, glass (1988), Mason's lime, open-hearth steel, other chemical and industrial, paper and pulp, sewage treatment, sugar refining, and tanning.

State map. Tables 3 and 4 present end-use statistics for Texas' nine districts.

Crushed.—Texas was the third ranking crushed stone-producing State. Output and total value in 1989 were down moderately from figures for 1987 (the last year canvassed), 9% and 8%, respectively. The average price was $3.29 per short ton, $1.10 less than the average price nationally.

Although 93% of the crushed stone produced in 1989 was limestone, Texas has a wide variety of rock types: dolomite, marble, marl, sandstone, and traprock (dark-colored igneous rocks such as basalt, diabase, and gabbro). No shell was recovered from coastal areas in 1989. Of the State's 254 counties, 72 had crushed stone operations.

In Texas, the greatest demand for crushed stone was for use as graded road base. More than 21% was so used, of which 90% was dolomite and limestone.

Of the other rock types, crushed marble was used to make terrazzo for floors and counter tops and other uses. Its average price per short ton was $26.19. Crushed marl was used in the manufacture of cement. Crushed sandstone was used for many purposes, including making bituminous aggregate, graded road base, concrete aggregate, and nine other products. The average price of all uses was $6.07. Filter stone, however, also made from crushed sandstone, averaged $12.69 per short ton. The greatest tonnage of traprock was used for railroad ballast and averaged $4.42 per ton.

Dimension.—Granite and limestone were quarried for use as dimension stone. Production rose 22% over that of 1988. Of the 15 dimension stone quarries in Texas, 10 were granite and 5 were limestone. Twelve quarries accounted for more than 67,000 short tons of cut, or veneer, stone priced at an average of $159.22 per ton, although one type of cut stone was priced nearly four times higher. Stone also was trimmed as rough blocks, monumental stone, sawed blocks, and other types of cuts. The leading dimension stone firm, Cold Spring Granite Co., operated eight granite quarries.

***Sulfur.*—Frasch.**—Sulfur was extracted by the Frasch method from sites in Culberson, Pecos, and Wharton Counties. More than 2.4 million metric tons of Frasch sulfur was sold by two firms in 1989 compared with 2.6 million metric tons in 1988. Price per metric ton increased insignificantly.

TABLE 3

TEXAS: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	294	1,776
Filter stone	92	421
Coarse aggregate, graded:		
Concrete aggregate, coarse	6,996	25,253
Bituminous aggregate, coarse	3,893	18,845
Bituminous surface-treatment aggregate	1,835	7,600
Railroad ballast	403	1,655
Fine aggregate (-3/8 inch):		
Stone sand, concrete	1,791	5,415
Stone sand, bituminous mix or seal	1,370	4,878
Screening, undesignated	923	2,549
Coarse and fine aggregates:		
Graded road base or subbase	16,427	38,721
Unpaved road surfacing	306	525
Terrazzo and exposed aggregate	119	1,714
Crusher run or fill or waste	985	2,107
Other construction materials[2]	824	2,118
Agricultural: Agricultural limestone and poultry grit and mineral food	385	1,832
Chemical and metallurgical:		
Cement manufacture	8,531	20,718
Lime manufacture	686	3,368
Special: Asphalt fillers or extenders	322	2,602
Other miscellaneous uses[3]	1,001	4,332
Unspecified:[4]		
Actual	23,631	81,268
Estimated	6,010	25,285
Total	[5]76,823	252,982

[1]Includes limestone, sandstone, dolomite, marl, traprock, marble, and miscellaneous stone.
[2]Includes stone used in coarse aggregate (graded) and dam construction.
[3]Includes stone used in dead-burned dolomite manufacture, flux stone, chemical stone for alkali works, sulfur oxide removal, and whiting or whiting substitute.
[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.

Recovered Elemental.—Sulfur was recovered as a nondiscretionary byproduct of petroleum refining. Refineries in 27 counties recovered 1.6 million metric tons of sulfur valued at $141.8 million in 1989.

Sulfuric Acid.—Sulfuric acid was a byproduct from a copper smelter in Texas. Output increased more than 6% over that of 1988, continuing a 4-year upward trend. Lead and zinc facilities at El Paso formerly recovered sulfuric acid. The industry has had a problem in marketing sulfuric acid because the Texas points of recovery are far from large sulfuric acid markets on the east coast.

The largest end use of sulfur was to make sulfuric acid, the world's most universally used mineral acid. Sulfuric acid also was used to make phosphatic fertilizers.

Talc.—Talc production and total value fell insignificantly. Texas' output was the second largest, behind Montana, of 10 talc-producing States. Talc was used in ceramics, paint, paper, roofing, plastics,

TABLE 4

TEXAS: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	—	—	(2)	(2)	(2)	(2)
Coarse aggregate, graded[3]	432	2,935	(2)	(2)	267	1,526
Fine aggregate (-3/8 inch)[4]	230	1,170	—	—	204	1,287
Coarse and fine aggregates[5]	327	1,325	(2)	(2)	944	2,369
Other construction aggregates	—	—	290	1,044	16	58
Agricultural[6]	—	—	—	—	—	—
Chemical and metallurgical[7]	—	—	—	—	(8)	(8)
Special[9]	—	—	—	—	(8)	(8)
Other miscellaneous	—	—	—	—	581	1,781
Unspecified:						
Actual[10]	536	2,084	422	1,428	952	2,659
Estimated[11]	419	2,281	527	2,411	1,336	7,454
Total[12]	1,944	9,795	1,239	4,883	4,300	17,133

	District 4		District 5		District 6	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	(2)	(2)	62	406	W	W
Coarse aggregate, graded[3]	738	3,546	5,000	19,174	W	W
Fine aggregate (-3/8 inch)[4]	155	741	1,247	2,647	—	—
Coarse and fine aggregates[5]	1,412	2,861	3,555	10,497	W	W
Other construction aggregates	27	200	27	64	—	—
Agricultural[6]	—	—	(8)	(8)	—	—
Chemical and metallurgical[7]	(8)	(8)	2,695	5,739	—	—
Special[9]	—	—	(8)	(8)	—	—
Other miscellaneous	396	802	581	5,070	—	—
Unspecified:	—	—				
Actual[10]	—	—	12,477	41,593	—	—
Estimated[11]	891	3,218	1,868	5,720	—	—
Total[12]	3,619	11,367	27,510	90,909	W	W

	District 7		District 8		District 9	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	271	1,403	W	W	—	—
Coarse aggregate, graded[3]	6,370	24,245	—	—	(2)	(2)
Fine aggregate (-3/8 inch)[4]	2,248	6,998	—	—	—	—
Coarse and fine aggregates[5]	9,631	20,646	W	W	1,529	3,457
Other construction aggregates	558	1,508	—	—	389	1,747
Agricultural[6]	(8)	(8)	—	—	—	—
Chemical and metallurgical[7]	6,466	18,899	—	—	—	—
Special[9]	(8)	(8)	—	—	—	—
Other miscellaneous	207	562	—	—	—	—
Unspecified:						
Actual[10]	9,244	33,504	—	—	—	—

See footnotes at end of table.

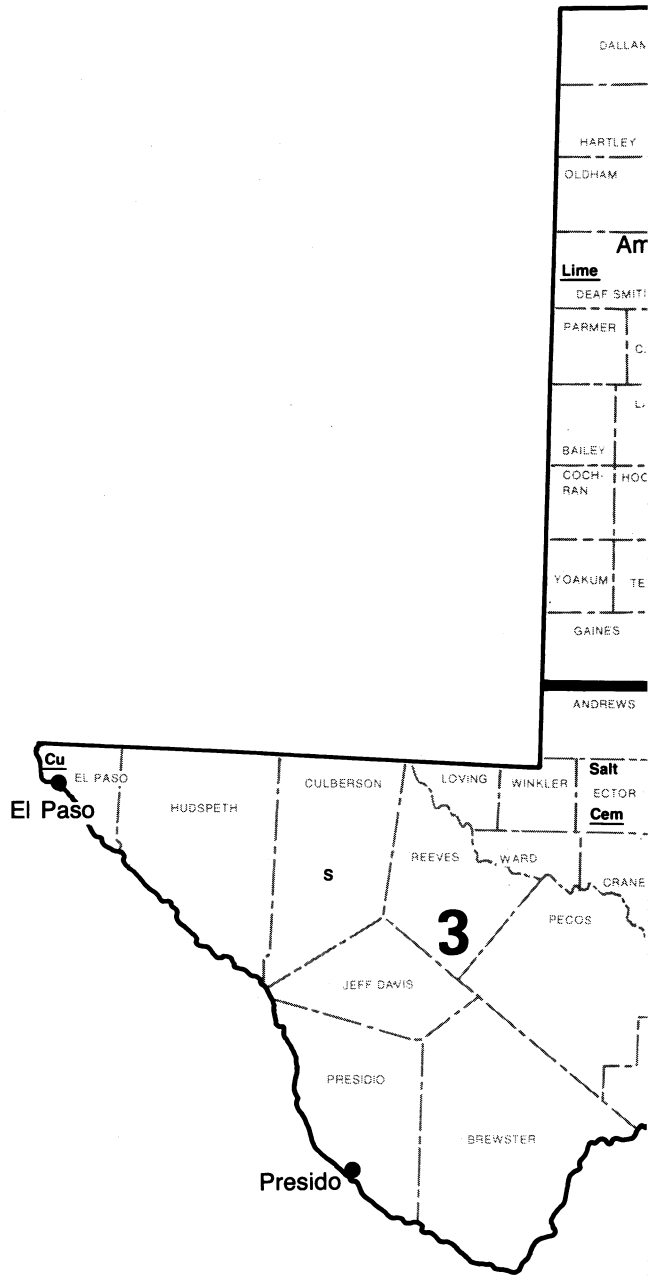
TEXAS

LEGEND

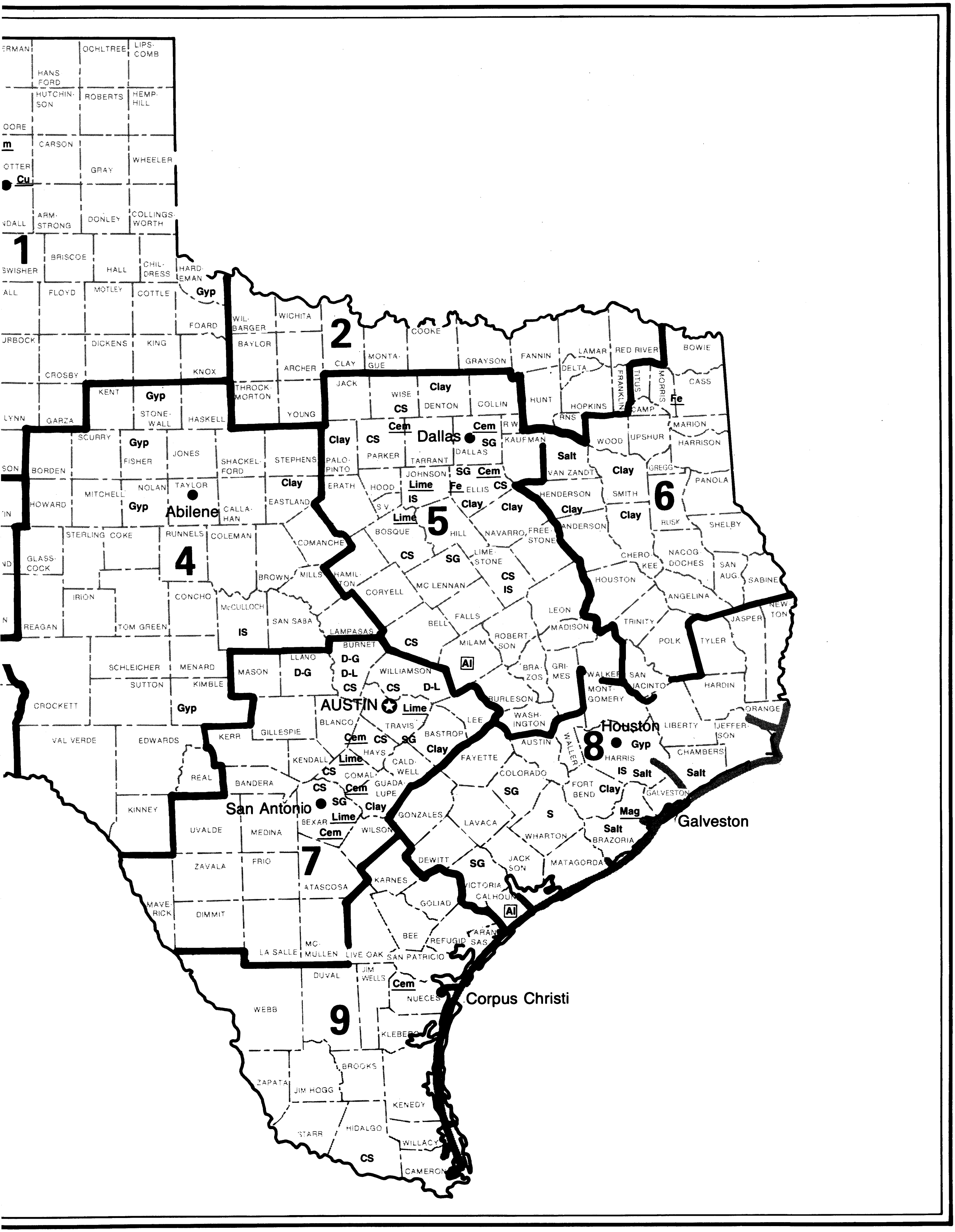
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Al	Aluminum plant
Cem	Cement plant
Clay	Clay
CS	Crushed Stone
Cu	Copper plant
D-G	Dimension Granite
D-L	Dimension Limestone
Fe	Iron ore and/or scrap steel plant
Gyp	Gypsum
IS	Industrial Sand
Lime	Lime plant
Mag	Magnesium metal from seawater
S	Sulfur
Salt	Salt
SG	Sand and Gravel



Principal Mineral-Producing Localities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HUTCHIN-SON
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HEMP-HILL
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MONTA-GUE
GRAYSON
FANNIN
LAMAR
RED RIVER
BOWIE
CROSBY
KNOX
DELTA
FRANKLIN
TITUS
MORRIS
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Dallas
SG
KAUFMAN
WOOD
UPSHUR
HARRISON
BORDEN
FISHER
JONES
SHACKEL-FORD
STEPHENS
PALO-PINTO
PARKER
TARRANT
DALLAS
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TAYLOR
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ERATH
HOOD
Lime
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ELLIS
CS
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SMITH
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PANOLA
MITCHELL
Gyp
Abilene
CALLA-HAN
EASTLAND
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HOWARD
Lime
5
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SABINE
BROWN
MILLS
HAMIL-TON
CORYELL
MC LENNAN
CS
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HOUSTON
IRION
CONCHO
ANGELINA
McCULLOCH
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REAGAN
TOM GREEN
SAN SABA
FALLS
TRINITY
JASPER
IS
LAMPASAS
BELL
MADISON
POLK
TYLER
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ROBERT-SON
BURNET
MILAM
SCHLEICHER
MENARD
LLANO
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D-L
WILLIAMSON
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BRA-ZOS
GRI-MES
WALKER
SAN JACINTO
HARDIN
SUTTON
KIMBLE
MASON
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AUSTIN
Lime
BURLESON
Gyp
CROCKETT
BLANCO
LEE
WASH-INGTON
ORANGE
Houston
LIBERTY
TRAVIS
JEFFER-SON
GILLESPIE
Cem
CS
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BASTROP
8
Gyp
VAL VERDE
EDWARDS
KERR
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AUSTIN
WALLER
HARRIS
CHAMBERS
KENDALL
Lime
CALD-WELL
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COMAL
COLORADO
BANDERA
CS
Cem
GUADA-LUPE
FORT BEND
Clay
GALVESTON
SG
KINNEY
San Antonio
SG
Clay
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GONZALES
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BEXAR
Cem
WILSON
WHARTON
Salt
BRAZORIA
ZAVALA
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MATAGORDA
ATASCOSA
KARNES
VICTORIA
MAVE-RICK
DIMMIT
GOLIAD
CALHOUN
Al
BEE
REFUGIO
ARAN-SAS
LA SALLE
MC-MULLEN
LIVE OAK
SAN PATRICIO
DUVAL
JIM WELLS
Cem
NUECES
Corpus Christi
WEBB
9
KLEBERG
BROOKS
ZAPATA
JIM HOGG
KENEDY
STARR
HIDALGO
WILLACY
CS
CAMERON

TABLE 4—Continued

TEXAS: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 7		District 8		District 9	
	Quantity	Value	Quantity	Value	Quantity	Value
Estimated[11]	402	1,148	284	2,488	284	564
Total[12]	35,396	108,913	W	W	2,202	5,768

W Withheld to avoid disclosing company proprietary data.
[1]Includes riprap and jetty stone, filter stone, and coarse aggregates.
[2]Withheld to avoid disclosing company proprietary data; included with "Other construction 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 fine aggregate (screening-undesignated).
[5]Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run or fill or waste.
[6]Includes agricultural limestone and poultry grit and mineral food.
[7]Includes crushed stone for cement manufacture, lime manufacture, dead-burned dolomite, flux stone, chemical stone for alkali works, and sulfur oxide removal.
[8]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[9]Includes crushed stone for asphalt fillers or extenders and whiting or whiting substitutes.
[10]Includes production reported without a breakdown by end use.
[11]Includes estimates for nonrespondents.
[12]Data may not add to totals shown because of independent rounding.

cosmetics, insecticides, and several other applications.

Vermiculite (Exfoliated).—Vermiculite Products Inc., in Harris County, and W. R. Grace & Co., in Dallas County, exfoliated vermiculite from out-of-State sources. Output declined nearly 5% from that of 1988. The product was sold for use in block aggregates, concrete aggregates, fireproofing, loose fill, plaster aggregates, and soil conditioning.

Metals

Aluminum.—In addition to primary aluminum plants, such as Alcoa's plant at Rockdale, another site in Texas was to become part of the aluminum industry. San Antonio was chosen as the site of an aluminum rolling minimill by Golden Aluminum Co., a subsidiary of Adolph Coors Co., a brewer, of Golden, CO. The Colorado firm chose to build in San Antonio rather than in Colorado because of its proximity to several beverage can producers, the availability of used beverage cans, and San Antonio's proximity to Houston's international port. Golden Aluminum was planning to use continuous casting of aluminum sheet from molten metal; but, primarily, the mill will use used beverage aluminum metal cans as its raw material. The mill was to cost $150 million and produce 130 million pounds of aluminum sheet for can manufacture annually. The Texas Air Control Board approved the permit to begin construction of the mill in February 1990; the target for completion was late 1991.

Reynolds Metals Co. announced plans to spend about $50 million during the next 2 years to increase the efficiency of its 1.7-million-ton-per-year alumina plant near Corpus Christi. Reynolds also purchased Conductor Products Inc.'s cable plant in Marshall.

Copper.—Refined copper was recovered at a Texas refinery. No copper-bearing ore was mined in the State.

Texas Copper Corp., a consortium of Mitsubishi Metal Corp. of Japan (51%), and four other Japanese companies announced in January 1989 that it would construct a $280 million copper smelter at Texas City. A continuous copper-processing method was to be used, where concentrates are fed into a series of furnaces before being made into copper anode. This process reportedly allows for the efficient capture of sulfur emissions because material transfer between furnaces is by covered chutes. Before construction could begin, however, the firm needed a permit from the Texas Water Commission to allow it to discharge wastewater into Galveston Bay. It also needed permits from the Texas Air Control Board and the Army Corp. of Engineers.

Concentrates from Chile and other Latin American countries, as well as Arizona and New Mexico, were to be used in the smelter. When completed, the plant would have the capacity to produce 200,000 tons of copper anodes plus sulfuric acid and other byproducts. The copper anodes would be marketed in the United States and Europe. Mitsubishi officials said the smelter would employ about 200 persons and generate a $5 million annual payroll.

At its El Paso copper smelter, ASARCO Incorporated planned to spend $30 million to replace the roasters with dryers and to retrofit the reverberatory furnaces with ConTop flash-smelting units developed by KHD of West Germany. The new smelting configuration was expected to reduce costs and sulfur dioxide emissions. The retrofit also would increase sulfuric acid production. Total defined capacity of the plant, which included treatment of copper scrap, will be increased to 135,000 tons per year. These expenditures were part of a 3-year plan for improvements in Texas and other States where the company has property.

Iron Ore and Slag.—Usable iron ore output rose 43% over that of 1988, and total value increased 58%. However, the related tubular steel goods manufacturing business in the State continued in the doldrums, a result of the significant decline in oil well drilling that began in 1986. Sold or used iron and steel slags increased in both quantity and value over figures for 1988.

Iron and Steel.—A three-partner venture called Buffalo Steel selected the long-idled USX Corp.'s Baytown Texas Works to reopen as a flat-roll steel minimill. The triumvirate, formed by Birmingham Steel

Corp., Proler International Corp., and Italian equipmentmaker Danilei & C. Officine Meccahaniche SpA, announced the site selection in December. Unlike two previous Houston-area sites tentatively picked for the $260 million project, the USX facility held the necessary environmental permits that would allow the project to move forward. The Buffalo Steel minimill was planned to have an annual capacity of 1.2 million tons of 5-inch-thick cast-steel slabs and employ 400 to 500 persons.

As one of the three top domestic producers of wide-flange beams, Chaparral Steel Co., a subsidiary of Texas Industries Inc. (TXI), lowered its price as much as $30 per ton for some beam sizes. Chaparral made the steel beams and a variety of other forms from scrap metal. Its plant near Midlothian, Ellis County, employed 1,000 people.

Lone Star Technologies Inc. renamed its bankrupt main steel unit Lone Star Steel Co. 8 months after it had abandoned that name. The return to the name Lone Star Steel was an attempt to distance its potentially more profitable steel and nonsteel holdings from troubled operations in oil country tubular goods. Lone Star had dropped the Lone Star Steel name in favor of East Texas Steel Facilities Inc. shortly before posting $25 million in losses for 1988; the yearend loss eventually soared to $40 million. Lone Star Steel operated under chapter 11 bankruptcy protection after June 30, 1989.

LTV Corp., Dallas, produced hot- and cold-rolled sheet and stainless steel strip and sheet, aircraft products, missiles, electronics, and energy products. The LTV corporation employed 38,000 persons.

Keystone Consolidated Industries Inc., Dallas, manufactured carbon steel rod, wire, and wire products for agricultural, industrial, commercial, and consumer markets. Keystone's total employment was 1,970 persons.

From January through September, Port of Houston officials reported steel imports "way down" and steel exports "way up."

Magnesium Metal.—Magnesium metal from refinery production declined 3.5% from that of 1988. Nationwide, magnesium metal was worth $3,345.05 per metric ton. Demand remained strong for magnesium for aluminum alloying, casting applications, and iron and steel desulfurization. Magnesium metal was used in applications where its built-in shielding against electromagnetic interference, high strength-to-weight ratio, ability to maintain precision tolerances, and more effective heat dissipation were important considerations.[6]

Tin.—As a result of the poor market for tin, TexTin Corp.'s smelter at Texas City, formerly the Nation's only tin smelter, ceased tin production in May 1989 and was converted to processing scrap copper.

[1]State Mineral Officer, Bureau of Mines, Denver, CO. She has covered the mineral activities in Texas for 8 years. Assistance in the preparation of the chapter was given by Pat La Tour, editorial assistant.

[2]Research associate, Bureau of Economic Geology, The University of Texas at Autstin, TX.

[3]Texas Business Review. Employment and Unemployment Rate by Metropolitan Area (table). Bureau of Business Res., College and Graduate School of Business, Univ. of Texas at Austin, Dec. 1989.

[4]Snoddy, W. Alcoa Plant Tops Toxic 500 List. Am. Met. Market, Aug. 14, 1989, p. 2.

[5]Southdown Inc. Interim Report for 3 months ended March 31, 1990, May 15, 1990.

[6]Kramer, D. A. Magnesium. Ch. in BuMines Minerals Yearbook, 1988, v. 1, pp. 637–650.

TABLE 5

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.
Tin:		
TexTin Corp.:		
Texas City smelter	Galveston	Ore and concentrates.

[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 6

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Cement:			
BoxCrow Cement Co.	4835 LBJ Freeway Lock Box 102 Dallas, TX 75244	Plant	Ellis.
Gifford-Hill & Co. Inc., a subsidiary of Beazer U.S.A.[1]	Box 520 Midlothian, TX 76065	Quarry and plant	Do.
Lafarge Corp.[2]	3333 Fort Worth Ave. Dallas, TX 75211	Quarries and plant	Comal, Dallas, Tarrant.
Texas Industries Inc.[3]	8100 Carpenter Freeway Dallas, TX 75247	do.	Comal and Ellis.
Clays:			
Acme Brick Co., a division of Justin Industries Inc.	Box 886 Denton, TX 76202	Pits and plants	Denton, Guadalupe, Nacogdoches, Parker, Van Zandt, Wise.
Featherlite Building Products Corp.	Box 141 Ranger, TX 76470	Pit and plant	Eastland.
Wolff Inc.	Box 34870 San Antonio, TX 78265	do.	Guadalupe.
Gypsum:			
Domtar Gypsum Inc.	Box 720 Sweetwater, TX 79556	Quarry and calcining plant	Nolan.
Georgia-Pacific Corp.	900 S.W. 5th Ave. Portland, OR 97204	do.	Hardeman.
National Gypsum Co., Gold Bond Div.	2001 Rexford Rd. Charlotte NC 28211	Quarries and calcining plants	Fisher, Kimble, Stonewall.
Standard Gypsum Co.	Box 27 Fredericksburg, TX 78624	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.
Lime:			
APG Lime Corp.	Rt. 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.	Box 427 Clifton, TX 76634	Plant	Bosque and Burnet.
Holly Sugar Corp.	Drawer 1778 Hereford, TX 79045	do.	Deaf Smith.
Redland Worth Corp.[4]	Rt. 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.	Johnson and Travis.
Salt:			
The Dow Chemical Co.[5]	2020 Dow Center Midland, MI 48640	Brine	Brazoria.
Morton Thiokol Inc.	110 North Wacker Dr. Chicago, IL 60606	Underground mine and brine.	Van Zandt.
Texas Brine Corp., a subsidiary of United Salt Corp.	2000 West Loop S. Houston, TX 77027	Brine	Fort Bend, Harris, Jefferson, Matagorda.

See footnotes at end of table.

TABLE 6—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
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.	Drawer 928 Buda, TX 78610	Pits and plants	Hays and Travis.
The Fordyce Co.	Box 1981 San Antonio, TX 78297	do.	Hidalgo and Victoria.
Ideal Basic Industries Inc., a subsidiary of Holnam Inc.	363 North Belt Houston, TX 77054	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]	Box 12449 Dallas, TX 75225	Pits and plants	Colorado, Liberty, Montgomery.
Industrial:			
Oglebay Norton Co., Texas Mining Co.	2104 East Randol Mill Rd. Suite 101 Arlington, TX 76011	Pits and plant	McCulloch.
UNIMIN Corp.	50 Locust Ave. New Canaan, CT 06840	Plant	Johnson.
U.S. Silica Co.	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 13010 San Antonio, TX 78213	Plants and quarries	Bexar, Brown, Crockett, 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, Van Zandt, Wood.
Chevron U.S.A. Inc.	575 Market St. San Francisco, CA 94105	do.	Crane, El Paso, Hopkins, Jefferson, Karnes.
Exxon Chemical Americas	Box 77253-3272 Houston, TX 77079	do.	Atascosa, Crane, Harris.
Phillips Petroleum Co.	Bartlesville, OK 74003	do.	Andrews, Brazoria, Crane, Hutchinson.
Smackover Shell Ltd.	Rt. 2, Box 152 Eustace, TX 75124	do.	Henderson.
Texaco Producing Inc.	Box 8 Scroggins, TX 75480	do.	Franklin and Freestone.
Native:			
Pennzoil Sulphur Co.	1906 First City National Bank Houston, TX 77002	Frasch mine	Culberson.

See footnotes at end of table.

TABLE 6—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Sulfur—Continued			
Native—Continued			
Texasgulf Chemicals Co., a subsidiary of Elf Aquitaine Inc.	Glenwood at Glen Eden Box 30321 Raleigh, NC 27622-0321	Frasch mine	Wharton.
Talc:			
Apache Minerals Inc. and Pioneer Talc Co.	1000 Coolidge St. South Plainfield, NJ 07080	Pits and plant	Hudspeth.
Dal Briar Corp. (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.[9]	Box 44 Gonzales, TX 78629	Pit and plant	Hudspeth.
Vermiculite (exfoliated):			
W. R. Grace & Co.	2651 Manila Rd. Dallas, TX 75200	Exfoliating plants	Bexar and Dallas.
Vermiculite Products Inc.	Box 7327 Houston, TX 77008	Exfoliating plant	Harris.

[1]Also clays, Ellis County; sand and gravel, Brazos, Dallas, Ellis, and McLennan Counties; and crushed stone, Comal, Cooke, Ellis, Limestone, Walker, and Wise Counties.
[2]Also clays, Dallas County; sand and gravel, Dallas, Johnson, Tarrant, and Wise Counties; and stone, Dallas, Tarrant, 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, Jack, and Wise Counties.
[4]Also crushed stone, Bexar, Hidalgo, Limestone, Medina, Midland, and San Petricio Counties.
[5]Also magnesium compounds and magnesium chloride for magnesium metal, Brazoria County.
[6]Also crushed stone, Comal County.
[7]Also crushed stone, Burnet and Parker 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 and Mineral Survey for collecting information on all nonfuel minerals.

By Michael N. Greeley[1] and Robert W. Gloyn[2]

Utah mines continued to increase their production of nonfuel minerals in 1989. The total value of output rose to nearly $1.3 billion, about 27% over that of 1988. This record-high value moved the State up to ninth place in the nonfuel mineral industry of the Nation.

Approximately 83% of the mineral value was accounted for by the production of metals. Chief components of the metals sector were copper, gold, and magnesium. Other commodities important to the State, some of which posted impressive gains in 1989, included beryllium, gypsum, iron, molybdenum, portland cement, phosphate, potash, sand and gravel, salt, and silver.

TRENDS AND DEVELOPMENTS

After reaching a low point in 1985, the production of nonfuel minerals in the State has continued an upward trend through the end of the decade. Both segments of mineral output, metals and industrial minerals, have contributed to the impressive growth. The value of production has virtually quadrupled in the past 4 years.

The principal factors that have bolstered this trend are the modernization of the Bingham Canyon Mine facility and resumption to full production, the start-up of two new gold mines, the reopening of a steel plant, and the renovation of mineral production facilities adjacent to the Great Salt Lake.

During the period of 1986–88, output of construction-related commodities generally declined or stagnated when both residential and nonresidential construction activity decreased. A reversal of this trend occurred in 1989, however, as construction and demand for building materials began to recover. The value of all construction increased more than 19% over that of the previous year.[3]

EMPLOYMENT

According to the Utah Department of

TABLE 1

NONFUEL MINERAL PRODUCTION IN UTAH[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Beryllium concentrates	metric tons	5,499	$6	5,308	$6	1,592	$5
Cement (portland)	thousand short tons	935	50,565	772	39,664	W	W
Clays	metric tons	285,903	1,959	308,585	2,469	321,949	2,633
Gem stones		NA	105	NA	370	NA	659
Lime	thousand short tons	562	17,894	365	17,252	373	17,974
Salt	do.	1,108	34,264	1,006	35,294	1,183	40,421
Sand and gravel:							
Construction	do.	e21,000	e56,700	17,843	49,796	e14,300	e41,500
Industrial	do.	6	11	3	60	3	60
Stone:							
Crushed	do.	7,989	23,606	e7,300	e20,600	4,683	19,176
Dimension	short tons	2,004	93	e2,004	e93	—	—
Combined value of cement (masonry), copper, gold, gypsum, iron ore, magnesium compounds, magnesium metal, mercury, molybdenum, phosphate rock, potassium salts, silver, sodium sulfate (natural, 1988–89), vanadium, and value indicated by symbol W		XX	514,661	XX	849,243	XX	1,168,022
Total		XX	699,864	XX	1,014,847	XX	1,290,450

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

Employment Security, the State's mining industry employed an average of 8,130 workers during 1989. This figure, which represents a decrease of about 5.5% from industry employment in 1988, included employees in the fuels sector.

The mining industry provided total income to its workers of $283 million. Average wages paid on a monthly basis to individual employees rose about 3% from those of 1988 to $2,905.

REGULATORY ISSUES

Early in 1989, the Governor established a 27-member Commission on Clean Air. The commission was charged with formulating strategies to keep the State within Federal clean-air standards and to deal with the increasing population. Of immediate concern was improving air quality in the population centers on the west flank of the Wasatch Range.

During the year, Geneva Steel was criticized for its alleged contamination of air and water in Utah County. PM-10 emissions (particulates less than 10 microns in diameter), for example, were said to be a major type of air pollutant originating at the steel mill. Company officials pointed out, however, that an ongoing modernization program will result in the control of 96% of all particulates and will reduce current PM-10 emissions by 92%. When all improvements in the plant have been completed, Geneva expects most pollutants to be significantly reduced or eliminated entirely.

The AMAX Magnesium Corp. plant at Rowley, on the west side of the Great Salt Lake, was cited by the Environmental Protection Agency (EPA) as the single largest air polluter in the Nation. This assertion was based on the amount of emissions officially reported for 1987 by the operating company. A large component of these emissions was fugitive chlorine gas generated at the plant as magnesium chloride was converted to magnesium metal. Although it was not clear how dangerous the chlorine emissions might be in the relatively remote location in Tooele County, installation of new equipment was begun during the year to reduce the escaping chlorine by 50%.

Concern continued to be expressed during the year over a final solution to a cleanup project involving mill tailings at Midvale in Salt Lake County. Approximately 14 million cubic yards of the tailings, on a 260-acre site, was identified by the EPA as potentially hazardous. A concern was raised that certain metals such as lead, arsenic, and cadmium, contained in the tailings and found in the soil of neighboring yards, could be health threatening. It was suggested that these metals could eventually be leached by rainwater from the tailings pile and carried into ground water. Some experts, however, reported that there was no evidence to support these fears.

The site, which was abandoned in 1971 by the Sharon Steel Corp., was placed on the EPA's Superfund list in 1984. Toward the end of 1989, UV Industries and Atlantic Richfield Co., two other companies that were potentially responsible for cleanup requirements, continued to test for metal contamination in ground water and soil and for anomalous blood lead in the local residents.

In July, the EPA formally notified Lone Star Industries Inc. that it was a potentially responsible party with regard to a site in Salt Lake City where cement kiln dust had been disposed. The company was cooperating in the preparation of a remedial investigation-feasibility study of the site. Although Lone Star expected to be held responsible for a portion of the costs of cleanup of the site, it sought acknowledgement from other owners for their share of the responsibility.

A report issued toward yearend by the Bureau of Land Management (BLM) recommended that 1.9 million acres of its land be designated as Federal wilderness. This recommendation covers almost 60% of the total wilderness study area that the Agency had reviewed. Wilderness proposals, ranging from 850,000 acres to 5.1 million acres, were made by members of Utah's congressional delegation.

EXPLORATION ACTIVITIES

The level of exploration effort for nonfuel minerals increased in Utah during 1989. Although most attention was given to the location of precious metals, there was considerable activity focused on exploration and evaluation of base metal and industrial mineral deposits. Exploration for gold and silver was concentrated in the mining districts of the Tintic area south of Salt Lake City and in Beaver and Washington Counties. The search for other commodities was widespread.

Records maintained by the BLM ranked Utah fourth in the Nation in the number of active claims for all minerals. According to the Utah Division of Oil, Gas and Mining, 71 new applications to drill and conduct other exploration activities in the State were submitted to the agency in 1989.

In the Tintic area, the Western Mining Corp. completed a metals exploration program that was begun in 1986. Western, an Australian company, terminated its agreement with property owners in the area after spending more than $4 million.[4] Centurion Mines Corp. concentrated its main exploration efforts in the Tintic and West Tintic mining districts; under an agreement with the company, the Teck Corp. of Canada carried out gold exploration in the West Tintic area during 1989. Centurion also explored properties in the southern Oquirrh Mountains that border Tooele and Utah Counties and in the Jackson Ridge area of western Millard County.

The Sunshine Mining Co. continued an extensive exploration program in the East Tintic mining district. During the year, the company explored the Eureka Standard Mine by drilling and underground drifting. Sunshine also continued its attempts to attract a joint-venture partner to develop the Burgin Mine. In its 1989 annual report, the company reported that the property has proven and probable ore reserves of one million short tons containing 23.9 million troy ounces of silver, 275,000 short tons of lead, and 90,000 short tons of zinc.

According to the annual report for 1989 of Gold Standard Inc., the company conducted airborne magnetic surveys and other exploration for gold on its Dugway property in Tooele County. Gold exploration was continued during the year by the company on its Long Ridge prospect in Utah County.

In the vicinity of the Goldstrike Mine in Washington County, an intensive effort was made to locate additional gold reserves. Tenneco Minerals Inc. drilled the Mineral Mountain property, and the North Lily Mining Co. of Canada drilled its nearby Perry property.

Precious metals were the target of exploration conducted by Bethlehem Resources in Beaver County. In its annual report for 1989, the company reported that it completed surface and underground

mapping, sampling, and geophysical surveying on the Horn Silver property west of Milford. A drilling program was also carried out during the year.

Other exploration projects in the State included the evaluation of properties containing base metals, beryllium, clay, gypsum, and perlite.

LEGISLATION AND GOVERNMENT PROGRAMS

The control of hazardous waste was a major goal of the Utah Legislature in 1989. To this end, two bills were passed, the Hazardous Substances Mitigation Fund (House bill 37) and the Hazardous Materials Cost Recovery Act (Senate bill 95). House bill 37 established procedures, powers, and mechanisms for supervision of the generation and disposal of hazardous waste. It also defined the liability and penalties for noncompliance. Senate bill 95 established liability for damage owing to the release of hazardous materials. This bill empowered the Division of Comprehensive Emergency Management to recover costs incurred by State and local governments for abatement operations necessitated by spills of hazardous materials.

In other legislation, the passage of House bill 208 created the Great Salt Lake Development Authority. The authority was given the power to acquire and maintain an interisland diking project while appropriating and obtaining water rights. The organization was also given the right to levy property taxes, collect fees and charges, and otherwise raise funds to accomplish its purpose. What effect passage of this bill will have on those companies that extract mineral products from the waters of the Great Salt Lake is unknown.

House bill 47 was passed to repeal the State requirement that the notice of annual assessment work performed on a mining claim be posted at the discovery monument.

The Utah Geological and Mineral Survey (UGMS) continued its program of funding outside geologic projects designed to encourage economic development of Utah's resources. During the 1989-90 fiscal year, approximately $150,000 generated from State mineral leases and Federal rebates was allocated to 27 projects, of which 5 were directly related to the mineral industry. During 1989, the UGMS published eight geologic maps on different areas of the State and one bulletin on the geology and mineral resources of Kane County. Considerable progress was made on the 1:250,000-scale mineral occurrence maps for the western part of the State. In addition, studies were initiated to evaluate high-calcium limestone resources in Utah and saline resources of oilfield brines.

The Utah Division of Oil, Gas and Mining issued new regulations governing notices of intent required for exploration and mining activities. Public workshops were sponsored to explain the new reporting and reclamation requirements. The regulatory agency also continued its program of securing abandoned mine sites. As of mid-1989, 503 mine openings had been sealed at 58 different mine sites.

In addition to operating the Salt Lake City Research Center, the Bureau of Mines supervised the administration of the Utah Mining and Mineral Resources Research Institute and the Comminution Generic Center. The Institute and the Generic Center were housed at the University of Utah and administered by faculty members of the College of Mines and Earth Sciences. Total grant money awarded by the Bureau to both units in 1989 exceeded $900,000.

During the year, the Bureau issued 10 open file reports addressing mineral land assessment in Utah. These reports summarized the mineral evaluation of wilderness study areas under the jurisdiction of the BLM.

In a joint effort, the Bureau of Mines and the U.S. Geological Survey published "Mineral Summaries—Bureau of Land Management Wilderness Study Areas in Utah." The summaries covered approximately 3 million acres of public land currently under consideration for Federal wilderness status in Utah. Studies were conducted on 66 of the 91 proposed wilderness areas. According to the report, nearly 80% of the areas studied have identified mineral resources; 92% have moderate or high potential for mineral resources.

A study begun during 1988 under the auspices of the Inventory of Land Use Restraints Program (ILURP) was continued. This long-term program was initiated by the Bureau of Mines to inventory Federal land use restrictions in order to assess accurately the availability of Federal lands for mineral entry. Under ILURP in 1989, the Bureau coded land status data for all master title plats in the State and entered them into a computer data base. In addition, mineral favorability data for selected locatable and leasable minerals were plotted on maps.

REVIEW BY NONFUEL MINERAL COMMODITIES

Metals

Beryllium.—The largest operating beryllium mine in the world is in Juab County, located at Spor Mountain. The ore consists of bertrandite-bearing tuffs and is mined with open pit methods by Brush Wellman Inc. The company converts this ore, including small quantities of domestically produced beryl and imported beryl, to beryllium hydroxide at its facility in Delta (Millard County). This facility is the only extraction plant in a market economy country that can recover beryllium from both types of ore.

In 1989, Brush Wellman celebrated 20 years of operation in Utah. The company announced that its minable ore reserve of 6 million short tons was sufficient to supply the mill, at current operating rates, for 60 years. In its annual report for 1989, the company reported that the mine produced 85,000 short tons of ore with an average grade of 0.231% beryllium.

In response to reduced demand in computer, defense, and semiconductor markets, the production of beryllium declined for the third consecutive year. New applications of beryllium alloys in automotive components and plastic molds, however, heralded increased consumption of the light metal in the future.

Copper.—In 1989, Utah retained its position as the third largest copper-producing State in the Nation. This ranking was supported almost exclusively by the output of the Bingham Canyon open pit mine in Salt Lake County. This mine was the second largest domestic producer of copper during the year, and it is the deepest mortal-made excavation in the world. Some copper was contributed to the State total by the Trixie flux mine in Utah County.

The British Petroleum Co. PLC sold the Bingham Canyon Mine and its integrated production facilities and other assets for $3.7 billion to the RTZ Corp. PLC in June. London-based RTZ is reportedly the world's largest mining

company. Shortly after the transaction, BP Minerals America, the former Utah-based subsidiary of British Petroleum, was renamed the Kennecott Corp.

In 1989, during its first full year of production since a $400 million modernization program was completed the previous year, the Bingham Canyon Mine produced copper totaling 229,700 metric tons (253,200 short tons).[5] The value of this copper represented a significant percentage of the value of all nonfuel mineral production in the State. The mining operation is one of the most cost-effective copper producers in the Nation.

Gallium and Germanium.—In March, Hecla Mining Co. acquired the Apex Mine in Washington County for $5.5 million from the St. George Mining Corp., a wholly owned subsidiary of Musto Exploration Ltd. of Canada. The underground mine, in operation during 1986 and 1987, has been the only known primary source of gallium and germanium in the world.

At the Apex facility in 1989, Hecla dismantled the germanium refinery, refurbished the existing equipment, installed new extraction systems, and increased automation in the processing plant. The recovery facility will use a series of solvent extraction, precipitation, and hydrometallurgical processes to produce sodium germanate concentrate, gallium metal, and byproduct copper cathode. Approximately 85 people will be employed at the operation when it is in full production, which is slated to begin in the second half of 1990.

Gold.—Utah mines increased their production of gold more than 67% compared with that of 1988, pushing the State into third place in the Nation. Although most of the gold was a mine byproduct, several primary gold producers were major contributors to the total production.

The leading primary producer of gold in Utah was the Mercur Mine in Tooele County. The mine, owned by Barrick Mercur Gold Mines Inc., produced a record 3,655.6 kilograms (kg) or 117,536 troy ounces of gold in 1989, which was an increase of about 2% over that of the previous year. It ranked 17th among all gold mines in the Nation during the year. According to the company's annual report for 1989, the production record was achieved in spite of the unusually hard ore mined exclusively from the Marion Hill pit. Factors cited by Barrick for the record achievement were a grade of millfeed that was higher than expected, a major increase in dump-leach production, and excellent performance of the new autoclave.

The autoclave, which was installed to treat refractory sulfide ore, was operated for its first full year in 1989. Throughput in the new autoclave exceeded design capacity of 750 short tons per day, and the unit achieved an average recovery rate of 81.4% for the year.

The total production rate at the Mercur Mine was about 5,000 short tons per day. Preproduction development of the Sacramento pit continued in 1989 along with construction of additional leach facilities and expansion of the tailings dam. Capital expenditures totaled $6.2 million.

Primary production by Tenneco Minerals Inc. at the Goldstrike Mine in Washington County began officially in May. Approximately $8.5 million was invested to bring the property into production. The new open pit and heap-leach operation has the capacity to produce 1,244 kg (40,000 troy ounce) each of gold and silver per year. In 1989, the mine reportedly produced 715 kg (23,000 troy ounce) of gold.[6]

The Jumbo Mining Co. continued to recover gold by leaching at the Drum Mine in Millard County, and the North Lily Mining Co. maintained its leaching of gold from mill tailings near Silver City in Juab County. North Lily completed its first full year of production in 1989. According to its annual report, the company produced 183.1 kg (5,887 troy ounce) of gold during the year; in 1988, the output of gold was 58.1 kg (1,868 troy ounce).

North Lily began an expansion program, including enlargement of the pad at the heap-leach facility, for a budgeted cost of $1.1 million. This expansion will accommodate additional ore contained in the Mammoth dump. The dump, purchased by the company in 1989, contains 320,000 short tons of ore that averages 0.035 troy ounce of gold per ton and 0.95 troy ounce of silver per ton.

During the fall, Kennecott began primary gold production at its new $32 million Barney's Canyon Mine in Salt Lake County. About 4 miles north of Bingham Canyon, the new open pit and heap-leach mine was designed to produce approximately 2,500 kg (80,000 troy ounce) of gold annually.

During the year, Kennecott's Bingham Canyon Mine was the largest producer of gold in Utah and the second largest producer in the Nation. All of this gold was produced as a byproduct of the mine's copper output. In 1989, the combined gold production of Barney's Canyon Mine and the Bingham Canyon Mine was 15,769 kg (507,000 troy ounce).[7]

The Sunshine Mining Co. operated the Trixie Mine in Utah County throughout the year and shipped flux ore containing precious metals to Kennecott's smelter at Garfield, UT and to ASARCO Incorporated's smelter at El Paso, TX. In its 1989 Form 10-K, Sunshine reported total byproduct gold from the mine was 282.2 kg (9,074 troy ounce). One of the owners of the property, the South Standard Mining Co., stated in its annual report that the ore mined during the year averaged 0.32 troy ounce of gold per short ton and 8.13 troy ounce of silver per short ton.

Iron Ore and Steel.—The Geneva Steel Co. continued operating its integrated steel facility in Utah County. During 1989, the company shipped more than 1 million short tons of steel. Approximately 700,000 long tons of iron ore was fed to the steel plant from Geneva's contract mining operations in Iron County. The balance of the iron ore requirement, about 60%, was imported as iron ore pellets from Minnesota.[8] In October, the company reduced steel production by 25% because of a nationwide decline in demand.

In September, Geneva announced a $400 million modernization program that would require 3 to 5 years to complete.[9] It was anticipated that improvements made during the first 3 years would cost $226 million and would include installation of the following: (1) continuous casting facility, (2) basic oxygen process furnaces, (3) coil-box and rolling-mill improvements, (4) oxygen plant, (5) gas desulfurization facility, and (6) wastewater treatment plant.

The Nucor Corp. continued to operate a steel minimill at Plymouth in Box Elder County. In the plant, electric arc furnaces melt ferrous scrap from which steel is produced on continuous casting equipment. The annual production capacity is about 600,000 short tons of billet.

Magnesium.—Magnesium metal production in the State rose approximately

20% over that of 1988. This increase was attributed in part to a full-year operation of AMAX Magnesium Corp.'s new evaporation and precipitation pond system completed in 1988. Utah continued to be one of only three States in which the refined metal was produced.

Sale of the primary magnesium facility to the Renco Group Inc. was finalized in September. The operation was purchased for an undisclosed amount and renamed Magnesium Corp. of America (Magcorp). The new company planned to increase annual production to 38,000 short tons in 1990, making it the second largest producer of magnesium in the United States and the third largest producer in the free world.

Molybdenum.—Kennecott continued as the sole producer of molybdenum in Utah. Molybdenite concentrates were recovered as a byproduct of copper production at the Bingham Canyon Mine. The sulfide concentrates were roasted and converted to molybdic oxide in the company plant at Magna.

Molybdenum output rose almost five times that of the previous year; production in 1989 was 4,200 metric tons (9.3 million pounds).[10] The increase was due chiefly to modifications of the molybdenum circuit in the new Copperton concentrator and to its operation for a full year.

Silver.—Mine production of silver in the State increased dramatically by 33% over 1988 output. This production raised Utah into fourth place among all States. The rise was due primarily to increased copper and gold production and an accompanying increase of byproduct silver.

Production of byproduct silver at the Bingham Canyon Mine ranked the mine sixth among all silver producers in the country. In 1989, this output was approximately 116.8 metric tons (3,755,000 troy ounce).[11]

Sunshine reported in its 1989 Form 10-K that flux ores shipped from the Trixie Mine contained 7.2 metric tons (230,494 troy ounce) of byproduct silver. Barrick's Mercur Mine in Tooele County, North Lily's Silver City tailings operation in Juab County, and Tenneco's Goldstrike Mine in Washington County also continued to produce byproduct silver.

In recent years, the Escalante Mine in Iron County has been Utah's only primary silver producer. At the end of 1988, however, the mine was closed because the known ore body was mined out and because exploration efforts to discover additional ore were not successful. The mill has continued to process stockpiled ore and is expected to continue until mid-1990. According to Hecla's Form 10-K, silver production in 1989 was 50.6 metric tons (1,626,965 troy ounce).

Uranium-Vanadium.—Uranium concentrate produced from ores mined in Utah accounted for approximately 3% of domestic output in 1989. Umetco Minerals Corp. continued to operate several underground mines in San Juan County and to ship the ore to the White Mesa Mill at Blanding, also in San Juan County. About 91,000 short tons of ore was mined at the following properties: La Sal Area mines, La Sal-Bonanza Mine, Rim Mine, Section 10 Mine, and Wilson Mine. Some low-grade stockpile ore was shipped from the Calliham Mine.[12] Vanadium was recovered as a coproduct of this ore. During the year, independent miners in the State shipped slightly more than 10,000 short tons of uranium-vanadium ore to the mill at Blanding.

Uranium was also recovered from Kennecott's copper-leach solutions at the ion-exchange (IX) plant operated by the Energy Fuels Nuclear Co. adjacent to the Bingham Canyon Mine. This plant was placed on standby in March because of low uranium prices. The Atlas Corp. and the Rio Algom Mining Corp. continued decommissioning their mills and conducting reclamation programs near Moab and La Sal Junction.

The White Mesa Mill, a joint venture of Umetco and Energy Fuels, treated ores from Arizona, Colorado, and Utah. It is the only mill in the United States that has both uranium and vanadium recovery circuits. In 1989, the mill produced 3.743 million pounds of uranium oxide and 5.424 million pounds of vanadium oxide. The output of vanadium more than quadrupled that of 1988 primarily because of a surge in price during early 1989 and because the mill was the only facility capable of recovering vanadium from uranium-vanadium ores.

Other Metals.—The Mercur Mine continued recovery of byproduct mercury. By virtue of this production, Utah was one of only a few producers of quicksilver in the United States during 1989.

Until it was closed during the year, the Energy Fuels IX facility in Salt Lake County recovered scandium as a uranium byproduct. In 1989, this plant was the only producer of mined scandium in the Nation. Various trace metals, including palladium, platinum, and selenium, were recovered from anode slimes at the copper refinery owned by Kennecott at Magna in Salt Lake County. Kennecott was one of only three domestic producers of refined selenium.

Western Zirconium continued production of primary zirconium sponge and coproduct hafnium sponge from zircon concentrates. The concentrates were imported from Australia to the company plant near Ogden in Weber County.

Industrial Minerals

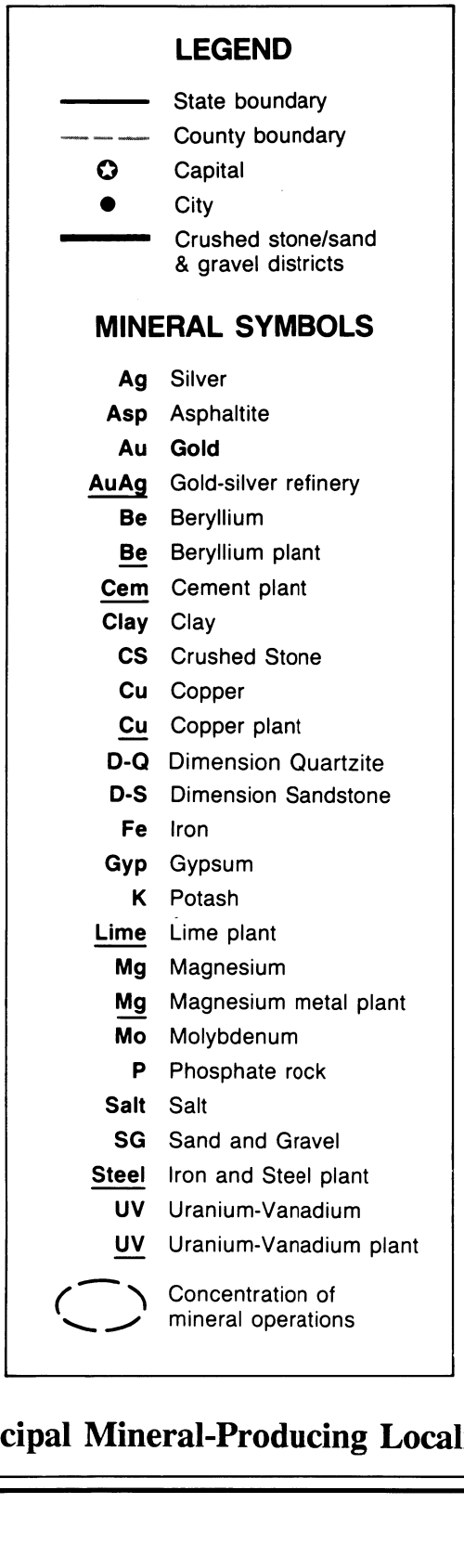
Cement.—In 1989, the production of portland cement recovered somewhat from previous years as construction activity rebounded. Output increased significantly over that of 1988. There was no change in the output of masonry cement.

Late in the year, Lone Star Industries Inc. approved a restructuring plan that authorized the sale of its cement plant and distribution terminal in Salt Lake City (Salt Lake County) and its limestone quarry at Grantsville (Tooele County). The plan also included the company's 50% interest in its joint venture, the Mountain Cement Co, formed with a subsidiary of the Centex Corp. The Lone Star cement plant, with a rated capacity of 420,000 short tons per year, was idle throughout the year, but the plant site was operated for a fee as a distribution terminal of the Mountain Cement Co.

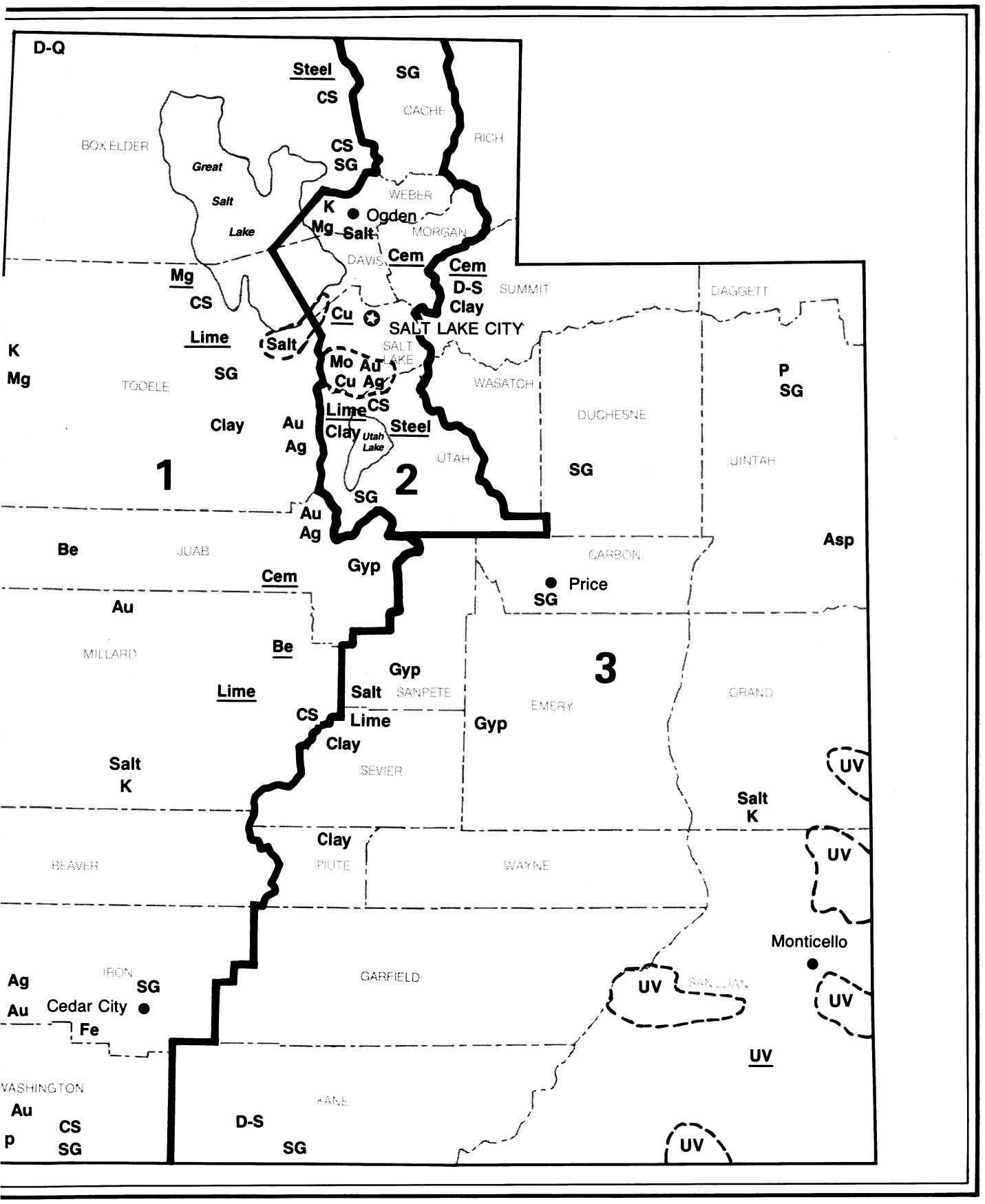
Effective the end of March, Southdown Inc. relinquished its lease on a cement plant in Leamington (Millard County) owned by Martin Marietta Corp. According to its 1989 annual report, Southdown shipped approximately 62,000 short tons of cement from the plant before the facility reverted to Martin Marietta. The dry-process plant has a capacity of 650,000 short tons per year and was purchased by Ash Grove Cement West Inc. later in the year. This acquisition included a distribution terminal at Murray in Salt Lake County.

A proxy statement and prospectus issued February 14, 1990, by Ideal Basic Industries Inc. reported that the company's cement plant at Devil's Slide in Morgan County had an annual rated capacity of 350,000 short tons. The wet-process plant, built in 1948, operated at 94% of capacity during 1989.

UTAH



Principal Mineral-Producing Localities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DAVIS
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Clays.—During the year, clay production in Utah increased slightly in quantity and value. The increase occurred primarily because of a large rise in the production of bentonite which, in 1989, was 45,650 metric tons (50,320 short tons) or approximately 53% more than that of the previous year.

The two largest clay producers in the State were Interstate Brick Co. and Interpace Corp., both of which blended clays from numerous quarries to manufacture brick. Bentonite was produced by the Redmond Clay and Salt Co. and by the Western Clay Co. Fuller's earth was produced by Western Clay at its mine near Aurora in Sevier County. An organic-rich shale, which is expanded and used as lightweight aggregate, was mined by the Utelite Corp. in western Summit County.

Gypsum.—Most gypsum mined in the State was from several open pit mines northeast of Sigurd in Sevier County. While the production of crude gypsum registered a moderate increase of about 8% over that of 1988, output of calcined gypsum, used primarily in wallboard, declined slightly in 1989. During the year, the average price of crude gypsum remained steady at about $7.30 per short ton, but the average price of calcined gypsum dropped from 1988 prices to $17.12 per short ton.

The two principal producers in the Sigurd area were Georgia-Pacific Corp. and the United States Gypsum Co. Other producers included T. J. Peck and Sons, which mined gypsum near Nephi (Juab County) for export to a cement plant in Idaho, and Standard Gypsum Products, which mined gypsum in Washington County for export as an agricultural supplement. Some production was sold by other suppliers to cement plants operating in the State.

Lime.—Output of lime increased about 2% over that of 1988. Most of the commercial production was provided by Chemstar Inc. in Tooele County and Continental Lime Inc. in Millard County. Both of these companies have large total domestic capacity and, in 1989, were among the top 10 producers of lime in the Nation. In Utah, most of Chemstar's dolomitic lime was hydrated and used in construction applications. Continental's high-calcium lime was used for a variety of purposes, including removal of sulfur dioxide from smokestack gases and control of pH in mineral processing. The only other producer of lime was Materials Energy Research and Recovery Inc., which used quicklime as a neutralizer in the company-owned landfill in Tooele County and sold dead-burned dolomitic lime to Geneva Steel.

Magnesium Compounds.—The production of magnesium compounds in Utah dropped about 23% from that of 1988. The decline was probably due to a drop in sales of magnesium chloride to AMAX Magnesium from the Reilly Tar and Chemicals Corp. Reilly's product was supplied to AMAX as feedstock for the production of magnesium metal until AMAX commissioned its new evaporation and precipitation pond system. This system, which supplies the necessary magnesium chloride, was operated for a full year in 1989.

Great Salt Lake Minerals & Chemicals Corp. produced magnesium chloride from brines of the Great Salt Lake west of Ogden in Weber County. The chloride was used primarily as a suppressor of dust on roads and in industrial areas and in sugar beet processing. Early in the year, the company was sold for $33.4 million by its parent, Gulf Resources & Chemical Co., to the GSL Acquisition Corp.

Phosphate Rock.—In 1989, the output of phosphate rock in Utah declined about 9% from that of the previous year. Chevron Resources' open pit mine near Vernal at Little Brush Creek (Uintah County) was the only producer in the State. The phosphate rock was beneficiated at the Little Brush Creek facility and pumped as slurry through a 94-mile pipeline to the company's fertilizer plant in Rock Springs, WY.

Potash.—Utah continued in 1989 as the second largest producer of potassium salts in the Nation. Although output increased only about 3% over that of 1988, total sales volume rose more than 24%. The average annual price nationwide for all potash products increased 5%.

Great Salt Lake Minerals and Chemicals completed the repair of its harvesting facility that had been severely damaged in 1984 by flood waters from the Great Salt Lake. During 1989, the company resumed production of potassium sulfate by solar evaporation and conversion from kainite.

The Reilly Wendover plant, owned by the Reilly Tar and Chemicals Corp. at the west end of the Bonneville Salt Flat, produced potassium chloride by solar evaporation and flotation from shallow, subsurface brines.

In eastern Utah, near Moab in Grand County, Moab Salt Inc. extracted potassium chloride and byproduct salt from underground bedded deposits by solution mining and evaporation. Moab Salt is an affiliate of Texasgulf Inc., which is a wholly owned subsidiary of Elf Aquitaine Inc. In its annual report, Elf Aquitaine stated that although the solution mine produced 455 million gallons of brine in 1989, up 3% from 1988, potash production was 90,000 short tons or 18% less than that of 1988. The company explained that the drop was due to a gradually declining concentration of potash in the brine.

Salt.—Utah mines produced nearly 1.2 million short tons of salt in 1989, approximately 18% more than in the previous year. Recovery of salt from surface brines of the Great Salt Lake improved because the water level in the lake receded and salt concentration increased.

During the year, eight firms produced salt in the State. In some operations, salt was recovered as a primary product; in others, it was recovered as a byproduct or coproduct. Four operators produced salt from the brines of the Great Salt Lake: Akzo Salt Inc. (formerly International Salt Co.), American Salt Co., Great Salt Lake Minerals and Chemicals Corp., and Morton Salt Co. These companies harvested salt from shallow solar evaporation ponds; Great Salt Lake Minerals and Chemicals has the largest annual production capacity, 1.5 million short tons of salt. At midyear, Morton Salt became a division of Morton International, which had been spun off from Morton Thiokol Inc.

Shallow subsurface brines were the feedstock for two salt producers: Crystal Peak Minerals Corp. and Reilly Tar and Chemicals Corp. In 1989, Crystal Peak, a subsidiary of the W. D. Hayden Co., began producing salt from solar evaporation ponds constructed at the southern end of Sevier Lake in Millard County.

Salt was extracted in a manner similar to that of Crystal Peak by Reilly Tar and Chemicals at its plant near the Bonneville Salt Flats in Tooele County. Sylvinite was recovered in solar evaporation ponds and treated to extract sylvite and halite.

In central Utah, at Redmond in Sevier County, the Redmond Salt and Clay Co. produced rock salt from an underground mine. Near Moab in Grand County, solar

salt was produced as a byproduct of Moab Salt's potash operation and marketed by the firm's affiliate, Carey Salt. The 1989 annual report of Elf Aquitaine stated that salt production for the year was 99,000 short tons.

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Utah construction sand and gravel statistics are compiled according to geographical districts as depicted on the State map. The State's production in 1989 was estimated to have dropped almost 20% from that of 1988. The actual production may be different, however, since there was a considerable increase overall in construction activity during the year. Most of the output in Utah was from District 2, which encompasses the population centers of Ogden, Provo, and Salt Lake City.

Industrial.—Utah's sole producer of industrial sand was Salt Lake Valley Sand and Gravel Co. Mined from the Nash pit in Salt Lake County, the commodity was sold for the construction of molds and linings and as a traction sand.

Sodium Sulfate.—During 1989, Great Salt Lake Minerals and Chemicals produced sodium sulfate by solar evaporation of lake brines. The brines were recovered from the eastern portion of the Great Salt Lake in Weber County. Output during the year fell about 48% from that of 1988.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Statistics for crushed stone production are separated into three geographical districts as shown on the State map. Table 3 presents end-use statistics for these districts. Production in 1989 declined almost 18% from the estimated level of output in 1988.

Dimension.—Aragonite in Tooele County and quartz schist in Box Elder County were mined intermittently during the year as dimension stone.

Other Industrial Minerals.—Two companies continued production of the hydrocarbon asphaltite from underground mines in Uintah County. A third company in the area, Lexco Inc., began sinking a mine shaft in preparation for asphaltite production in 1990. The commodity was marketed as an additive for foundry sand, printing inks, drilling muds, and a variety of other nonfuel applications.

AMAX Magnesium recovered chlorine as a byproduct at its Rowley facility. In 1989, Utah's natural gem stone industry grew in value an impressive 78% over that of the previous year. Some principal gem stones mined in the State were agate, aquamarine, and beryl.

TABLE 2

UTAH: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Agricultural: Poultry grit and mineral food and other agricultural uses	8	182
Other miscellaneous uses[2]	1,716	7,408
Other uses not listed[3]	507	3,128
Unspecified:[4]		
Actual	2,452	8,459
Total	4,683	[5]19,176

[1]Includes dolomite, limestone, granite, quartzite, volcanic cinder, and scoria.
[2]Includes stone used in cement and lime manufacture, mine dusting, and roofing granules.
[3]Includes stone used in screenings-fine, graded road base or subbase, and crusher run or fill or waste.
[4]Data represents production reported without a breakdown by end use.
[5]Data do not add to total shown because of independent rounding.

TABLE 3

UTAH: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Fine aggregate (-3/8inch)[1]	W	W	—	—	—	—
Coarse and fine aggregates[2]	W	W	W	W	—	—
Other construction aggregates	26	21	144	520	—	—
Agricultural[3]	([4])	([4])	([4])	([4])	—	—
Chemical and metallurgical[5]	([4])	([4])	([4])	([4])	—	—
Special[6]	([4])	([4])	([4])	([4])	—	—
Other miscellaneous	1,200	6,192	860	3,984	—	—
Unspecified:						
Actual[7]	261	917	2,191	7,542	—	—
Total[8]	1,488	7,130	3,196	12,046	—	—

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[1]Includes screening (undesignated).
[2]Includes crushed stone for graded road base or subbase and crusher run or fill or waste.
[3]Includes poultry grit and mineral food, and other agricultural uses.
[4]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[5]Includes crushed stone for cement manufacture and lime manufacture.
[6]Includes crushed stone for mine dusting or acid water treatment and roofing granules.
[7]Includes production reported without a breakdown by end use.
[8]Data do not add to totals shown because of independent rounding.

Synthetic graphite was produced for use in composite materials developed and manufactured by Hercules Inc. at its plant near Salt Lake City (Salt Lake County). As in prior years, perlite was shipped in from out of the State to be expanded at a plant owned by the Pax Co. in Salt Lake County.

A relatively small amount of sulfur was recovered at the petroleum refinery owned by Chevron Oil Co. in Salt Lake County. As a byproduct of smelting copper ore, Kennecott produced sulfuric acid at its Magna facility. Although acid production declined slightly during the year, its value rose considerably.

Intermountain Products Inc. continued to purchase crude vermiculite from out-of-state sources and produce exfoliated vermiculite at its plant in Salt Lake County.

[1]State Mineral Officer, Bureau of Mines, Tucson, AZ. He has covered the mineral activities in Utah for 2 years. Assistance in the preparation of the chapter was given by Donna Bruns, editorial assistant.

[2]Senior geologist, Utah Geological and Mineral Survey, Salt Lake City, UT.

[3]Sargent, A., and C. Lewis. Utah's Economy Continues to Grow in 1989. Utah Econ. and Business Rev., v. 50, No. 4, pp. 1-6.

[4]Centurion Mines Corp. 1989 Annual Report, 18 p.

[5]RTZ Corp. PLC 1989 Annual Report, 66 p.

[6]Salt Lake Tribune, Mar. 1, 1990.

[7]Work cited in footnote 5.

[8]———. Aug. 20, 1989.

[9]———. Feb. 17, 1990.

[10]Work cited in footnote 5.

[11]Work cited in footnote 5.

[12]Private communication, Oct. 25, 1990, available upon request from Umetco Minerals Corp., Blanding, UT.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of Activity	County
Asphaltite:			
American Gilsonite Co., a subsidiary of Chevron Corp.	136 East South Temple, #2350 Salt Lake City, UT 84111	Underground mines and plant	Uintah.
Ziegler Chemical and Mineral Corp.	Star Rt. 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. (formerly Southdown Inc.)[1 2]	Box 51 Nephi, UT 84648	Quarries and plant	Millard.
Ideal Basic Industries Inc., Cement Div.[1]	Star Rt. Morgan, UT 84050	do.	Morgan.
Clays:			
Interpace Industries	Box 12118 Ogden, UT 84402	Open pit mines and plant	Utah.
Interstate Brick Co., a division of Pacific Coast	9780 South 5200 West West Jordan, UT 84084	do.	Box Elder, Tooele, Utah.
Utelite Corp.	Box 387 Coalville, UT 84017	Open pit mine and plant	Summit
Western Clay Co.[1]	Box 127 Aurora, UT 84620	Open pit mines	Sevier.
Copper:			
Kennecott Corp., a subsidiary of RTZ Corp. PLC (formerly BP Minerals America Inc.)[3]	Box 11248 Salt Lake City, UT 84147	Open pit mine, mills, smelter, refinery	Salt Lake.
Gold:			
Barrick Mercur Gold Mines Inc., a subsidiary of American Barrick Resources Corp.[4]	Box 838 Tooele, UT 84074	Open pit mine, mill, carbon in-pulp plant	Tooele.
Jumbo Mining Co.	Box 999 Delta, UT 84624	Heap leach	Millard.
North Lily Mining Co.[5]	1111 Bayhill Dr., #210 San Bruno, CA 94066	do.	Juab.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of Activity	County
Gypsum:			
Georgia-Pacific Corp.	Box 80 Sigurd, UT 84657	Open pit mine and plant	Sevier.
United States Gypsum Co., a subsidiary of USG Corp.	Box 160 Sigurd, UT 84657	do.	Do.
Iron and steel:			
Geneva Steel[1]	Box 2500 Provo, UT 84603	Mines and plant	Iron and Utah.
Nucor Steel Div., Nucor Corp.	Box 488 Plymouth, UT 84330	Plant	Box Elder.
Lime:			
Chemstar Lime[1]	Box 537 Grantsville, UT 84029	Open pit mine and plant	Tooele.
Continental Lime Inc., a subsidiary of Steel Bros. Canada Ltd.[1]	Box 266 Delta, UT 84624	Quarry and plant	Millard.
Materials Energy Research & Recovery Corp., a subsidiary of United States Pollution Controls Inc.[1]	Box 596 Grantsville, UT 84029	Open pit mine and plant	Tooele.
Magnesium:			
Magnesium Corp of America, a subsidiary of Renco Group Inc. (formerly AMAX Magnesium Corp.)[6 7]	238 North 2200 West Salt Lake City, UT 84116	Plant and solar evaporation ponds	Do.
Phosphate rock:			
Chevron Resources Co., a subsidiary of Chevron Corp.	9401 N. Highway 191 Vernal, UT 84078	Open pit mine and plant	Uintah.
Potassium salts:			
Great Salt Lake Minerals & Chemicals Corp., a division of GSL Acquisition Corp.[8]	Box 1190 Ogden, UT 84402	Plant, concentrator, solar evaporation ponds	Weber.
Moab Salt Inc., a division of Texasgulf, Inc., a subsidiary of Societe Nationale Elf Aquitaine[7]	Box 1208 Moab, UT 84532	Solution mine, solar evaporation, concentrator, plant	Grand.
Reilly Tar and Chemicals Corp., Reilly Wendover Div.[7 9]	Box 580 Wendover, UT 84083	do.	Tooele.
Salt:			
Akzo Salt Inc. (formerly International Salt Co.)	1428 J. Palmer Rd. Lake Point, UT 84074	Plant	Do.
American Salt Co.	Box 477 Grantsville, UT 84029	do.	Do.
Morton Salt Co., a division of Morton International Inc.	A.M.F. Box 22054 Salt Lake City, UT 84122	do.	Salt Lake.
Redmond Clay & Salt Co.[2]	370 S. State St. Redmond, UT 84652	Underground mine	Sanpete.
Sand and gravel (construction):			
W. W. Clyde & Co.	Box 350 Springville, UT 84663	Pits and plants	Utah.
Concrete Products Co., a division of Gibbons & Reed Co.[2]	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.
Monroc Inc.	Box 537 Salt Lake City, UT 84110	do.	Do.

See footnotes at end of table.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of Activity	County
Sand and gravel (construction)—Continued			
Jack B. Parson Co. Inc.	5200 South Washington Blvd. Ogden, UT 84402	Pits and plants	Box Elder, Cache, Davis.
Savage Rock Products[1]	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.
Torno America Inc.	450 Sansome St., #1000 San Francisco, CA 94111	do.	Wasatch.
Western Rock Products Corp.	820 North 1080 East St. George, UT 84770	do.	Washington.
Silver:			
Hecla Mining Co., Escalante Unit.[10]	Box 310 Enterprise, UT 84725	Concentrator	Iron.
Stone (crushed):			
Cedarstrom Calcite & Clay Corp.	145 East 5th North Lehi, UT 84045	Quarry	Utah.
Diversified Marketing Services Inc.	Box 1181 Filmore, UT 84631	Quarry and plant	Millard.
Larson Limestone Co.	95 North 200 East American Fork, UT 84003	Quarry	Utah.
Lava Products Inc.	94 West Tabernacle St George, UT 84770	do.	Washington.
Legrand Johnson Construction Co.	Box 248 Logan, UT 84321	Quarries	Cache.
Santaquin Calcite Co.	355 East 100 North Santaquin, UT 84655	Quarry	Santaquin.
Stone (smelter flux):			
Sunshine Mining Co.[5 10]	Box 250 Eureka, UT 84628	Underground mine	Utah.
Uranium-Vanadium:			
Energy Fuels Nuclear[11]	1 Tabor Center, #2500 1200 17th St. Denver, CO 80202	Ion-exchange plant	Salt Lake.
Umetco Minerals Corp.	Box 669 Blanding, UT 84511	Underground mines, ore-buying station, mill	Emery, Garfield, San Juan.

[1]Also crushed stone.
[2]Also clay.
[3]Also gold, molybdenum, and silver.
[4]Also silver and mercury.
[5]Also silver.
[6]Also chlorine.
[7]Also salt.
[8]Also magnesium compounds, salt, and sodium sulfate.
[9]Also magnesium compounds.
[10]Also gold.
[11]Also scandium.

THE MINERAL INDUSTRY OF VERMONT

This chapter has been prepared under a Memorandum of Understanding between the 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] and Charles A. Ratté[2]

The value of Vermont's nonfuel mineral production in 1989 was nearly $89 million, a $13 million increase over the 1988 value. Leading mineral commodities produced, in descending order of value, were dimension stone, crushed stone, sand and gravel, talc, and asbestos. Nationally, the State ranked third of 10 States that produced talc. It ranked third in quantity in dimension stone output, but first in value. Vermont was one of only two States that produced asbestos; the other was California.

TRENDS AND DEVELOPMENTS

Vermont's construction industry, which was the major consumer of the State's mineral output, accounted for the largest job growth in the State in 1989, growing 10% or double the rate it grew in 1988. Although total housing starts in 1989 were down 24% from those of 1988, work remaining on 1988 housing starts, which had increased by 15% from the previous year, buoyed the construction industry in 1989. As a result, output of crushed stone and construction sand and gravel increased in 1989.

LEGISLATION AND GOVERNMENT PROGRAMS

In March, Vermont and several other States won a decision from the U.S. Court of Appeals that would force the U.S. Environmental Protection Agency (EPA) to address the need for new air quality standards for sulfur oxides, the primary cause of acid rain. In the decision by the Second Circuit of the U.S. Court of Appeals in New York City, the Court reversed a lower court decision that had concluded that the court could not direct the EPA to revise air quality standards. The decision stems from a suit brought in late 1985 by Vermont, New York, Massachusetts, New Hampshire, Connecticut, Minnesota, the Environmental Defense Fund, and three other national environmental groups. The plaintiffs in that action before the Federal District Court in New York had sought to end years of inaction by the EPA, which had failed to revise inadequate air quality standards for sulfur oxides despite growing evidence that these pollutants were creating massive environmental damage.[3]

The Office of the State Geologist, Vermont Geological Survey, was preparing a legislative proposal for introduction in the 1990 legislative session. The purpose of this new legislation would be to redefine the role of the State Geologist and to create a Division of Geology and Mineral Resources within the Vermont Agency of Natural Resources.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Asbestos.—Vermont Asbestos Group Inc. (VAG), one of two active asbestos producers in the United States, operated an open pit mine and a dry-processing mill near Lowell, Orleans County. The plant produced a wide range of grades of chrysotile asbestos. In 1989, sales of asbestos declined about 15%. Asbestos was sold primarily for automotive clutches and brake components and for diaphragms for chlorine production equipment.

TABLE 1

NONFUEL MINERAL PRODUCTION IN VERMONT[1]

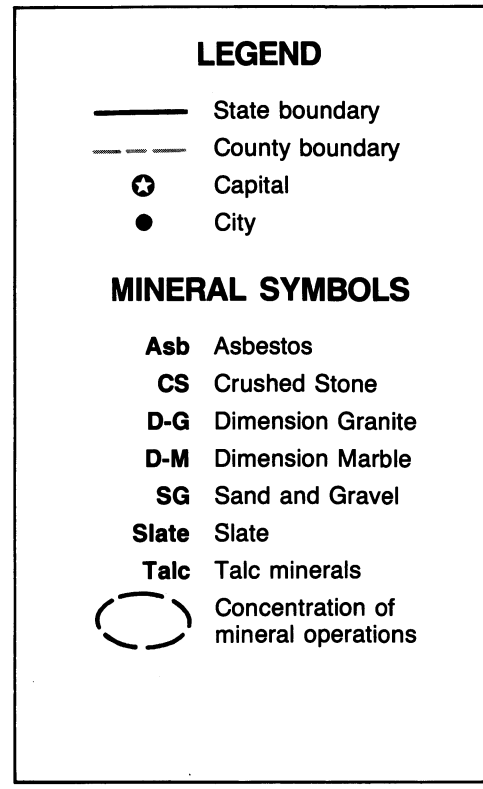
Mineral	1987		1988		1989	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones	NA	$10	NA	$10	NA	$10
Sand and gravel (construction) thousand short tons	e4,700	e10,800	6,047	17,478	e6,900	e20,400
Stone:						
Crushed do.	[2]2,159	[2]20,400	e [2]2,000	e [2]18,000	3,119	28,110
Dimension short tons	103,923	30,074	e105,000	e30,500	100,698	31,413
Combined value of other industrial minerals	XX	12,160	XX	10,957	XX	8,969
Total	XX	73,444	XX	75,655	XX	88,902

eEstimated. NA Not available. XX Not applicable.

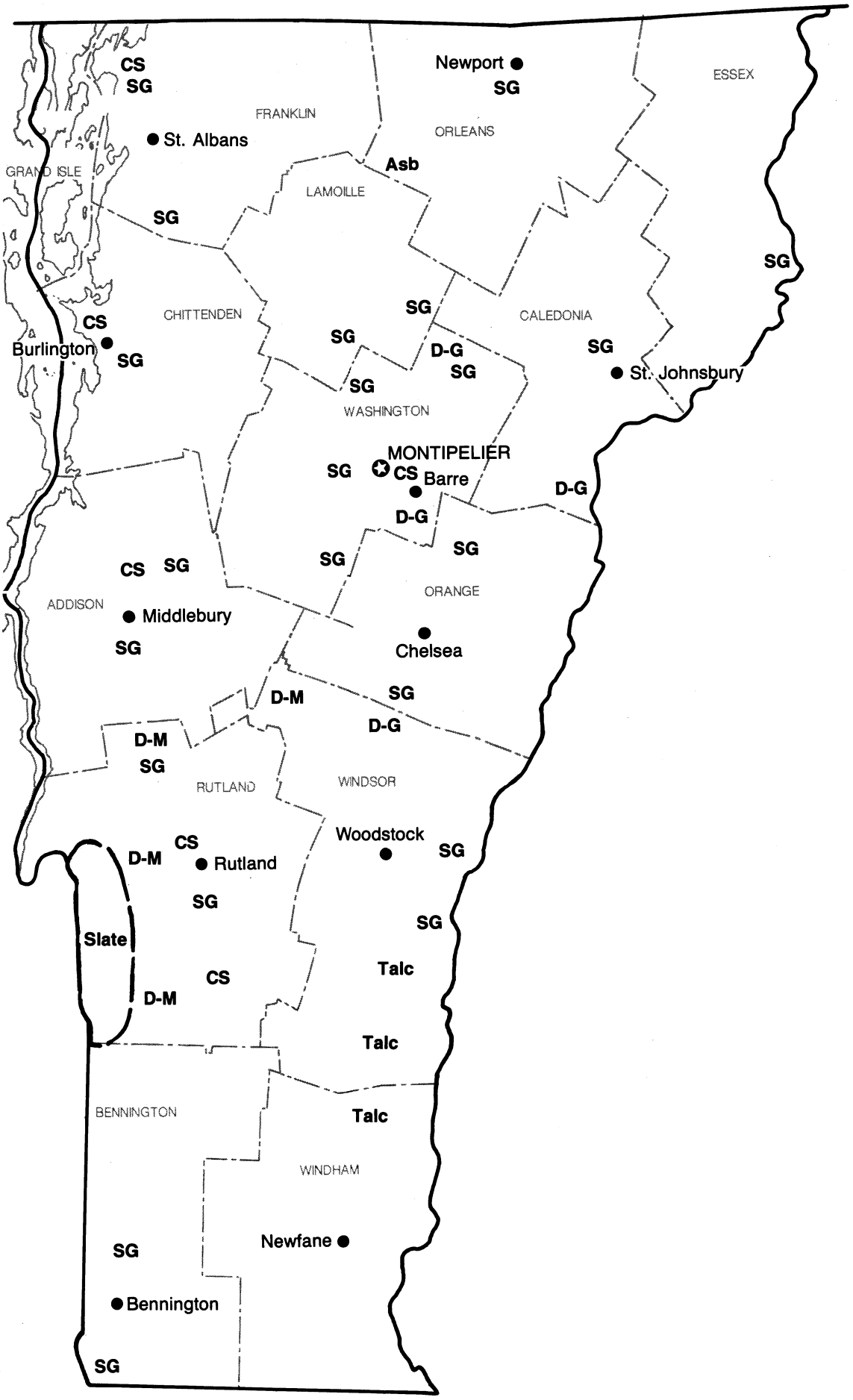
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

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

VERMONT



Principal Mineral-Producing Localities


CS
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FRANKLIN
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ORLEANS
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GRAND ISLE
LAMOILLE
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CHITTENDEN
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CALEDONIA
CS
Burlington
SG
SG
D-G
SG
SG
St. Johnsbury
WASHINGTON
MONTIPELIER
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Barre
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ADDISON
ORANGE
Middlebury
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Chelsea
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RUTLAND
WINDSOR
Woodstock
CS
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Rutland
SG
SG
Slate
Talc
CS
D-M
Talc
BENNINGTON
Talc
WINDHAM
Newfane
SG
Bennington
SG

During the year, a $1.8 million offer was made to stockholders of VAG to purchase the company's mine and turn it into an asbestos-waste storage site, the first of its kind. The sale would be contingent on obtaining permits from the State and local governments. According to the prospective buyer, asbestos would be collected along the east coast, mixed with incinerator ash into a concrete-like mixture, and shipped by rail to the mine in Lowell. The asbestos mixture would be dumped into the open pit mine and would eventually harden into a solid block. In order to operate the mine as a disposal site, the operator would need permits from the State, approval from solid waste districts in Lamoille and Orleans Counties, and a permit under Act 250, Vermont's Development Control Law. In addition, the project would have to be made part of the regional solid waste plans in the established solid waste districts. The proposal, however, drew strong criticism from both town officials and residents, who were concerned about the environmental safety of the project. At yearend, the purchase had not been completed.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

Based on these estimates, output and value of construction sand and gravel increased 14% and 17%, respectively. More than 60 companies and local government agencies mined construction sand and gravel in all of the State's counties. Leading counties, in order of output, were Chittenden, Rutland, and Lamoille. Main uses were for road base and coverings, concrete aggregate, and fill.

In response to tough State and local restrictions concerning sand and gravel operations, a new association of contractors and earth movers was started in Vermont. The Vermont Earth Moving Contractors Association, with about 60 members, planned to educate State legislators and the public about the problems they faced in opening and operating sand and gravel pits.[4]

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Crushed stone was the State's second leading mineral commodity produced and accounted for nearly one-third of the State's mineral value. Output and value increased 56% over 1988 estimates. Limestone was the primary rock quarried, followed by marble and granite. Crushed stone was produced at 17 quarries in 7 of the State's 13 counties. Leading counties, in order of output, were Chittenden, Addison, Rutland, and Franklin. Crushed stone was also quarried in Caledonia, Orleans, and Rutland Counties. Major uses were for road base, bituminous concrete, and fill.

Dimension.—Dimension stone, the State's leading mineral commodity in terms of value, accounted for more than one-third of the State's mineral production value. Nationally, the State ranked third in output of dimension stone but first in value. Types of rocks quarried, in descending order of tonnage, were granite, slate, and marble. Major uses were for monumental stone, roofing slate, rough blocks, and veneer.

The Barre Granite Association (BGA), the trade organization supporting the Barre granite industry, celebrated its 100th anniversary in April. The BGA represented 60 area granite quarrying and manufacturing companies in the Barre area, as well as other firms that supported the granite industry. During the year, companies of the BGA underwent major growth. Two firms built new plants, two more constructed major additions, and others were updating and modernizing their production processes.[5] The granite industry in the Barre area remained the backbone of the economy in the area. More than 1,700 workers were employed in various jobs at the quarries and finishing plants. Granite also provided $25 million into the local economy in wages and benefits.[6]

Blue Mountain Quarry in Ryegate received a $175,000 low-interest loan from the Vermont Agency of Development and Community Affairs. The loan would be used to expand operations and create additional jobs. The quarry, which has been operational since 1986, employed seven workers and planned to expand to a second shift and hire seven additional workers. The largest market for Blue Mountain granite was for curbing. During the year, the company was also negotiating to sell granite to a Japanese firm.[7]

Talc.—Nationally, the State ranked third of 10 States that produced talc. Cyprus Industrial Minerals Co. operated four mines and four mills in the State. The company had purchased the mines and mills in 1988 from the Vermont Talc Co. and Windsor Minerals Inc. Cyprus Industrial Minerals produced cosmetic-, paint-, and plastic-grade talc at its mills in Johnson and Chester. The Chester mill also produced talc for roofing, rubber, and other industrial-grade talc. At the company's two mills in Windsor County, cosmetic- and industrial-grade talc were produced.

TABLE 2

VERMONT: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse and fine aggregates: Other construction materials[2]	962	3,818
Other miscellaneous uses[3]	1,198	19,681
Unspecified[4]		
Actual	469	1,843
Estimated	489	2,768
Total	[5]3,119	28,110

[1]Includes limestone, marble, granite, and miscellaneous stone.
[2]Includes stone used in filter stone, graded road base or subbase, and waste material.
[3]Includes stone used in other agricultural uses, whiting or whiting substitute, and other fillers or extenders.
[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.

[1]State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in Vermont for 4 years. Assistance in the preparation of the chapter was given by Sally J. Stephenson, editorial assistant.

[2]State Geologist, Agency of Natural Resources, Division of Geology and Mineral Resources, Waterbury, VT.

[3]Rutland (VT) Herald. State Wins Acid Rain Law Dealing With Sulfur Oxides. Aug. 19, 1989, p. 9.

[4]Vermont Business. Gravel Pits Are Becoming Controversial. July 1990, p. 11.

[5]The World (Barre, VT). Granite Companies Building and Expanding. June 7, 1989, p. 4.

[6]Vermont Business. Central Vermont Economy Remains Stable. Nov. 1989, p. 55.

[7]Journal Opinion (Bradford, VT). Ryegate Quarry Gets $175,000 Loan To Expand Operations. Apr. 26, 1989, p. 9.

TABLE 3

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Asbestos:			
Vermont Asbestos Group Inc.	Box 54B Morrisville, VT 05661	Pit	Orleans.
Sand and gravel (construction, 1988):			
Calkins Sand & Gravel Inc.	Box 82 Lyndonville, VT 05851	Pits and plant	Caledonia and Orleans.
Joseph P. Carrara & Sons Inc.	Rt. 116 Middlebury, VT 05753	Pits	Addison and Rutland.
William E. Daily Inc.	Rt. 1, Box 51 Shaftsbury, VT 05262	do.	Bennington.
Hinesburg Sand & Gravel Co.	Box 200 Hinesburg, VT 05461	do.	Chittenden.
Frank W. Whitcomb Construction Corp.	Box 429 Bellows Falls, VT 05101	Pit and plant	Rutland.
Stone:			
Crushed:			
L. A. Demers Co.	Box 359 Essex Junction, VT 05452	Quarry	Addison.
Pike Industries Inc.	Rt. 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.	Box 429 Bellows Falls, VT 05101	do.	Chittenden.
White Pigment Corp.	Florence, VT 05744	do.	Addison and Rutland.
Dimension:			
OMYA Inc.	61 Main St. Florence, VT 05744	Quarry and plant	Rutland and Windsor.
Rock of Ages Corp., a subsidiary of John Swenson Granite Co. Inc.	Box 482 Barre, VT 05641	Quarries	Washington and Windsor.
John Swenson Granite Co. Inc.	North State St. Concord, NH 03301	Quarry	Washington.
Talc:			
Cyprus Industrial Minerals Co.	Box 117 Chester, VT 05143	Mines and mills	Lamoille, Windham, Windsor.

THE MINERAL INDUSTRY OF VIRGINIA

This chapter has been prepared under a Memorandum of Understanding between the 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]

For the first time in State history, the value of nonfuel mineral production in Virginia exceeded $500 million. Output of most mineral commodities remained about the same. Production of mineral aggregates declined slightly but increased in value.

A total of about 81 million short tons of nonfuel minerals was produced in Virginia in 1989. Nationally, the State ranked 20th in value of production and accounted for about 1.6% of the U.S. value. Virginia also ranked seventh nationally in coal production and mined a State record of 51 million short tons in 1989. The most significant mining-related development in 1989 was the exploration for titanium-bearing sands in three counties in southeastern Virginia.

EXPLORATION ACTIVITIES

Two companies signed lease agreements with landowners in southern Virginia where titanium-bearing sands had been sampled and tested during the year. The South East TiSand joint venture leased about 2,000 acres in the Brink area, Greensville County.[3] South East TiSand was a joint venture between Becker Minerals Inc. of the United Kingdom and Consolidated Rutile Ltd. of Australia. Renison Goldfields Consolidated Ltd. of Australia signed lease agreements with landowners for 7,000 acres in southern Dinwiddie and western Sussex Counties. Both companies planned to continue sampling programs in 1990 and to begin the process for obtaining mining permits.

EMPLOYMENT

The Virginia Department of Mines, Minerals, and Energy, Division of Mineral Mining, reported 2,710 plant workers and 2,069 quarry workers were employed in the nonfuels mining industry in 1989. Compared with 1988, employment of plant workers dropped by 225 while quarry workers increased by 210. Overall, in 1989, the limestone industry employed the most workers, with a total of 1,246 employees. The division also reported that about 630 nonfuel mining operations were active in the State in 1989.

LEGISLATION AND GOVERNMENT PROGRAMS

The Virginia General Assembly adopted water resources legislation authorizing the State Water Control Board (SWCB) to regulate water withdrawals from surface waters. Through the legislation, the SWCB was responsible for issuing water protection permits and establishing surface water management areas.

In November, the SWCB revoked Avtex Fibers Inc.'s wastewater discharge permit for its plant in Front Royal. Avtex produced carbonized rayon fiber for rocket nozzles used by the National Aeronautics and Space Administration and the U.S. Department of Defense. The firm had been accused of discharging polychlorinated biphenyls into the Shenandoah River.

The Division of Mineral Resources (DMR), Department of Mines, Minerals,

TABLE 1

NONFUEL MINERAL PRODUCTION IN VIRGINIA[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	metric tons	1,065,437	$6,291	1,010,114	$6,614	1,001,394	$6,302
Gem stones		NA	20	NA	20	NA	27
Lime	thousand short tons	699	29,435	741	33,875	821	38,353
Sand and gravel (construction)	do.	e12,100	e43,400	12,551	42,573	e12,900	e49,700
Stone:							
Crushed	do.	60,376	295,903	e66,000	e326,700	64,061	328,050
Dimension	short tons	9,077	2,720	e10,000	e2,900	W	W
Combined value of aplite, cement, clays (fuller's earth), gypsum, iron oxide pigments (crude), kyanite, sand and gravel (industrial), talc and pyrophyllite, vermiculite, and value indicated by symbol W		XX	83,673	XX	81,830	XX	86,698
Total		XX	461,442	XX	494,512	XX	509,130

eEstimated. NA Not available. W Withheld to avoid disclosing individual company proprietary data, value included with "Combined value." 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.

and Energy at Charlottesville, was the primary State agency investigating the geology and economic potential of Virginia's mineral resources. In 1989, the DMR prepared an updated version of its directory on nonfuel mineral operations. The directory included mineral producers as well as operations that processed minerals received from out-of-State sources and was scheduled for publication in 1990.

Two comprehensive reports on Virginia's copper, lead, and zinc resources were published by the DMR during the year. The first publication listed information on 283 copper, lead, and zinc mines, prospects, and occurrences throughout the State.[4] The work was done in cooperation with the U.S. Geological Survey. The other report included papers on vein copper mineralization of the Virgilina District and the geochemistry of the lead-zinc ores of the Austinville-Ivanhoe District.[5]

The Virginia Department of Mines, Minerals, and Energy, Division of Mineral Mining, published "Safety and Health Regulations for Mineral Mining 1989." All safety and health regulations and provisions for mining nonfuel minerals in Virginia are contained in the publication.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

In 1989, crushed stone was the leading mineral commodity produced in Virginia. Output of crushed stone in the State exceeded that of coal, the second leading mineral commodity, by about 13 million tons.

Crushed stone accounted for 64%; lime, 8%; and construction sand and gravel, 10% of the State's total nonfuel value of production. The other 18% of Virginia's value of nonfuel mineral production came from the mining of 13 different mineral commodities. Most of these commodities were mined by one company. Some of these commodities produced in Virginia, such as iron oxide pigments, soapstone, and vermiculite, were mined in only a few States nationwide. Virginia also held the distinction of being the only State in the United States that mined kyanite and a feldspar material termed "Virginia aplite."

Cement.—Tarmac Virginia Inc. was the State's leading producer of portland cement, having completed an acquisition of Lone Star Industries Inc.'s operations in Virginia. Tarmac Virginia, a subsidiary of Tarmac PLC of the United Kingdom, had purchased a 60% interest in Lone Star's Virginia operations in 1986.

In 1989, masonry cement was produced at 81 plants in the United States; 2 of these plants manufactured masonry cement only. Riverton Corp. operated one of these plants in Warren County. Another type of cement, called aluminous cement, was produced at only three plants in the United States; one of them was at Chesapeake in Virginia.

Clays and Shale.—For the third consecutive year, Virginia's clay and shale industry reported production of more than 1 million metric tons of material. Nationally, the State ranked 10th in output of this commodity. Virginia's nine brick plants had the capacity for manufacture of about 500,000 bricks per year. Shale was used both in making brick and for lightweight aggregate. In 1989, clay and shale production was reported from 14 pits and mines, and fuller's earth from 1 pit.

Kyanite.—Kyanite Mining Corp. was the only producer of kyanite in the United States in 1989. The company mined kyanite from two surface mines in Buckingham County. The kyanite deposit at the Willis Mountain Mine was considered the largest in the world.[6]

In 1989, the firm began construction of a new calcining plant at a site about one-half mile from both of the mines. The plant was expected to be in operation in 1992 and was designed to convert kyanite to mullite. Mullite manufactured from the calcining of kyanite has traditionally been used in refractory linings but has also been used in sanitary porcelain, wall tile, and precision casting molds.

Lime.—Output of lime increased for the third year in a row. Production of 821,000 short tons was the highest total reported since 1980, when 824,000 tons was produced. For the decade of the 1980's, Virginia produced 6.9 million tons of lime valued at $306 million. In 1989, lime was manufactured at five plants in the State; two of the operations, both in Giles County, obtained limestone feedstock from underground mines. A limited breakdown on end-use patterns for lime produced in Virginia is given in table 2.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Virginia stone statistics are compiled by geographical districts as depicted in the State map. Table 4 presents end-use statistics for Virginia's three districts.

In 1989, production of crushed stone accounted for about $330 million or 64% of Virginia's total value of nonfuel mineral output. Nationally, the State ranked fourth in production of crushed stone. As the decade of the 1980's ended, demand for crushed stone in Virginia was the strongest in State history. From 1987 through 1989, crushed stone production averaged 63.5 million short tons per year, compared with an average of 39 million

TABLE 2

VIRGINIA: LIME SOLD OR USED BY PRODUCERS, BY USE

Mineral	1988		1989	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Acid water neutrilization	81,044	$3,898	67,217	$2,061
Paper and pulp	W	W	166,150	8,292
Steel, basic oxygen	90,905	4,241	93,369	4,670
Steel, electric	33,336	1,546	W	W
Other[1]	535,463	24,190	493,945	23,330
Total	740,748	33,875	820,681	38,353

W Withheld to avoid disclosing individual company proprietary data; included with "Other."
[1]Includes, agriculture, alkalies, citric acid, ladle desulfurization, mason's lime, ore concentration, other chemical and industrial, precipitated calcium carbonate, road stabilization, sewage treatment, water purification, tanning, and uses indicated by symbol W.

tons per year during the first 3 years of the eighties. In the 1980's, Virginia produced nearly 500 million tons of crushed stone valued at $2.2 billion.

As a result of the continued demand for crushed stone, producers opened or expanded quarries throughout the State. In 1989, Hanover County approved a permit allowing General Crushed Stone Co. to expand its granite quarry. Rockydale Quarries Corp. received approval to develop a granite quarry in Franklin County. The quarry was expected to be operating in 1990 with about 300,000 tons of crushed granite to be produced annually. In December, Vulcan Material Co. obtained permission from Stafford County officials to open a granite quarry in Hartwood. Vulcan also resubmitted an application to Prince William County officials to open a quarry in Gainesville. A decision on that application was pending at yearend. In Campbell County, Blue Ridge Stone Corp.'s request to expand its Mount Athos Quarry was approved. Also during the year, Acme Stone Inc. sold its Abingdon Quarry to American Limestone Co., a subsidiary of ASARCO Incorporated.

[1]State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in Virginia for 5 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]The Southside Sun (Emporia, VA). Nov. 28, 1989, p. 1.

[4]Sweet, P. C., et al. Copper, Lead, and Zinc Resources in Virginia. Publication 93, VA Div. of Min. Res., 1989, 185 pp.

[5]Evans, N. H. (ed.) Contributions to Virginia Geology. V. I, Publication 88, VA Div. of Min. Res., 1989, 91 pp.

[6]Virginia Mineralk Producers, Kyanite Mining Corp., VA Div. of Min. Res., No. 5, 1990.

TABLE 3

VIRGINIA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	1,097	7,502
Filter stone	700	3,478
Coarse aggregate, graded:		
Concrete aggregate, coarse	9,422	51,979
Bituminous aggregate, coarse	4,471	27,420
Bituminous surface-treatment aggregate	2,254	13,472
Railroad ballast	1,229	5,799
Fine aggregate (-3/8 inch):		
Stone sand, concrete	939	4,869
Stone sand, bituminous mix or seal	458	2,142
Screening, undesignated	2,195	10,393
Coarse and fine aggregates:		
Graded road base or subbase	15,591	77,681
Unpaved road surfacing	1,011	5,563
Crusher run or fill or waste	4,803	21,281
Other construction materials[2]	3,606	18,638
Agricultural: Agricultural limestone and poultry grit and mineral food	1,013	7,693
Chemical and metallurgical: Lime manufacture	743	3,819
Other miscellaneous[3]	2,694	12,378
Unspecified:[4]		
Actual	10,508	47,911
Estimated	1,327	6,031
Total	64,061	[5]328,050

[1]Includes limestone, dolomite, granite, marble, sandstone, traprock, quartzite, slate, and miscellaneous stone.
[2]Includes stone used in macadam and other coarse and fine aggregates.
[3]Includes stone used in other agricultural uses, cement manufacture, flux stone, mine dusting and acid-water treatment, asphalt and other fillers and extenders, and waste material.
[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.

TABLE 4

VIRGINIA:[1] CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[2]	541	1,897	180	1,165	1,490	9,660
Coarse aggregate, graded[3]	2,539	11,782	2,827	15,665	11,887	70,514
Fine aggregate (-3/8 inch)[4]	1,223	5,758	579	3,313	2,521	11,653
Coarse and fine aggregates[5]	3,551	14,867	3,254	15,261	14,451	73,678
Other construction aggregates	432	1,562	285	1,052	1,623	10,403
Agricultural[6]	868	6,631	W	W	W	W
Chemical and metallurgical[7]	2,152	6,307	—	—	—	—

See footnotes at end of table.

VIRG

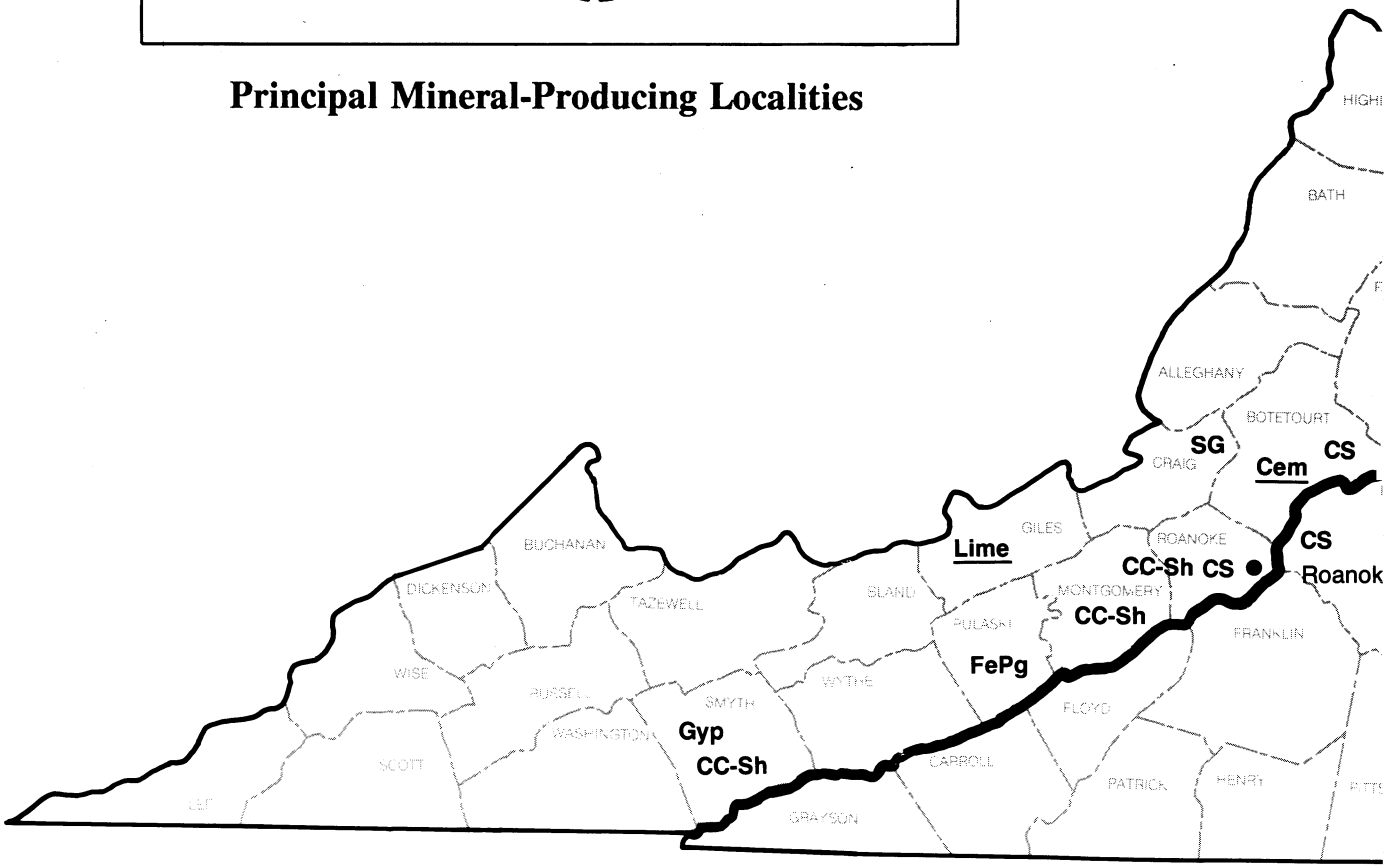
LEGEND

- 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



NIA

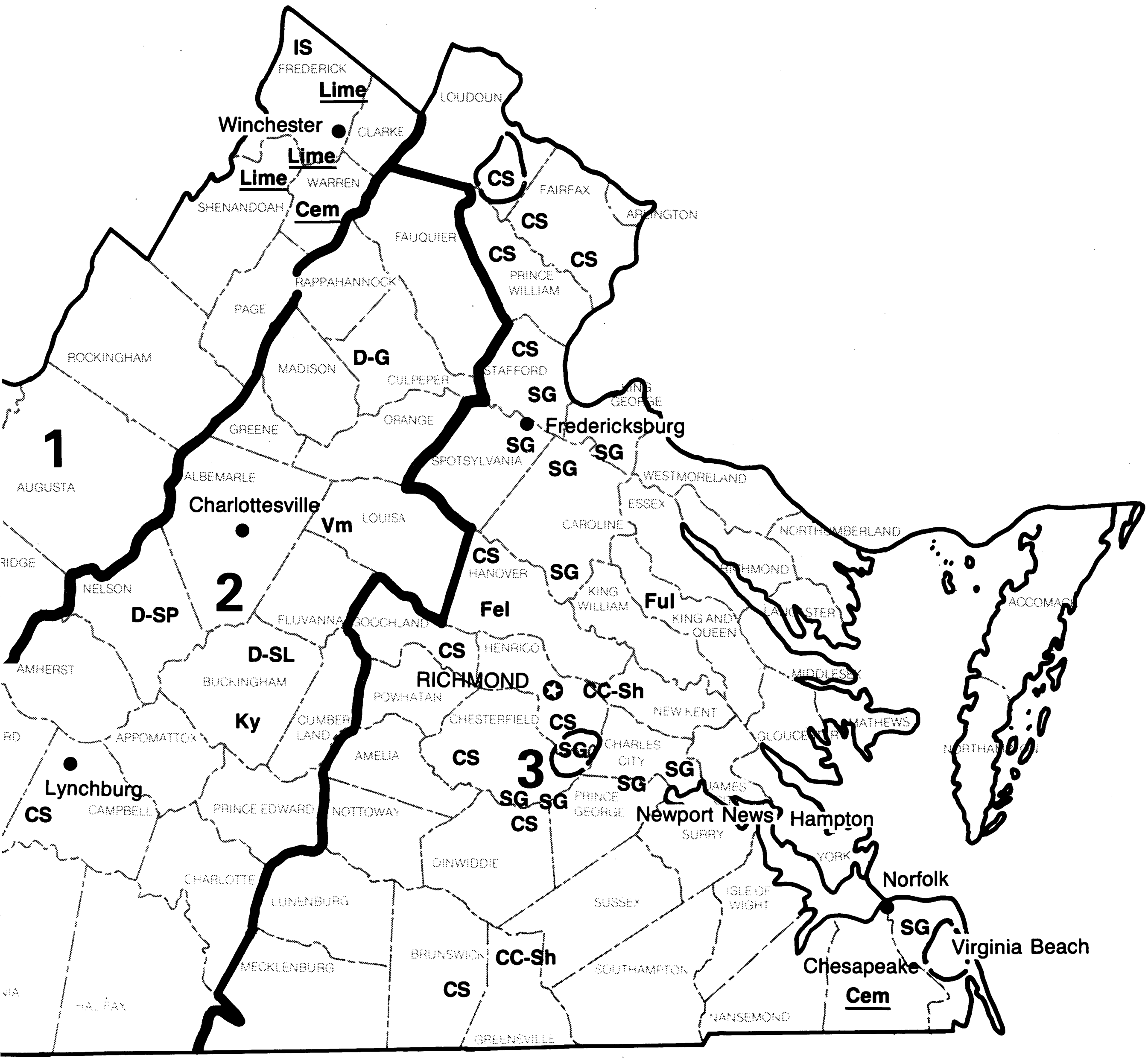

IS
FREDERICK
Lime
Winchester
CLARKE
Lime
Lime
WARREN
SHENANDOAH
Cem
LOUDOUN
CS
FAIRFAX
ARLINGTON
CS
CS
CS
FAUQUIER
PRINCE WILLIAM
RAPPAHANNOCK
PAGE
ROCKINGHAM
MADISON
D-G
CULPEPER
CS
STAFFORD
SG
KING GEORGE
ORANGE
GREENE
Fredericksburg
SG
SG
SG
SPOTSYLVANIA
1
AUGUSTA
ALBEMARLE
WESTMORELAND
ESSEX
Charlottesville
Vm
LOUISA
CAROLINE
NORTHUMBERLAND
CS
HANOVER
SG
RICHMOND
NELSON
D-SP
2
KING WILLIAM
Ful
LANCASTER
ACCOMACK
FLUVANNA
GOOCHLAND
Fel
KING AND QUEEN
CS
HENRICO
AMHERST
D-SL
BUCKINGHAM
RICHMOND
POWHATAN
CC-Sh
MIDDLESEX
NEW KENT
Ky
CUMBERLAND
CHESTERFIELD
CS
MATHEWS
APPOMATTOX
AMELIA
CS
SG
CHARLES CITY
GLOUCESTER
NORTHAMPTON
3
SG
SG
JAMES CITY
Lynchburg
CS
CAMPBELL
PRINCE EDWARD
NOTTOWAY
SG
SG
CS
PRINCE GEORGE
Newport News
Hampton
SURRY
DINWIDDIE
YORK
CHARLOTTE
LUNENBURG
SUSSEX
ISLE OF WIGHT
Norfolk
SG
Virginia Beach
BRUNSWICK
CC-Sh
SOUTHAMPTON
Chesapeake
MECKLENBURG
CS
Cem
HALIFAX
NANSEMOND
GREENSVILLE

TABLE 4—Continued

VIRGINIA:[1] CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Special[8]	1,226	9,605	—	—	—	—
Other miscellaneous	27	236	82	654	95	456
Unspecified:						
Actual[9]	3,942	17,109	2,840	14,253	3,727	16,548
Estimated[10]	591	2,739	736	3,292	—	—
Total	17,092	[11]78,494	10,783	54,655	35,794	192,912

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[1]Excludes 391,925 short tons valued at $1,988,559 not reported by county.
[2]Includes macadam, riprap and jetty stone, filter 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), fine aggregate (screening-undesignated), and other fine aggregates.
[5]Includes crushed stone for graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste, and other coarse and fine aggregates.
[6]Includes agricultural limestone, poultry grit and mineral food, and other agricultural uses.
[7]Includes crushed stone for cement manufacture, lime manufacture, and flux stone.
[8]Includes crushed stone for mine dusting or acid water treatment, asphalt fillers or extenders, other fillers or extenders, and waste material.
[9]Includes production reported without a breakdown by end use.
[10]Includes estimates for nonrespondents.
[11]Data do not add to total shown because of independent rounding.

TABLE 5

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
Aplite:			
The Feldspar Corp.	Route 1, Box 305 Montpelier, VA 23192	Quarry and plant	Hanover.
Cement:			
Masonry:			
Riverton Corp.	Box 4004 Front Royal, VA 22630	do.	Warren.
Portland:			
Tarmac Virginia Inc.[1]	Box 34527 Richmond, VA 23237	do.	Botetourt.
Clays and shale:			
Common:			
Brick & Tile Corp.	Box 45 Lawrenceville, VA 23868	Pits and plant	Brunswick and Greensville.
General Shale Products Corp.	Box 3547 Johnson City, TN 37601	do.	Rockbridge and Smyth.
General Shale-Webster Inc.	Box 306 Blue Ridge, VA 22064	do.	Botetourt and Orange.
Glen-Gery Corp.	9905 Godwin Dr. Manassas, VA 22110	Pit and plant	Prince William.
Virginia Solite Co.	Rt. 1, Box 101 Cascade, VA 24069	do.	Pittsylvania.
Fuller's earth:			
Bennett Mineral Co.	Box 28 Walkerton, VA 23177	do.	King and Queen.
Gypsum:			
USG Corp.	Rt. 1 Saltville, VA 24370	Mine and plant	Smyth.

See footnote at end of table.

TABLE 5—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
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.	Dillwyn, VA 23936	Mines and plant	Buckingham.
Lime:			
APG Lime Corp.	Star Rt. 635 Ripplemead, VA 24145	Underground mine and plant	Giles.
Chemstone Corp.	Route 629, Box 71 Strasburg, VA 22657	Quarry and plant	Shenandoah.
Sand and gravel:			
Construction:			
Culpepper Stone Co. Inc.	Box 1318 Culpepper, VA 22701	Pit and plant	Stafford.
Isle of Wight Material Co. Inc.	Box 216 Carrollton, VA 23314	Pits and plants	Isle of Wight.
Solite Corp.	Box 27211 Richmond, VA 23230	Pit and plant	King George.
Tarmac-Virginia Inc.	Box 34527 Richmond, VA 23237	Pits and plants	Charles City, Chesterfield, Henrico, Prince George.
Industrial:			
Unimin Corp.	Box 38 Gore, VA 22637	Mine and plant	Frederick.
Soapstone:			
New Alberene Stone Co.	Box 300 Schuyler, VA 22969	Pit and plant	Nelson.
Stone:			
Crushed:			
W. W. Boxley Co.	Box 13527 Roanoke, VA 24034	Quarries and plants	Amherst, Augusta, Bland, Botetourt, Campbell, Henry, Richmond (city), Tazewell.
Luck Stone Corp.	Box 29682 Richmond, VA 23229	do.	Albemarle, Augusta, Fairfax, Fauquier, Goochland, Greene, Halifax, Loudoun, Nottoway, Richmond, Rockingham.
Tarmac Virginia Inc.	Box 34527 Richmond, VA 23237	do.	Chesterfield, Dinwiddie, Henrico.
Vulcan Materials Co., Mideast Div.	Box 1590 Manassas, VA 22110	do.	Brunswick, Fairfax, Fauquier, Goochland, Halifax, Prince William, Pittsylvania, Stafford.
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.

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] and N. L. Joseph[2]

Nonfuel mineral production value in Washington rose to $480.9 million in 1989, an increase of almost 5% over that of 1988. Substantial increases in the production value of construction materials—portland cement, construction sand and gravel, and crushed stone—more than offset declines in gold and olivine values. Construction sand and gravel was the leading commodity in terms of value, followed by magnesium metal, gold, crushed stone, and portland cement.

Washington ranked 21st in the Nation in the value of nonfuel minerals production, up from a 22d ranking in 1988.

TRENDS AND DEVELOPMENTS

In 1989, Washington's mineral industry showed signs of strength and a potential for growth. Three metal mines were reported in operation with gold and silver the primary commodities. Three precious-metal mines were under development or in the permitting stage. Although interest grew in Washington's precious metals, the metallic minerals—gold, magnesium, and silver—accounted for only 44% of the State's nonfuel mineral value in 1989, a 5% drop from that of 1988. The downturn mainly could be attributed to a decline in gold and silver prices. There was also increased exploration activity for base metals, primarily lead and zinc deposits in the Metaline Formation in Stevens and Pend Oreille Counties and copper porphyry deposits.

Industrial minerals showed a sharp increase in value of almost 16% over that of 1988, with construction sand and gravel, crushed stone, and portland cement leading the way. Twenty companies produced industrial minerals from 29 sites during the year.

EMPLOYMENT

The State's mining industry employment increased by 9% over that of 1988. According to the State of Washington Employment Security Department, mining and quarrying employment rose to about 3,600 workers, 300 more than the total recorded in 1988. Employment in the State's primary metals industry rose to 13,200 in 1989, an increase of 500 over that of 1988. Continued strength in the aluminum smelting sector was reflected in its employment numbers—8,900 workers by yearend, up from 8,600 in 1988 and 7,400 in 1987.

REGULATORY ISSUES

The U.S. Forest Service awarded Del Hur Industries of Port Angeles a $3.1

TABLE 1

NONFUEL MINERAL PRODUCTION IN WASHINGTON[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Cement (portland)	thousand short tons	1,282	$63,600	979	$48,233	W	W
Clays	metric tons	377,020	2,356	376,924	2,235	233,267	$1,591
Gem stones		NA	200	NA	200	NA	208
Peat	thousand short tons	7	191	5	142	W	W
Sand and gravel:							
Construction	do.	e25,300	e78,900	31,170	94,402	e37,800	e124,700
Industrial	do.	294	5,186	W	W	W	W
Stone:							
Crushed	do.	14,754	49,618	e13,900	e48,700	13,259	55,624
Dimension	short tons	297	42	e697	e60	W	W
Combined value of calcium chloride (natural, 1987-88), cement (masonry), copper (1987), diatomite, gold, gypsum, lime, magnesium metal, olivine, silver, and values indicated by symbol W		XX	238,341	XX	265,362	XX	298,756
Total		XX	438,434	XX	459,334	XX	480,879

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

million contract to clean up the extensive tailings pile at the former copper mine near Holden Village above Lake Chelan in Chelan County. The mine was operated by Howe Sound Mining Co. and produced copper and some gold, silver, and zinc between 1939 and 1957. Ownership of the tailings at the Holden Mine was held by the nearby Lutheran Church retreat; the tailings were leased to Red Butte Resources Ltd. The remote area could only be reached by boat and a steep, winding mountain road. The project included revegetation and the placement of riprap along a creek; 3 years were estimated for completion.

Negotiations continued on a disagreement between ASARCO Incorporated and the Environmental Protection Agency (EPA) about Asarco's plan to clean up the Superfund (Comprehensive Environmental Response, Compensation, and Liability Act of 1980) site around its former copper smelter near Tacoma, Pierce County. Asarco proposed to clean up two playgrounds near the closed smelter and create a cleanup fund instead of following an EPA plan to sample more than 1,100 residential lots for arsenic contamination.

EXPLORATION ACTIVITIES

Metals exploration and development remained strong in 1989 with more than 80 companies and individuals active.

According to Crown Resources Corp., results of the drilling program at its Buckhorn Mountain gold property, east of Chesaw, Okanogan County, were encouraging. The company announced several acquisitions, including the nearby Crystal Butte property optioned from Orvana Resources Corp. The 2,140-acre Keystone Gold Inc. property on the west and east sides of Buckhorn Mountain was optioned from Curlew Lake Resources; also included was the Strawberry Lake property, 4 miles west of Buckhorn Mountain.

The joint venture of Crown Resources and Cambior USA Inc. continued exploration and development of the Ida and Mount Elizabeth gold properties in Okanogan and Ferry Counties. United States Borax & Chemical Corp. and Westmont Mining Inc. maintained exploration programs near Manhattan Mountain in the Torada Creek Graben. In the Republic Graben, Crown Resources and Sutton Resources Inc. explored the South Penn and Seattle gold prospects; Boise Cascade Corp. did some drilling and trenching west of the town of Republic. Inland Gold and Silver Corp. and Pegasus Gold Corp., in a joint venture with N. A. Degerstrom Inc., explored for gold at the Leland-Kellogg property, which is west and north of the Overlook Mine, currently being developed by Echo Bay Exploration Inc. In addition to drilling and mapping the site, the joint venture did an array of geophysical and geochemical tests.

In the Wenatchee Heights area of Chelan County, Asamera Minerals Inc. conducted a drilling program approximately 3.5 miles southeast of its Cannon gold mine and staked new claims at several sites north of the Wenatchee River. U.S. Borax explored for gold at its Skyline property northwest of Wenatchee.

Orient Mining Co., a joint venture of Boise Cascade and Pathfinder Gold Corp., drilled and mapped in the First Thought area, Stevens County. Also in Stevens County, Boise Cascade drilled for gold at the McNally-Freedom prospect, Newmont Exploration Ltd. drilled near the old Kettle River Mine, Vanhorn and Watson Mining Co. sampled at the Copper Penny and Gold Nugget properties, and Formation Capital investigated the Reed Iron deposit.

Steelhead Resources Ltd. reached an agreement with FMC Gold Corp. wherein FMC Gold obtained an option and performed a detailed feasibility evaluation of the Excelsior gold property in Whatcom County. In Pend Oreille County, Raven Hill Mining Co. continued surface exploration for copper and silver at the Cooks Copper property and began the dewatering of its Glass Mountain base and precious-metals mine.

Interest in base metal exploration was renewed. The joint venture of Vanderbilt Gold Corp. and Brenda Inc. leased a copper-molybdenum property near Mazama, Okanogan County, from Quintana Minerals Corp. Wilbur Hallauer drilled the Starr Molybdenum property on Aeneas Mountain 10 miles west of Tonasket and also the Kelsey property, a low-grade porphyry copper and molybdenum deposit. In Skamania County, Plexus Resources Corp. drilled the Silver Star property looking for copper, molybdenum, and silver.

The joint venture of Southern Talc Co. and First Mississippi Corp. explored for talc at their Totem Talc property in Pend Oreille County; a plan of operation was submitted to the U.S. Forest Service. Basic Resources Corp. continued to drill and test deposits of nonswelling bentonite clays at the Rock Top property in Grant County.

LEGISLATION AND GOVERNMENT PROGRAMS

Total revenue to the State from prospecting, mining, and quarrying on State lands was $687,000 for the fiscal year ending June 30, 1989. Increased payments from sand and gravel quarrying resulted in a 44% increase in revenue to the State compared with the fiscal year ending June 30, 1988.

The Mining and Mineral Resources Institute of the University of Washington, Seattle, received an allotment of $195,000 from the Bureau of Mines in 1989. The school had received a total of $1.7 million since inception of the Mineral Institute Program in 1978.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Calcium Chloride.—Occidental Chemical Corp. in Tacoma, Pierce County, manufactured synthetic calcium chloride using hydrochloric acid and limestone barged in from British Columbia, Canada.

Cement.—The State's portland cement production and sales remained relatively the same in quantity and showed a modest increase in value from those of 1988.

Portland cement was produced by Ideal Basic Industries Inc. in King County and by LaFarge Corp. in Pend Oreille County. Also 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 from where it sold portland cement. All three facilities sold modest amounts of masonry cement.

The Lehigh Portland Cement Co. plant in Metaline Falls was purchased, along with the company's distribution terminals,

by LaFarge Corp., a prominent French cement manufacturer. This dry-process facility was the only cement plant to use stone that was mined in the State. Ideal Basic was the State's largest producer of cement. Limestone for its wet-process facility in Seattle was barged in from Texada Island, British Columbia. The Bellingham cement plant operated by Tilbury Cement Co. of Delta, British Columbia, was used only to grind clinker for portland cement in 1989.

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 II and high-sulfate-resistant Type V; oil well and pozzolanic cements also were produced. Portland cement was used by ready-mixed concrete companies (63%), building material dealers (10%), other contractors (8%), concrete products manufacturers (6%), highway contractors and government agencies (2%), and miscellaneous customers (11%).

Individual cement plants used a mix of natural gas, fuel oil, and bituminous and anthracite coal for fuel; electricity also was purchased for energy. Raw materials consumed were anhydrite, cement rock, clay, fly ash, gypsum, iron ore, limestone, pyrite, quartz, sand, and slag.

Clays.—Clay production in 1989 dropped sharply, by 38% in quantity and 29% in value, from that of 1988. Common clay was produced by five companies from eight pits in five counties. About 82% of the production came from Clallam and King Counties. Fire clay was produced from three pits in two counties.

Mutual Materials Co. was the largest clay producer in the State. Most of its clay was mined from pits in King County. Another major King County clay producer was Moulden & Sons Inc. Ideal Basic Industries mined the Twin River Quarry, Clallam County, the largest clay pit in the State. The clay was barged to the Ideal Cement plant at Seattle for the production of portland cement. Clay was also mined by Interpace Industries Corp. and used at its Mica brick plant in Spokane County.

Diatomite.—Washington diatomite production dropped slightly in quantity and more than 6% in value from that of 1988. The Inorganic Specialties Div. of Witco Corp., the State's sole producer, mined diatomaceous material from two pits in Grant County. A new pit was permitted in the Frenchman Hills. Diatomaceous earth was processed and calcined at a plant in Quincy. The bulk of the diatomite was used for filtration, with a small quantity consumed as paint filler.

Gypsum.—The quantity of crude gypsum produced in the State remained relatively the same, but value almost doubled from that of 1988. Agro Minerals Inc. operated the Poison Lake Mine near Tonasket, Okanogan County, the only crude gypsum 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.

Lime.—Although the quantity of lime produced dropped by more than 2%, value increased by more than 2% from that of 1988. Quicklime was produced at a plant in Addy, Stevens County, by Northwest Alloys Inc., the State's largest producer. The Tacoma Lime Div. of Continental Lime Inc. produced both quicklime and hydrated lime at its Tacoma plant in Pierce County.

Olivine.—Washington was one of two States to produce olivine in 1989. The level of production dropped sharply, quantity declined by 10%, and value fell almost 52% from that of 1988. Olivine Corp. mined and milled olivine from the Swen Larsen quarry in Whatcom County. Part of the production was used in the fabrication of modular olivine refractory slabs. Olivine Corp. no longer refined the crude production but sold it to Applied Industrial Minerals Corp. (AIMCOR), which processed the material at its plant in Skagit County. AIMCOR sold the refined product for use as foundry and blasting sands both domestically and as an export to South America and Pacific Rim countries. AIMCOR formerly mined an olivine-bearing till from the Twin Sisters quarry in Skagit County, but the deposit is now depleted.

Peat.—The quantity and value of Washington's peat production dropped sharply from that of 1988. Three companies in Grays Harbor, Kitsap, and Okanogan Counties reported production.

***Sand and Gravel.*—Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

The State's 1989 construction sand and gravel production increased significantly, more than 21% in quantity and about 32% in value. Prosperity in the private-sector construction industry and the ongoing construction of several large-scale Puget Sound area governmental projects kept construction sand and gravel production at a high level.

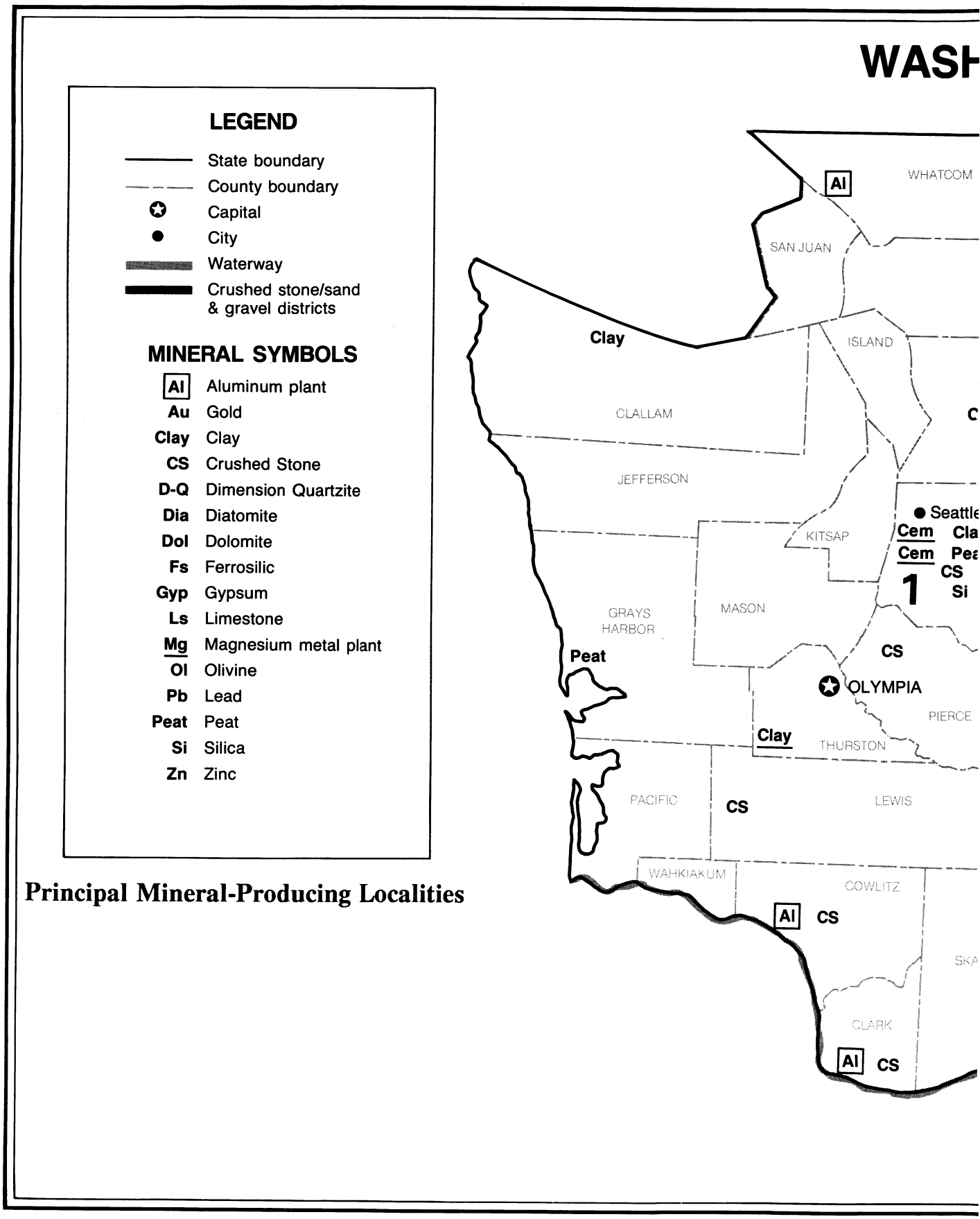
Industrial.—Production of industrial sand and gravel rose modestly in tonnage and by almost 6% in quantity from that of 1988. Production was reported from three operations: L-Bar Products Inc. mined one pit near Ravensdale, King County, and Lane Mountain Silica Co. operated two pits near Valley, Stevens County. Ash Grove Cement West mined, crushed, and screened silica at the Superior Quarry, King County. Primary uses for the industrial sand and gravel were glass containers (43%), flat-glass manufacture (15%), cement manufacture (12%), sandblasting (10%), and fiberglass (9%).

***Stone.*—Crushed.**—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

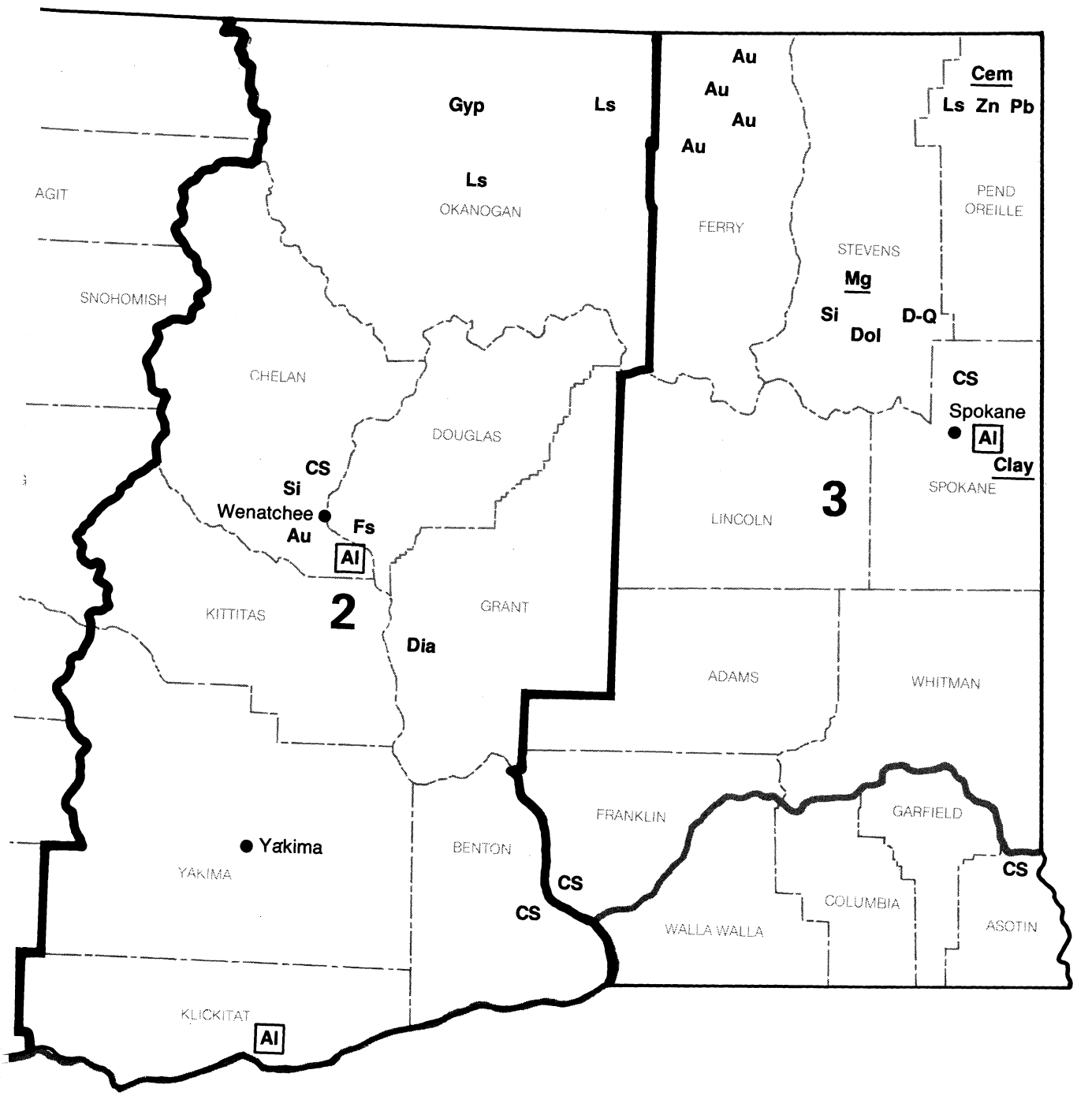
The volume of crushed stone produced in 1989 dropped nearly 5% from that estimated for 1988, but the value increased more than 14%. Production was reported in 36 of the State's 39 counties. Five counties—Benton, Clark, Cowlitz, Snohomish, and Spokane—accounted for nearly 52% of the State's total production. Traprock accounted for the bulk of the production, almost 77% of the total Washington crushed stone output, followed by, in order of quantity produced, sandstone, limestone, granite, dolomite, and volcanic cinder.

Dimension.—Dimension stone was produced by two companies: Island Frontier Landscape Construction Co. operated two quarries in Skagit County, and Heatherstone Inc. reported production from one quarry in Yakima County.

Sulfur (Recovered).—All of the State's sulfur production was recovered as


WASH
LEGEND
State boundary
County boundary
Capital
City
Waterway
Crushed stone/sand & gravel districts
MINERAL SYMBOLS
Al Aluminum plant
Au Gold
Clay Clay
CS Crushed Stone
D-Q Dimension Quartzite
Dia Diatomite
Dol Dolomite
Fs Ferrosilic
Gyp Gypsum
Ls Limestone
Mg Magnesium metal plant
Ol Olivine
Pb Lead
Peat Peat
Si Silica
Zn Zinc
Principal Mineral-Producing Localities
WHATCOM
Al
SAN JUAN
Clay
ISLAND
CLALLAM
JEFFERSON
KITSAP
Seattle
Cem Cla
Cem Pea
CS
1
Si
GRAYS HARBOR
MASON
Peat
CS
OLYMPIA
PIERCE
Clay
THURSTON
PACIFIC
CS
LEWIS
WAHKIAKUM
COWLITZ
Al CS
CLARK
Al CS

GTON


Gyp
Ls
Ls
OKANOGAN
Au
Au
Au
Au
FERRY
Cem
Ls Zn Pb
PEND
OREILLE
STEVENS
Mg
Si
D-Q
Dol
AGIT
SNOHOMISH
CHELAN
DOUGLAS
CS
Si
Wenatchee
Au
Fs
Al
KITTITAS
2
GRANT
Dia
LINCOLN
3
CS
Spokane
Al
Clay
SPOKANE
ADAMS
WHITMAN
Yakima
YAKIMA
BENTON
CS
CS
FRANKLIN
GARFIELD
CS
COLUMBIA
WALLA WALLA
ASOTIN
KLICKITAT
Al

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. Reported production dropped 13% in quantity and 14% in value from that of 1988.

Metals

Aluminum.—Aluminum production in Washington increased by almost 5% in quantity, but value dropped by nearly 17% from that of 1988. Prices, which averaged $1.10 per pound in 1988, fell to an average of 88 cents per pound in 1989. The State ranked first in aluminum output nationally and was credited with 30% of total domestic output. The State's seven aluminum smelters, in aggregate, operated at nearly 98% of total annual rated capacity of 1,231,000 metric tons of aluminum ingot in 1989.[3]

Kaiser Aluminum and Chemical Corp., a division of MAXXAM Inc., was the State's largest producer. The company operated two smelters—in Mead, Spokane County and Tacoma, Pierce County—with a total rated capacity of 274,000 metric tons per year. The largest single plant, rated at 260,000 metric tons per year, in Ferndale, Whatcom County, was operated by Intalco Aluminum Corp., a subsidiary of Alumax Inc.

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.

Arsenic.—Asarco shipped byproduct arsenic trioxide from stock at its closed Tacoma copper smelter. The smelter, permanently shut down in 1985, had been the only domestic processor of high-arsenic copper concentrate. In 1989, the shipments of arsenic from the stockpile decreased by 50%, and the value of shipments dropped by almost 42%.

Gold and Silver.—Two lode mines in Chelan and Ferry Counties reported production in 1989. Total gold production dropped 3% in quantity and more than 15% in value from that of 1988; the State's ranking for gold fell from sixth to seventh place nationally. Silver, as a byproduct from gold production, was also reported from the two lode mines. Production of silver fell almost 2% in quantity and more than 17% in value from that of 1988.

The Cannon Mine in Chelan County was the largest gold mine in the State and the second largest underground gold mine in the Nation. The joint venture between Asamera Minerals (U.S.) Inc., as the operator, and Breakwater Resources Ltd. ranked 15th nationally in terms of value of gold production in 1989. Corona Corp. announced that, if approved by the board of directors for both companies, it would acquire all of Asamera Mineral's U.S. mining properties and exploration projects from Gulf Canada Resources Ltd., including the Cannon Mine. Asamera continued exploration and development work underground and in the area immediately surrounding the mine.

Hecla Mining Co.'s Republic Unit Mine (Knob Hill) at Republic, Ferry County, was Washington's second-ranked gold producer and the State's top-ranked silver producer. In June, Hecla celebrated production of the 2 millionth ounce of gold hoisted from a single shaft. This milestone was achieved by the Knob Hill No. 2 shaft; only six other shafts in the Nation have achieved this production. Hecla was doing extensive underground and surface exploration and announced plans to

TABLE 2

WASHINGTON: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Macadam	549	2,182
Riprap and jetty stone	773	10,745
Filter stone	250	1,141
Coarse aggregate, graded:		
Concrete aggregate, coarse	209	874
Bituminous aggregate, coarse	371	1,197
Bituminous surface-treatment aggregate	365	1,113
Railroad ballast	233	764
Fine aggregate (-3/8 inch):		
Stone sand, concrete	170	604
Stone sand, bituminous mix or seal	130	414
Screening, undesignated	684	1,305
Coarse and fine aggregates:		
Graded road base or subbase	3,191	9,712
Unpaved road surfacing	762	2,736
Terrazzo and exposed aggregate	19	190
Crusher run or fill or waste	319	659
Other construction materials	102	525
Agricultural: Agricultural limestone and poultry grit and mineral food	21	134
Special: Other fillers and extenders	40	3,804
Other miscellaneous uses[2]	206	995
Unspecified:[3]		
Actual	1,816	4,959
Estimated	3,049	11,571
Total	13,259	55,624

[1]Includes traprock, sandstone, limestone, granite, dolomite, volcanic cinder or scoria, quartzite, and miscellaneous stone.
[2]Includes stone used in cement manufacture, asphalt fillers or extenders, whiting or whiting substitute, abrasives, and roofing granules.
[3]Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 3

WASHINGTON: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	1,562	14,050	W	W	W	W
Coarse aggregate, graded[2]	576	1,928	89	472	512	1,547
Fine aggregate (-3/8 inch)[3]	830	1,742	143	545	11	37
Coarse and fine aggregates[4]	3,130	9,571	348	1,438	813	2,289
Other construction aggregates	96	514	14	19	2	10
Agricultural[5]	4	6	([6])	([6])	([6])	([6])
Chemical and metallurgical[7]	—	—	—	—	93	265
Special[8]	—	—	37	3,715	5	136
Other miscellaneous	26	79	66	232	36	500
Unspecified:						
Actual[9]	947	3,391	576	1,055	293	513
Etimated[10]	1,729	6,184	698	3,298	621	2,089
Total[11]	8,901	37,465	1,972	10,773	2,386	7,386

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[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 aggregates (screening-undesignated).
[4]Includes crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run or fill or waste.
[5]Includes agricultural limestone and poultry grit and mineral food.
[6]Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[7]Includes crushed stone for cement manufacture.
[8]Includes crushed stone for asphalt fillers or extenders, whiting or whiting substitutes, other fillers or extenders, roofing granules, and abrasives.
[9]Includes production reported without a breakdown by end use.
[10]Includes estimates for nonrespondents.
[11]Data may not add to totals shown because of independent rounding.

construct a 4,000-foot underground ramp. The ramp would allow the use of rubber-tired vehicles to truck ore from the face to the mill. Also, it would provide opportunity to expand exploration efforts, especially in the Golden Promise area.

At its Kettle River gold project in Ferry County, construction was on schedule, and Echo Bay Exploration was moving toward commercial production, planned for early 1990. The project, which included both the Kettle and Overlook underground mines, was a joint venture with Crown Resources with Echo Bay as the operator. The company constructed main haulageways for both mines and a flotation mill. The 1,500-ton-per-day Key mill will contain a carbon-in-pulp vat-leach system to recover gold and silver from flotation concentrates. The mill is sited near the Overlook Mine.

Gold Mountain Mine, formerly the Gold Dike property, was acquired by Gold Express Corp. from Vulcan Mountain Mining Inc. The operation, a joint venture with N. A. Degerstrom Inc., was expected to resume production in 1990. Plans were to enlarge the original open pit and to expand onto the adjacent Gold Hill property owned by Sundance Mining and Development Inc. The company was in the process of acquiring necessary permits for a new heap-leach pad.

Magnesium Metal.—The quantity and value of magnesium metal production in 1989 remained essentially the same as in 1988; the State ranked second nationally in production of the metal.

Northwest Alloys, a wholly owned subsidiary of Alcoa, produced magnesium metal at its plant at Addy, Stevens County. The Addy plant produced the metal from locally mined dolomite, employing a silicothermic process using ferrosilicon and aluminum-quartzite flux. Approximately two-thirds of the production went to Alcoa for use as an alloy in aluminum.

Northwest Alloys sold its process waste sludge to L-Bar Products Inc., which produced fertilizer from the sludge at its plant near Chewelah, Stevens County.

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 British Columbia, Canada. The plant produced ferrosilicon for the iron and steel industry and silicon metal for the aluminum industry. Silica fume produced during the production of silicon metal and ferrosilicon was sold as a strengthener for concrete products.

Northwest Alloys closed its silicon furnaces at Addy. The company had mined quartzite from the Blue Creek Mine near Addy until silicon production ceased.

Zinc and Lead.—For part of the year, in Stevens County, Cordilleran Development Inc. shipped ore from the newly reopened Shumaker lead-zinc mine to a

mill near Greenwood, British Columbia. The company later closed the mine and said it would resume production when it could construct its own mill on-site or find one closer to the property.

Equinox Resources Ltd. optioned the Van Stone zinc property from Callahan Mining Co. The company completed a prefeasibility study examining the potential of developing an underground mine. The mine was last operated in 1971 by Asarco as an open pit. Equinox acquired funding from Cominco Ltd. in return for priority rights to purchase concentrate for its smelter at Trail, British Columbia, 25 miles to the north. The property includes a 1,100-ton-per-day mill and other infrastructure from when it was last operated. Mines Management Inc. leased its Advance and Iroquois zinc properties in Stevens County to Equinox Resources.

There was new activity at the dormant Pend Oreille zinc-lead mine at Metaline Falls, Pend Oreille County. Resource Finance Inc. (RFI) of Toronto, Ontario, acquired a lease option for the property from Pitlar Corp., a wholly owned subsidiary of Gulf Resources Corp. The mine, closed by Gulf Resources in 1977, was Washington's largest zinc producer. RFI was in the process of dewatering the mine and was doing underground exploration drilling.

[1]State Mineral Officer, Bureau of Mines, Spokane, WA. He has covered the mineral activities in Washington for 2 years. Assistance in the preparation of the chapter was given by W. A. Lyons, editorial assistant.

[2]Geologist, Washington Division of Geology and Earth Resources, Spokane, WA.

[3]American Metal Market, V. 97, No. 165, Aug. 24, 1989.

TABLE 4

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 Rt. 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.	5550 SW. Macadam Ave. Suite 300 Portland, OR 97201	do.	King.
Ideal Basic Industries Inc.	Box 8789 Denver, CO 80201	do.	Do.
LaFarge Corp.	210 East Third St. Metaline Falls, WA 99153	do.	Pend Oreille.
Clays:			
Ideal Basic Industries Inc.	Box 8789 Denver, CO 80201	Pit	Clallam.
Mutual Materials Co.	Box 2009 Bellevue, WA 98009	Pits and plant	King and Pierce.
Diatomite:			
Inorganic Specialities, a division of Witco Corp.	520 Madison Ave. New York, NY 10072	Mine and plant	Grant.
Gold:			
Asamera Minerals (U.S.) Inc.	2100, 144 4th Ave. SW. Calgary, AB T2P 3N4 Canada	Underground mine and mill	Chelan.
Hecla Mining Co.	6500 Mineral Dr. Box C-8000 Coeur d'Alene, ID 83814	do.	Ferry.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
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, Rt. 1 Addy, WA 99101	do.	Do.
Olivine:			
AIMCOR	Box 58 Hamilton, WA 98225	do.	Skagit.
Peat:			
Bonaparte Peat	Aeneas Rt., Box 5 Tonasket, WA 98855	Bog	Okanogan.
Chrystel Soils	Ocean City, WA 98569	Bog	Grays Harbor.
Sand and gravel:			
Industrial:			
Lane Mountain Silica Co.	Box 236 Valley, WA 99181	Quarry and plant	Stevens.
L-Bar Products 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	Quarries	Snohomish and King.
DeAtley Co., a division of Eucon Co.	Box 648 Lewiston, ID 83501	do.	Various.
Weyerhaeuser Co., Mineral Resource Div.	Tacoma, WA 98477	do.	Do.
Dimension:			
Island Frontier Landscape Construction Co.	435 Gibraltar Rd. Anacortes, WA 98211	do.	Skagit.

THE MINERAL INDUSTRY OF WEST VIRGINIA

This chapter has been prepared under a Memorandum of Understanding between the 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 was about $125 million in 1989. Value declined for the second year in a row, primarily reflecting a slight decrease in the production of crushed stone.

Although nonfuel mineral output decreased, coal production increased for the fifth consecutive year. In 1989, West Virginia produced nearly 152 million short tons of coal, the highest total since 1967. The State ranked third nationally in production, accounting for about 15% of U.S. output. The coal industry was the leading employer in West Virginia's mining sector. During the 1980's, developments in coal mining equipment and technology resulted in increased productivity. However, during that period, there was a decrease in employment. In 1980, West Virginia produced about 122 million short tons of coal and employed nearly 44,000 miners. In 1989, about 24,000 miners were employed in producing 152 million tons of coal.

The improved productivity allowed West Virginia's coal industry to remain competitive in the world marketplace. The State again led the Nation in coal exports, shipping about 35 million tons of coal overseas in 1989. However, high unemployment was commonplace in some areas in which coal mining had been the dominant industry. In 1989, the unemployment rate for West Virginia was 6.1%, about 1% higher than the U.S. rate.

LEGISLATION AND GOVERNMENT PROGRAMS

A State budget deficit prompted enactment of the Fiscal Responsibility Act of 1989. That measure increased taxes, including the severance tax on minerals. The tax rate on coal became 5% effective March 1; the old rate was 3.88%. The severance tax on limestone, which was 2.56% in 1988, will be gradually increased to 5% effective July 1, 1994. The severance tax was also raised to 5%, effective July 1, 1994, for all other minerals mined in West Virginia.

State government was reorganized during the year. All agencies with responsibilities for natural resources were placed under the authority of the Department of Commerce, Labor, and Environment. With that change, the Department of Energy, which regulated the mining industry in West Virginia, became the Division of Energy.

In December, the West Virginia Division of Energy settled a suit filed by a number of national and local environmental groups. The suit challenged the Division's interpretation and enforcement of State and Federal mining regulations. The settlement required the Division to maintain computerized records of all outstanding violations, to evaluate existing bond systems and procedures, and to provide additional verification of an operator's record to comply with regulations.

The West Virginia Geological and Economic Survey (WVG&ES) received a $100,000 grant from the U.S. Geological Survey to study how much coal is available for mining in parts of West

TABLE 1

NONFUEL MINERAL PRODUCTION IN WEST VIRGINIA[1]

Mineral		1987 Quantity	1987 Value (thousands)	1988 Quantity	1988 Value (thousands)	1989 Quantity	1989 Value (thousands)
Clays	metric tons	241,345	$565	239,473	$586	251,385	$553
Gem stones		NA	1	NA	1	NA	1
Sand and gravel (construction)	thousand short tons	e1,000	e3,200	1,653	6,099	e2,300	e6,700
Stone (crushed)	do.	12,458	50,947	e11,600	e47,600	2 10,904	2 42,538
Combined value of cement, lime, peat (1987-88), salt, sand and gravel (industrial), and stone (crushed granite, 1989),		XX	89,308	XX	73,169	XX	75,706
Total		XX	144,021	XX	127,455	XX	125,498

e 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.

WEST VIRGINIA

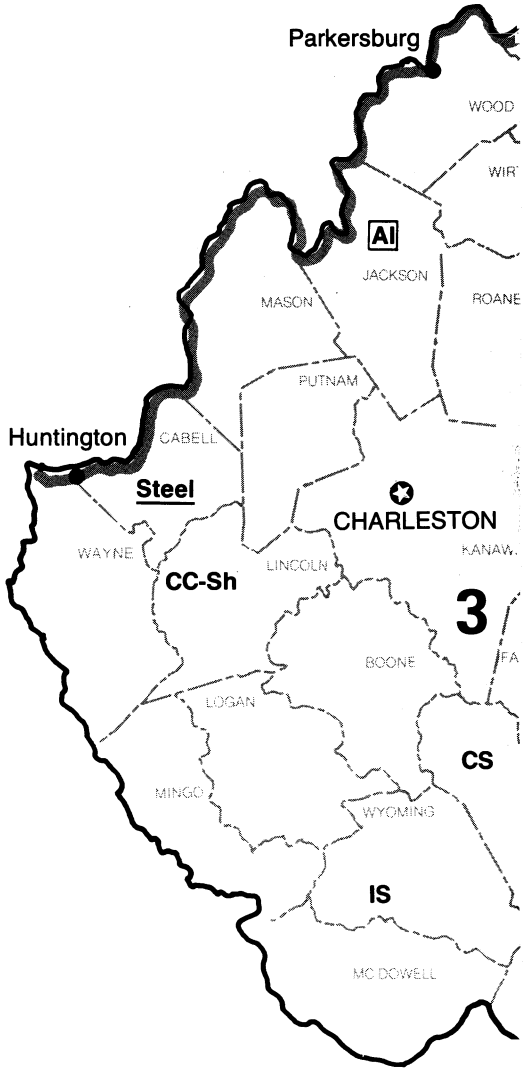
LEGEND

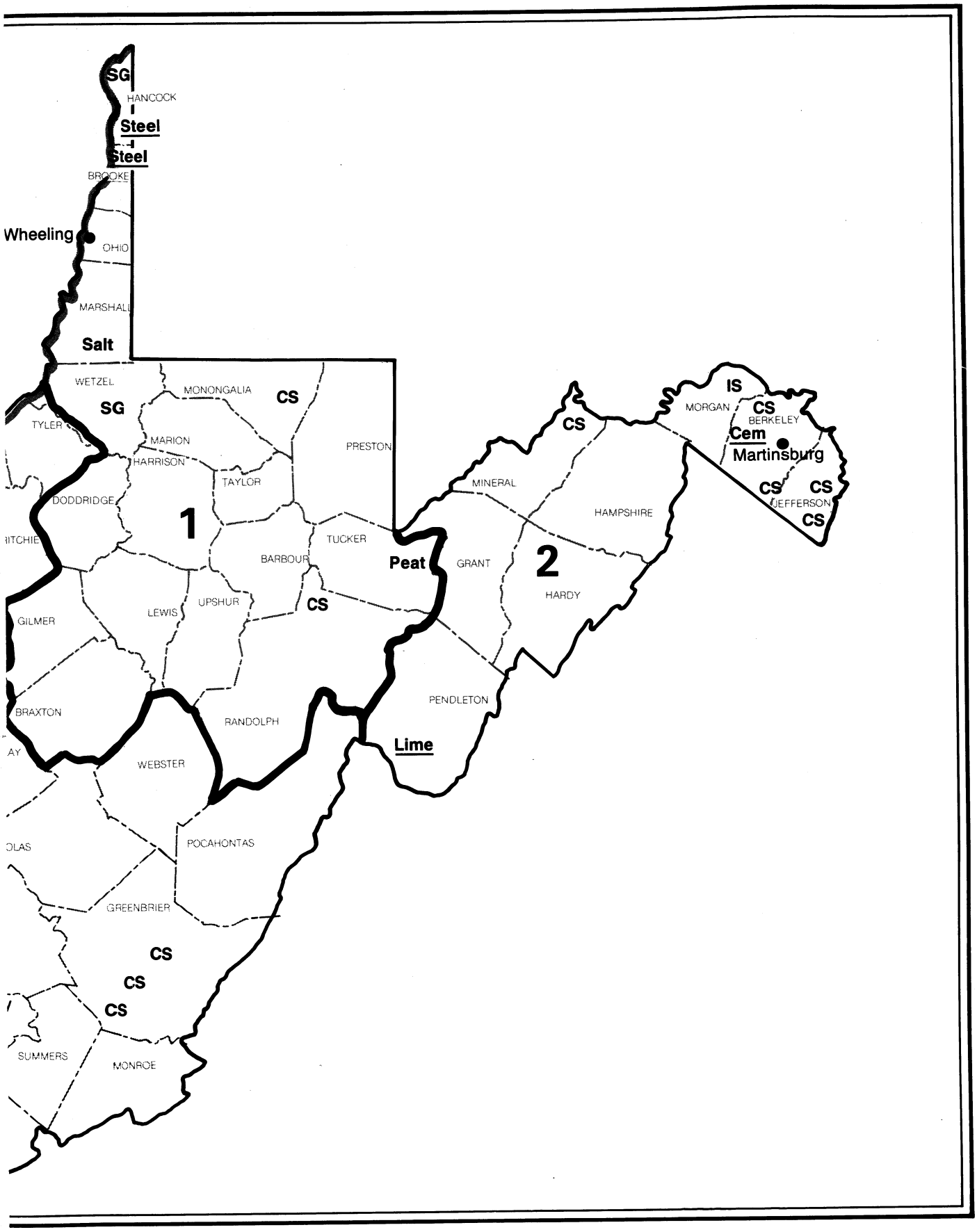
- State boundary
- County boundary
- Capital
- City
- Waterway
- Crushed stone/sand & gravel districts

MINERAL SYMBOLS

Al	Aluminum plant
CC-Sh	Common Clay & Shale
Cem	Cement plant
CS	Crushed Stone
IS	Industrial Sand
Lime	Lime plant
Peat	Peat
Salt	Salt
SG	Sand and Gravel
Steel	Iron and Steel plant

Principal Mineral-Producing Localities




SG
HANCOCK
Steel
Steel
BROOKE
Wheeling
OHIO
MARSHALL
Salt
WETZEL
SG
MONONGALIA
CS
TYLER
MARION
HARRISON
PRESTON
TAYLOR
DODDRIDGE
1
TUCKER
BARBOUR
Peat
UPSHUR
CS
LEWIS
GILMER
BRAXTON
RANDOLPH
WEBSTER
POCAHONTAS
GREENBRIER
CS
CS
CS
SUMMERS
MONROE
Lime
PENDLETON
GRANT
2
HARDY
MINERAL
CS
HAMPSHIRE
IS
MORGAN
CS
BERKELEY
Cem
Martinsburg
CS
CS
JEFFERSON
CS

Virginia. Previous coal availability studies were essentially based on the quantity of coal remaining in the ground. The new study is designed to provide more detailed estimates of coal resources considering new or potential constraints to mining.

Also in 1989, 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 Bureau of Mines, 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 1987 was $4.9 billion.

Bureau of Mines research work in West Virginia included a study on the development of large, open surface fractures over mined-out coal longwall panels.[4] Two mines, one in Boone County, the other in Raleigh County, were studied to define fracture characteristics and their controlling variables.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Output of industrial minerals in West Virginia was topped by crushed stone, which accounted for almost 35% of the State's total value of nonfuel mineral production. Other industrial minerals produced in West Virginia included cement, clays, lime, peat, salt, industrial sand, and sand and gravel. These commodities were produced at a total of 15 operations. Output fluctuated primarily in response to demand from the construction industry. During the 1980's, very little change occurred in these industries with the exception of 1981 and 1982 when a national recession resulted in lower output for most industrial minerals.

Clays.—In 1989, three companies mined clay and shale in West Virginia, each for a different end use. The coal industry used the clay produced by Sanders Dummy Co. as stemming for explosives. Clay and shale mined by Capitol Cement Corp. was used in cement manufacturing. Continental Brick Co. produced common clay used in brick manufacture at its 65-million-brick-capacity plant near Martinsburg.

Lime.—The State's only lime producer, Germany Valley Limestone Co., began a $5.75 million project for installation of a preheater kiln. Construction of the new facility was expected to be completed in May 1990 and allow for production of 350 short tons per day of pebble lime.

Sand and Gravel.—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

In 1989, West Virginia produced about 2.3 million short tons of sand and gravel.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

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.

Crushed.—Throughout the 1980's, crushed stone was the leading nonfuel mineral produced in West Virginia in terms of tonnage and value. Crushed stone output for the decade totaled 96.4 million short tons; the highest production during this period was 12.5 million tons in 1987 and the lowest was

TABLE 2

WEST VIRGINIA: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	205	1,041
Filter stone	119	492
Coarse aggregate, graded:		
Concrete aggregate, coarse	516	1,939
Bituminous aggregate, coarse	429	1,895
Railroad ballast	16	87
Fine aggregate (−3/8 inch):		
Stone sand, concrete	44	187
Stone sand, bituminous mix or seal	112	464
Screening, undesignated	142	533
Coarse and fine aggregates:		
Graded road base or subbase	490	2,334
Unpaved road surfacing	188	796
Crusher run or fill or waste	523	2,168
Other construction materials[2]	576	2,553
Agricultural: Agricultural limestone	15	90
Other miscellaneous uses[3]	1,098	2,302
Unspecified:[4]		
Actual	4,903	18,776
Estimated	1,529	6,882
Total[5]	10,904	42,538

[1] Includes limestone and sandstone; granite withheld to avoid disclosing company proprietary data.
[2] Includes stone used in macadam, bituminous surface-treatment aggregate, and terrazzo and exposed aggregate.
[3] Includes stone used in cement manufacture, and other fillers or extenders.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

TABLE 3

WEST VIRGINIA: CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:						
Coarse aggregate (+1 1/2 inch)[1]	W	W	W	W	293	1,462
Coarse aggregate, graded[2]	288	1,355	235	670	467	2,024
Fine aggregate (−3/8 inch)[3]	W	W	W	W	258	1,006
Coarse and fine aggregates[4]	355	1,473	W	W	W	W
Other construction aggregates	529	2,396	157	586	777	3,516
Agricultural[5]	(6)	(6)	(6)	(6)	(6)	(6)
Chemical and metallurgical[7]	—	—	(6)	(6)	—	—
Special[8]	(6)	(6)	—	—	—	—
Other miscellaneous	8	38	1,105	2,354	(9)	1
Unspecified:						
Actual[10]	1,185	4,913	3,182	12,023	537	1,840
Estimated[11]	917	4,191	440	1,913	172	778
Total[12]	3,282	14,366	5,119	17,546	2,503	10,626

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[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 crushed stone for graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregates, and crusher run or fill or waste.
[5] Includes agricultural limestone.
[6] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[7] Includes crushed stone for cement manufacture.
[8] Includes crushed stone for other fillers or extenders.
[9] Less than 1/2 unit.
[10] Includes production reported without a breakdown by end use.
[11] Includes estimates for nonrespodents.
[12] Data may not add to totals shown because of independent rounding.

5.9 million tons in 1982. The value of crushed stone production from 1980 to 1989 was about $375 million or about one-third of West Virginia's total value of nonfuel mineral output of $1.1 billion. Production in 1989 of 11 million tons of crushed stone was the third highest total of the decade.

Late in the year, Millville Quarry Inc. was in negotiations with Evered PLC of the United Kingdom to sell its limestone quarry in Jefferson County. Millville Quarry was the State's leading producer of crushed stone in 1989. Most of the stone produced at Millville was sold for use in construction in the Baltimore-Washington, DC, area. Brigham & Day Co. was also interested in the Baltimore-Washington, DC, market and proposed development of a quarry on a 310-acre site near Kearneysville, Jefferson County, about 15 miles from Millville. The company submitted a permit application to the West Virginia Division of Energy and requested rezoning from local government. Both matters were pending at yearend.

Metals

Metals discussed in this section were processed from materials received from both foreign and domestic sources; no metals were mined in West Virginia in 1989. Production and value data for these commodities, which are not included in table 1, are given, if available.

Aluminum.—Ravenswood Aluminum Corp. in Jackson County was the State's only aluminum producer. The operation was renamed the Ravenswood Aluminum Corp. after the sale by Kaiser Aluminum & Chemical Corp. was completed late in the year. The smelter capacity is about 120,000 tons per year.

Iron and Steel.—Output of steel in West Virginia in 1989 accounted for less than 5% of the U.S. total. Three firms produced steel in West Virginia: Weirton Steel Corp. and Wheeling-Pittsburgh Steel Corp., which are both integrated producers, and Steel of West Virginia Inc., a minimill.

Weirton Steel shipped 2.5 million tons of steel for sales of $1.3 billion in 1989.[5] Weirton Steel has operated profitably for 5 years under an employee stock ownership plan. In January, the firm decided to fund a $650 million modernization project through a public stock offering. The project was expected to enable Weirton to become a 100% continuous casting steel operation by 1992. About 60% of the steel produced in the United States was continuously cast in 1989.

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[1] State Mineral Officer, Bureau of Mines, Pittsburgh, PA. He has covered the mineral activities in West Virginia for 4 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, Nov. 1989, 200 pp.

[4] Ingram, D. K. Surface Fracture Development Over Longwall Panels in South-Central West Virginia. Bu-Mines RI 9242, 1989, 18 pp.

[5] Weirton Steel Corp. 1989 Annual Report. 41 pp.

TABLE 4

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.	Box 1111 Martinsburg, WV 25401	Pit and plant	Do.
Sanders Dummy Co.	Box 86 Midkiff, WV 25540	Pit	Lincoln.
Lime:			
Germany Valley Limestone Co.	Box 302 Riverton, WV 26814	Quarry and plant	Pendleton.
Salt:			
LCP 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.	1 Oliver Plaza Pittsburgh, PA 15222	Dredges	Marshall, Pleasants, Tyler.
ET&S Inc.	Route 1 Cheshire, OH 45620	Pit	Mason.
Jesco Corp.	Route 2, Box 186-A Letart, WV 25253	Pit	Do.
Standard Aggregate Co.	Box 448 Weirton, WV 26062	Pit	Hancock.
Industrial:			
U.S. Silica Co.	Box 187 Berkeley Springs, WV 25411	Quarry and plant	Morgan.
Stone:			
J. F. Allen Co.	Box 49 Clarksburg, WV 26301	Quarry	Randolph.
Greer Limestone Co., a division of Greer Steel Co.	Greer Bldg. Morgantown, WV 26505	Mine and quarries	Monongalia and Pendleton.
Mercer Crushed Stone Inc.	Box 127 Princeton, WV 24717	Quarry	Mercer.
Millville Quarry Inc.	Box 166 Millville, WV 25432	do.	Jefferson.

[1] Also clays and crushed stone.

THE MINERAL INDUSTRY OF WISCONSIN

This chapter has been prepared under a Memorandum of Understanding between the 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 Leon E. Esparza[1] and Thomas J. Evans[2]

Wisconsin's nonfuel mineral production in 1989 was valued at about $185 million,[3] a drop of about 10%. Nationally, Wisconsin ranked 38th in the value of nonfuel mineral production. Leading commodities produced were crushed stone, construction sand and gravel, industrial sand, and lime. Virtually all of the State's mined products were used in construction. According to the U.S. Department of Commerce, Bureau of the Census, authorized private and public residential units in 1989 increased nearly 12% to 26,900 units, up from 24,100 units in 1988. Value of nonresidential construction totaled more than $1.4 billion, up 17% from the $1.2 billion reported in 1988. Value of State road contract awards decreased nearly 8%, to $548 million.[4] Wisconsin's mining industry provided employment for 2,250 people, an increase of nearly 12%. Average annual wages paid to mine workers increased nearly 2% to $27,300, according to the Wisconsin Department of Industry, Labor and Human Relations. Total civilian unemployment was up slightly, to 4.4%.

TRENDS AND DEVELOPMENTS

Kennecott Corp., through its subsidiary Flambeau Mining Co., continued efforts to win mining permits for its copper deposit near Ladysmith, Rusk County. Permit applications and an Environmental Impact Report (EIR) were submitted to the Department of Natural Resources (DNR) in April. Public hearings on the draft EIR for the project were held in October. Some area residents and mining opponents objected to many aspects of the $184 to $324 million mine project, which proposed a 32-acre open pit that would be mined at a rate of 320,000 short tons per year for 6 years. Ore grades were 10.5% copper, 0.10 ounce of gold per short ton, and 2.1 ounces of silver per short ton. Crushed ore would be railed for processing to a concentrate and for smelting at a site undetermined at year-end. Post mine reclamation called for backfilling of the pit with broken waste rock. The proposed mine site would be less than 1 mile from Ladysmith, and the open pit would be 140 feet from the Flambeau River. Concerns were voiced about the potential for development of acid mine drainage, which some argued would harm ground water and the nearby fishery. Others were concerned about potential air pollution from dust generated by blasting and mine equipment traffic. Noise pollution also was a concern.

Groups opposed to mine development

TABLE 1

NONFUEL MINERAL PRODUCTION IN WISCONSIN[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Gem stones		NA	$15	NA	$15	NA	W
Lime	thousand short tons	393	21,733	452	23,986	437	$18,129
Peat	do.	9	237	11	270	13	309
Sand and gravel:							
Construction	do.	e23,900	e57,000	25,048	60,080	e21,700	e56,400
Industrial	do.	1,314	15,168	1,351	15,458	1,514	22,399
Stone:							
Crushed	do.	2 22,757	2 71,776	e 2 28,500	e 2 98,300	26,520	83,664
Dimension	short tons	36,903	3,697	e49,900	e6,200	35,587	4,376
Combined value of other industrial minerals and value indicated by symbol W		XX	16,846	XX	564	XX	(3)
Total		XX	186,472	XX	204,873	XX	4 185,277

e Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. 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.

included the Wisconsin Resources Protection Council, Rusk County Citizens Action Group, Wisconsin Greens, Lac Court Oreilles Tribal Government, Environmental Affairs Committee of the Wisconsin Conservation Congress, National Wildlife Federation, and Flambeau Valley Peace Coalition. The Lac Court Oreilles Tribe and three other Chippewa bands were opposed to the mine development even though tribal reservation land was not specifically involved. They claimed that at least three treaties dating back to 1837 gave them hunting and fishing rights on ceded territories and guarantees of clean air and water. Mining, they argued, would cause a violation of the treaty through various forms of pollution.

The next step in the mine permitting procedure was the preparation of a final Environmental Impact Statement (FEIS), which was expected to be released in March 1990. A master hearing on all necessary permits, licenses, and approvals was expected to begin about 120 days after issuance of the FEIS. Mining could begin in 1991 if all the permits are secured.

REGULATORY ISSUES

In late July, the Mole Lake Sokaogon band of Lake Superior Chippewa Indians won legal action to sue Exxon Corp. over alleged treaty violations. A ruling by the Seventh U.S. District Court of Appeals overturned a previous Federal court ruling that stated the Sokaogon could not sue Exxon without the Federal Government also being a defendant. The court previously had determined that the Government was not to be a party because the statute of limitations for Federal involvement in the suit had expired. The Sokaogon claimed ownership to 92,160 acres instead of the 2,000-acre reservation in Forest County it received in 1934. Prior to that time, the Sokaogon did not have a reservation. Sokaogon believed that it and other Chippewa bands were promised reservations in an 1854 treaty in exchange for land that spanned much of northern Wisconsin and parts of Michigan and Minnesota. Off-reservation hunting, fishing, and gathering rights also were understood to be retained under the treaty with the Federal Government. The suit was filed in 1986 to establish ownership of land near Crandon. Crandon was the site of a copper-zinc deposit discovered by Exxon in 1976. Until 1986, Exxon planned and sought mine permits for the deposit. Efforts were suspended because of the company's concern over low metals market prices. The Crandon deposit was estimated by the DNR to contain 67.4 million short tons of recoverable ore. Exxon, however, retained the property and maintained that it could renew its efforts in the future. The complex litigation with its potential for national implications continued at yearend.

In June, the Natural Resources Board directed the DNR to prepare a report for the board concerning mining on DNR-managed State lands. The directive resulted from a proposal by Talctron Inc. of Milwaukee to mine a 120-acre area in the Mead Wildlife Area of northwestern Wood County and from interest expressed in leasing land in the Potato Creek Wildlife Management Area in Rusk County, for which the DNR held rights to 50% of the minerals. The DNR stated in a September report that statutes did not provide broad authority for mineral exploration and development, and provided only limited and explicit authority on some land. Subsequently, the board decided to cease further inquiry and to not seek more authority over mining on public lands.

The Rusk County Board of Supervisors voted in October to delay, for up to 2 years, consideration of prospecting permits, mining leases, and sales on all county-owned land, pending a development of policy and a revision of ordinances. This decision followed a request from E. K. Lehmann to lease about 520 acres in the Town of Big Bend. The lease proposal had been recommended by the Forestry Committee. A subsequent attempt at lease approval also failed. Following this, the board requested that a citizens' task force be formed to develop ideas, collect opinions, and make recommendations to guide future board actions in these matters. At yearend, members of the task force had been selected, and meetings were expected to begin in the spring of 1990.

Marathon County became the first Wisconsin county to regulate nonmetallic mining comprehensively when its Board of Supervisors unanimously approved a revised nonmetallic mining reclamation ordinance in late February. The ordinance, which originally was enacted in 1988, was revised because of numerous objections to its cost. Operators of gravel pits will now pay a flat fee of $25 per acre for administration of a reclamation program instead of the originally proposed 4 cents per cubic yard. Pit operators will be required to post a bond or to give other financial assurance for reclamation. This charge was set at a sliding scale of 10 cents to 20 cents per cubic yard mined. Bonds will be returned to the mine operators 1 year after reclamation is completed to ensure cover crops are healthy and growing.

In December, the Wisconsin Court of Appeals ordered the city of Superior to pay $1.2 million to Burlington Northern Railroad (BNR) in settlement of a tax dispute. The city was ordered to pay BNR at a retroactive 12% interest rate, instead of the 5% rate for which it fought, on taxes collected illegally from 1977 through 1986. Taxes were on the amount of iron ore concentrates handled by, or shipped through, BNR's Allouez ore docks. The tax was ruled illegal in 1986 because it exempted Wisconsin-mined taconite, of which there has been no recent production. Subsequently, the city paid $5.4 million to BNR but disputed the retroactive interest rate.

EXPLORATION ACTIVITIES

Metallic mineral exploration drilling was conducted by four companies. Forty-five holes were drilled for a total footage of about 27,000. This was an increase of 14% over the footage drilled in 1988, but three fewer holes were drilled. Three companies presumably drilled massive sulfide targets. The fourth, Noranda Exploration Inc., drilled a gold prospect. The companies, holes, and counties were as follows:

Company	Holes	County
Chevron Resources Co.	7	Taylor
E. K. Lehmann & Associates of Wisconsin Inc.	3	Lincoln and Rusk
Newmont Exploration	2	Iron
Noranda Exploration Inc.	33	Marathon

Metallic mineral exploration licensees active during all or part of 1989 were American Copper & Nickel Co. Inc., Chevron, E. K. Lehmann, Exxon Minerals Co., Kerr-McGee Resources Corp., Noranda, and Utah International Inc. Newmont did not renew its license after it expired in July 1989.

In May, Oneida County held the first competitive mineral lease sale for county forest land in the State. Noranda, Lehmann, and Great Lakes Exploration Co. won leases on about 13,000 acres. Collectively, the companies submitted 35 bids on 26 tracts of land. Bids ranged from 1.17% to 12.24% of net proceeds above a minimum royalty of 3% net smelter returns, plus 4% net proceeds. Altogether, these three companies had exploration leases in six northern Wisconsin counties on 19,500 acres. In 1989, leasing activity involved the largest total acreage since 1981 and represented a 270% increase over that of 1988. The lease sale was somewhat of a benchmark because previously counties either negotiated direct leases with mining firms or withheld their forest land from exploration. Oneida County's lease system was under development for more than 1 year and included input from the DNR and the Wisconsin Geological and Natural History Survey (WGNHS), University of Wisconsin—Extension.

In November, the Wisconsin Board of Commissioners of Public Lands (BCPL) considered a proposal by E. K. Lehmann to lease 160 acres of State trust lands in the Town of Enterprise, Oneida County. The proposal was patterned after the lease Oneida County used for its sale in May. A Lehmann representative testified before the board and reported the presence of a linear geophysical anomaly on county land leased by the company that extended onto nearby State lands. Action on the lease proposal was expected in early 1990. A decision to lease State trust lands for mineral development would be the first such action by the BCPL.

In May, Lincoln County approved a negotiated lease with E. K. Lehmann for about 800 acres of county forest land in the Town of Harrison, about 8 miles south of Rhinelander. The company received the lease on behalf of Chevron Resources Inc. Terms of the agreement provided for annual payments starting at $6.25 per acre and increasing to $30 per acre in the 10th year. Royalty payments, based on net smelter returns, would be paid to the county if ore were found.

Chevron's activity on the Chequamegon National Forest was the only drilling on Federal land in Wisconsin; three holes were drilled. About 3,000 acres was covered by new prospecting permits. At yearend, 11 permit applications were pending, covering about 5,300 acres. Nine of these applications were for land in Taylor County; the remaining two were for Ashland County.

LEGISLATION AND GOVERNMENT PROGRAMS

Four bills related to mining were introduced in the 1989 State Legislature. At yearend, none of the bills had been acted upon but were carried over to the 1990 legislative session. Assembly bill 17 would require transporters of bulk materials, such as sand, gravel, stone, and dirt, to cover loads while operating vehicles on a highway unless the materials were in containers. This action was in response to motorists' complaints that flying debris from passing trucks caused property damage and, occasionally, personal injury. Assembly bill 89 proposed an amendment to existing statutes to allow the Wisconsin Department of Transportation to issue vehicle permits for oversized loads of construction materials transported from adjoining States. Vehicles would be authorized to use State highways. Previously, permits were limited to grain and coal haulers. Senate bill 362 and Assembly bill 756, introduced in November, proposed to ban mining on State-owned land under the jurisdiction of the DNR. Crushed stone and sand and gravel mining were exempted from the bills. These bills were introduced by antimining legislators dissatisfied with the proposed mine developments near the Mead Wildlife Area in central Wisconsin and concerned over potential future mine developments elsewhere in the State.

The WGNHS continued its principal emphasis on county ground water studies and basic geologic studies. Ground water studies were in progress in 11 counties. Projects completed in the hydrology program included a mine water transport study in Shullsburg, Lafayette County, an area previously mined for lead and zinc. Eight county bedrock geologic mapping projects were in progress. The survey also assisted the DNR in its preparation of a FEIS for Flambeau Mining Co.'s proposed mine near Ladysmith.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Lime.—Wisconsin ranked 12th of 32 States in production of lime. Quicklime and hydrated lime were produced by three companies in four counties. Western Lime & Cement Co. operated plants in Fond du Lac and Brown Counties, CLM Corp. in Douglas County, and Rockwell Lime Co. in Manitowoc County. In 1989, lime production and value dropped 3% and 24%, respectively, after having posted alltime highs in 1988. Average value per short ton dropped 22% to $41.49, down from $53.07 the previous year. Value of quicklime production accounted for 57% of the total value of lime produced. The State's total lime consumption from all domestic sources was 159,000 short tons, down 4%. Hydrated lime consumption was down 6%, to 47,000 short tons, and quicklime consumption fell 3%, to 112,000 short tons.

Peat.—Peat was harvested in two counties by four companies and sold in bulk and packaged form. Sales and value increased 18% and 14%, respectively. Peat varieties produced from Waukesha County, the State's leading production area, were humus, reed-sedge, and sphagnum. The hypnum variety was produced from Kewaunee County. Peat was sold for use mostly as a soil conditioner.

Sand and Gravel.—**Construction.**—Construction sand and gravel production is surveyed by the Bureau of Mines for even-numbered years only; data for odd-numbered years are based on annual company estimates. This chapter contains estimates for 1987 and 1989 and actual data for 1988.

The State was estimated to have ranked 12th of 50 producing States. Production and value were estimated to have fallen 13% and 6%, respectively.

WISCONSIN

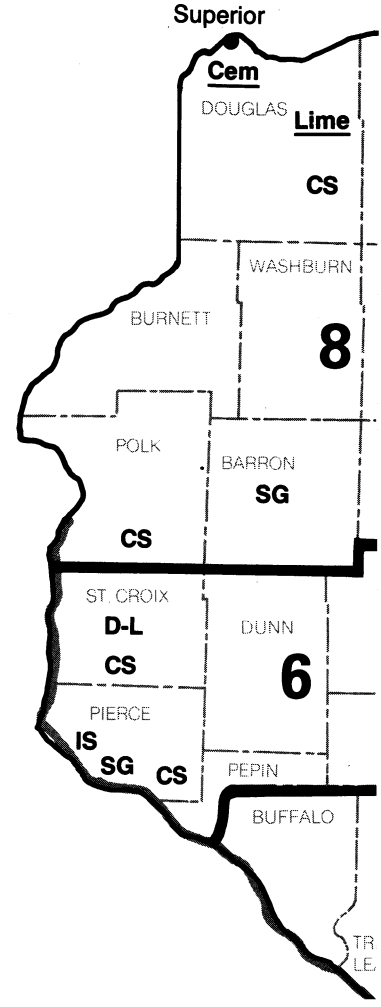
LEGEND

- 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



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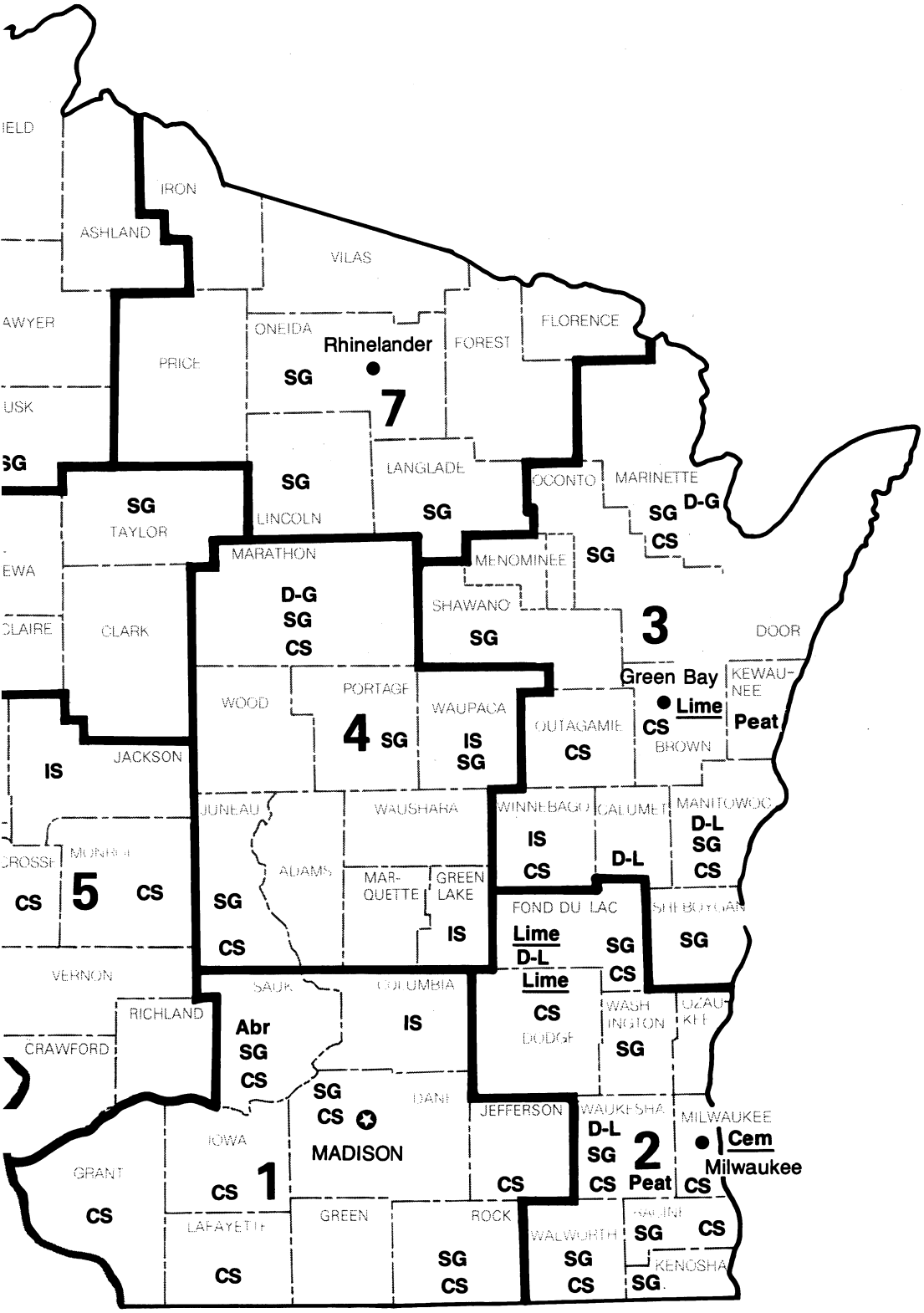
IELD
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TAYLOR
LINCOLN
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EWA
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SHAWANO
SG
3
DOOR
CLAIRE
CLARK
Green Bay
KEWAU-
NEE
WOOD
PORTAGE
WAUPACA
Lime
OUTAGAMIE
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JUNEAU
WAUSHARA
WINNEBAGO
CALUMET
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LAFAYETTE
GREEN
ROCK
WALWORTH
RACINE
SG
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SG
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KENOSHA
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Construction sand and gravel was the State's second leading mineral commodity in terms of value.

Industrial.—Industrial sand production and value increased 12% and 45%, respectively. Wisconsin ranked seventh of 38 producing States. Industrial sand was produced by four companies in five counties from seven pits. Badger Mining Corp., with operations in Green Lake and Jackson Counties, was the leading producer. About 51% of the State's production was used as foundry molding and core. Other large applications were in hydraulic fracturing, glass container manufacturing, and sandblasting. Average unit value for all sand production was $14.79 per short ton but ranged from $55.56 per ton for ground fillers—used in manufacturing rubber, paint, paper, or plastics—to $3.44 per ton for traction sand.

Stone.—Stone production is surveyed by the 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 1987 and 1989 and estimates for 1988.

Crushed.—Wisconsin ranked 19th of 48 producing States. Crushed stone, excluding traprock, decreased in production and value, 7% and 15%, respectively. Crushed stone production was reported from 241 quarries in 45 counties by 109 operators. Types of stone produced included dolomite, granite, limestone, sandstone, and traprock. Of these, limestone was produced in the largest quantity. The leading producers were Vulcan Materials Co., Mathy Construction Co., and Michels Pipeline Construction Inc.

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

In August, the Sauk County Board of Adjustments granted a special-exception permit on a 27-acre parcel of land near the Lower Narrows along Highway 33 in the Baraboo Hills. Edward Kraemer & Sons Inc. sought the permit following its purchase of the former Baraboo Quartzite Co. property. The company planned to renew operations at the site. In 1989, the site was cleared, and about 20,000 cubic yards of material was crushed, sized, and stockpiled. Potential markets for the quartzite included road base aggregate, railroad ballast, and deburring media. At yearend, the company was seeking to acquire additional acreage to the north for possible quarry expansion. Production by the previous operator, Baraboo Quartzite Co., ceased in June 1988. It had been the State's sole producer of abrasive stone used for deburring.

During the year, several inquiries to the WGNHS concerning quartzite resources appeared to signify growing emphasis on railroad ballast, filter-bed media beneath landfills, and high-durability riprap. Use of quartzite in highway aggregate applications also appeared to be receiving increased attention. Interest was focused on the Baraboo and Waterloo areas in Sauk and Jefferson Counties, respectively.

Dimension.—Wisconsin ranked 12th of 34 States producing dimension stone. Production and value decreased 29%. Eleven companies operated 15 quarries and produced 8 varieties of finished product. Limestone and/or dolomite was produced at 10 quarries and granite at 5. The State's leading producers were Anderson Bros. & Johnson Co., Lake Wausau Granite Co., and Cold Spring Granite Co. Dressed monumental stone, cut-veneer stone, and rough monumental stone were the most valuable varieties produced. Unit value for all uses averaged $123 per short ton, but ranged as high as $665 for dressed monumental stone and as low as a small fraction of this for rough blocks.

Other Industrial Minerals.—Iron oxide pigments were produced by DCS Color & Supply Co. Inc. of Milwaukee. DCS produced black magnetite, red iron oxide, and burnt red sienna variet-

TABLE 2

WISCONSIN: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	125	724
Filter stone	267	814
Coarse aggregate, graded:		
Concrete aggregate, coarse	1,297	4,636
Bituminous aggregate, coarse	398	1,498
Bituminous surface-treatment aggregate	286	968
Fine aggregate (−3/8 inch):		
Stone sand, bituminous mix or seal	44	122
Screening, undesignated	233	560
Coarse and fine aggregate:		
Graded road base and subbase	5,124	15,348
Unpaved road surfacing	1,549	3,188
Crusher run or fill or waste	464	1,119
Other construction[2]	1,352	4,974
Agricultural:		
Agricultural limestone and poultry grit	1,099	6,464
Other miscellaneous[3]	200	559
Other unspecified:[4]		
Actual	8,952	27,843
Estimated	5,131	14,846
Total[5]	26,520	83,664

[1] Includes limestone, dolomite, granite, sandstone, and traprock.
[2] Includes stone used in macadam, railroad ballast, stone sand (concrete), and combined aggregates.
[3] Includes stone used in lime manufacture, flux stone, and other fillers and extenders.
[4] Includes production reported without a breakdown by end use and estimates for nonrespondents.
[5] Data may not add to totals shown because of independent rounding.

TABLE 3

WISCONSIN:[1] CRUSHED STONE SOLD OR USED BY PRODUCERS IN 1989, BY USE AND DISTRICT

(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 aggregate (+1 1/2 inch)[2]	17	45	228	1,159	115	299	6	25
Coarse aggregate, graded[3]	1,226	4,642	1,339	5,017	484	1,447	47	131
Fine aggregate (−3/8 inch)[4]	65	220	W	W	164	359	W	W
Coarse and fine aggregates[5]	875	2,282	3,016	10,210	1,109	3,002	1,160	1,437
Other construction aggregates	—	—	18	45	(6)	1	(6)	1
Agricultural[7]	221	982	162	1,459	647	3,435	—	—
Chemical and metallurgical[8]	—	—	(9)	(9)	(9)	(9)	—	—
Special[10]	—	—	(9)	(9)	(9)	(9)	—	—
Other miscellaneous	—	—	11	36	144	426	42	90
Unspecified:								
Actual[11]	315	868	267	849	2,431	7,584	1,465	4,350
Estimated[12]	1,273	3,996	1,785	4,431	1,042	2,643	314	1,503
Total[13]	3,992	13,035	6,827	23,207	6,136	19,196	3,033	7,539

	District 5		District 6		District 7		District 8	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction aggregates:								
Coarse aggregate (+1 1/2 inch)[2]	38	210	—	—	—	—	7	7
Coarse aggregate, graded[3]	—	—	—	—	—	—	—	—
Fine aggregate (−3/8 inch)[4]	5	10	—	—	—	—	—	—
Coarse and fine aggregates[5]	307	1,143	167	478	—	—	—	—
Other construction aggregates	—	—	—	—	—	—	—	—
Agricultural[7]	15	81	23	299	—	—	(9)	(9)
Chemical and metallurgical[8]	—	—	—	—	—	—	—	—
Special[10]	—	—	—	—	—	—	—	—
Other miscellaneous	—	—	3	7	—	—	32	208
Unspecified:								
Actual[11]	2,896	9,383	545	1,726	—	—	1,032	3,083
Estimated[12]	83	335	565	1,715	—	—	60	194
Total[13]	3,344	11,162	1,303	4,226	—	—	1,131	3,491

W Withheld to avoid disclosing company proprietary data; included with "Other construction aggregates."
[1] Excludes 753,680 short tons valued at $1,807,819 not reported by county.
[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 crushed stone for graded road base or subbase, unpaved road surfacing, and crusher run or fill or waste.
[6] Less than 1/2 unit.
[7] Includes agricultural limestone and poultry grit and mineral food.
[8] Includes crushed stone for lime manufacture and flux stone.
[9] Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."
[10] Includes crushed stone for other fillers or extenders.
[11] Includes production reported without a breakdown by end use.
[12] Includes estimates for nonrespondents.
[13] Data may not add to totals shown because of independent rounding.

ies of pigments. Perlite from out-of-State sources was expanded by Midwest Perlite Co. at its Outagamie County plant. Finished products included cavity fill insulation, horticultural aggregates, concrete aggregates, and acoustic tile. Sulfur was recovered as a petroleum refining byproduct by Murphy Oil USA Inc. in Douglas County. Koos Inc. of Kenosha County expanded vermiculite for use in manufacturing insulation and filtration media. Quantity and value increased 12% and 15%, respectively.

[1] State Mineral Officer, Bureau of Mines, Minneapolis, MN. Assistance in the preparation of the chapter was given by Wanda J. West, editorial assistant.

[2] Associate professor, Minerals Information, Wisconsin Geological and Natural History Survey, Madison, WI.

[3] This is a partial total. It excludes the gem stones value to prevent disclosure of proprietary information provided by U.S. Shell Co., a freshwater pearl grower.

[4] Highway and Heavy Construction. Market Update: Battle Lines Form Over Gridlock, Gas Tax. V. 132, No. 3, Mar. 1989, p. 34.

TABLE 4

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
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.
Demilco Inc., Lipha Chemicals Inc.	3101 West Custer Ave. Milwaukee, WI 53209	do.	Do.
Honest to Peat 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 (1988):			
Janesville Sand & Gravel Co., Lycon Inc.	Box 427 Janesville, WI 53545	Pits and plants	Columbia, Dane, Rock.
Johnson Sand & Gravel Inc.	North 8 West 22590 Johnson Dr. Waukesha, WI 53186	Pit and plant	Waukesha.
Mann Bros. Sand & Gravel Inc.	Box 48 Elkhorn, WI 53121	Pits and plants	Dane, Kenosha, Racine, Rock, Walworth, Waukesha, Waushara.
Arthur Overgaard Inc.	Box 87 Elroy, WI 53929	do.	Adams and Juneau.
Tews Co. Inc.	Box 64 Colgate, WI 53017	do.	Racine and Waukesha.
Valley Sand & Gravel Co.	South 63 West 19750 Luchow Dr. Muskego, WI 53150	Pit and plant	Waukesha.
Vulcan Materials Co.	Box 7497 Birmingham, AL 35253	Pit	Do.
Industrial:			
Badger Mining Corp.	Box 97 Fairwater, WI 53931	Pits and plants	Green Lake and Jackson.
A. F. Gelhar Co. Inc.	Box 209 Berlin, WI 54923	do.	Green Lake and Waupaca.
Treco Sales Inc.	Box 38 Bay City, WI 54723	Underground mine and plant	Pierce.
Unimin Corp.	258 Elm St. New Canaan, CT 06840	Pit and plant	Columbia.

TABLE 4—Continued

PRINCIPAL PRODUCERS

Commodity and company	Address	Type of activity	County
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.
Limestone and dolomite:			
4X Corp.	Box 509 Neenah, WI 53929	Quarries and plants	Calumet, Fond du Lac, Winnebago.
C. C. Linck Inc.	1226 North Center St. Beaver Dam, WI 53916	do.	Various.
Michels Pipeline Construction Inc.	Box 128 Brownsville, WI 53006	do.	Fond du Lac, Green Lake, Winnebago.
Mathy Construction Co., Patterson Quarries Div.	Box 18 Onalaska, WI 54650	do.	Various.
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 and 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 Bureau of Mines, U.S. Department of the Interior, and the Geological Survey of Wyoming for collecting information on all nonfuel minerals.

By R. J. Minarik,[1] W. Dan Hausel,[2] and R. E. Harris[3]

Nonfuel mineral production in Wyoming was valued at $827.4 million in 1989, a nearly 17% increase over that of 1988. A gain in the production value of natural sodium carbonate (soda ash) accounted for the bulk of the increase. Other commodities that showed substantial increases were clays, Grade-A helium, and construction sand and gravel. Crushed stone and portland cement also made significant contributions to the State's total mineral production value. No metal production was reported.

In 1989, Wyoming ranked 13th among all States in nonfuel mineral production value, up from 14th in 1988. The State continued to be the major domestic producer of soda ash (88% of the total U.S. production) and bentonite clay (nearly 60% of the Nation's supply originated in Wyoming). Wyoming was second of 4 States that produced Grade-A helium and second in quantity produced among 26 States that recovered elemental sulfur.

According to the Wyoming State Economic Development and Stabilization Department, "The minerals industry is by far the largest single contributor to the economy of the State of Wyoming." The 1989 valuation on minerals produced represented 60% of the State's total assessed value.

TRENDS AND DEVELOPMENTS

Except for lime, which had a small decrease in value, and a slight drop in gypsum production, all remaining commodities produced in Wyoming recorded gains in both quantity and value. The value of 1989 nonfuel minerals production in Wyoming continued the upward trend that started in 1984, an almost 17% increase over that of 1988 and a gain of 28% over that of 1987. This recovery trend was due mostly to an increase in the value of soda ash production, with construction sand and gravel, Grade-A helium, and clays making significant contributions. All of Wyoming's soda ash mining operations produced at capacity; increased production was sought by increased efficiency. Several construction and expansion projects began, and additional plans were under consideration.

EMPLOYMENT

Employment in mining is more important in Wyoming than in most States, accounting for almost 10% of total nonfarm wage and salary employment. Wyoming Employment Security Commission reports indicated mining employment averaged 18,300 workers throughout 1989, a 5% increase over that of 1988.

In Wyoming, average weekly earnings in mining were $668 in December 1989, up slightly from that of December 1988. The U.S. average was $584. For the Wyoming mining industry in 1989, weekly hours worked averaged slightly more than 43 and hourly wages averaged $14.33.

REGULATORY ISSUES

A determination by the U.S. Forest Service of whether or not a deposit of quartzite in the Snowy Range Mountains can be defined as a locatable mineral and therefore extracted under the Mining Law of 1872 had yet to be resolved by

TABLE 1

NONFUEL MINERAL PRODUCTION IN WYOMING[1]

Mineral		1987		1988		1989	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays[2]	metric tons	1,930,169	$62,031	2,138,796	$72,174	2,166,497	$74,697
Gem stones		NA	150	NA	150	NA	157
Lime	thousand short tons	29	1,560	26	1,640	W	W
Sand and gravel (construction)	do.	e2,600	e9,000	3,413	11,351	e4,500	e15,400
Stone (crushed)	do.	3,171	15,049	e2,500	e11,400	2,990	12,120
Combined value of cement, clays (common), gypsum, helium (Grade-A), sodium carbonate (natural), and value indicated by symbol W		XX	557,265	XX	613,097	XX	724,987
Total		XX	645,055	XX	709,812	XX	827,361

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

yearend. Medicine Bow National Forest managers recommended that 21,000 acres of land in the Snowy Range area, including the proposed quartzite quarry near Browns Peak, be withdrawn from mineral activity.

The Wyoming Mining Association proposed that mining companies operating in the State be given the right to eliminate high walls from Federal reclamation requirements. The Wyoming Wildlife Federation was strongly opposed to the proposal.

The State was awarded a $2,456,679 grant for reclaiming abandoned mine lands. Reclamation work was expected to begin after 1992. The Federal money will be used to resolve subsidence problems, particularly in the Rock Springs area.

The Wyoming Economic Development and Stabilization Board approved a Community Development Block Grant of $25,000 to be used for exploratory drilling of a industrial mineral (limestone and volcanic ash) prospect north of Hartville, Platte County. The town of Guernsey will administer the grant.

EXPLORATION ACTIVITIES

Exploration continued at a moderate pace in 1989. The greatest interest was in gold and platinum-group metals, but other commodities, including copper, diamonds, iron, manganese, titanium, and zinc, were being sought.

Gold exploration was reported in a number of locations, including the Black Hills of northeastern Wyoming, the Medicine Bow and Laramie Mountains of southeastern Wyoming, the Bighorn Basin of northwestern Wyoming, and the South Pass area of western Wyoming.

The Geological Survey of Wyoming (GSW) reported several mineral companies were exploring the hills around Laramie for diamonds, gold, platinum, and other valuable minerals. Royal Gold Inc. was studying the prospect of developing a gold-copper porphyry mine in the Laramie Mountains between Cheyenne and Laramie. The company optioned Wyoming Gold Inc.'s Copper King property and was taking samples for metallurgical analysis. Drilling on the property had established the possibility of a low-grade ore deposit containing a smaller, higher grade zone. Stream sampling designed to locate diamond deposits was conducted in the central Laramie Range east of Laramie by the GSW. Several heavy-mineral anomalies were identified.

At least three drill rigs were testing for precious metals in the Mullen Creek and Lake Owen mafic complexes of the Medicine Bow Mountains. Vanderbilt Gold Corp. and Chevron Resources Co. investigated gold-platinum properties in the Lake Owen area. International Platinum Ltd. and ACN Corp. explored the Mullen Creek complex for platinum. Reconnaissance investigations of porphyry copper-silver deposits in the Absaroka Mountains also were reported. Timberline Minerals Inc. collected samples from its Sunlight Peak and Stinkingwater Peak claims in the upper Sunlight Basin mining district of the Shoshone National Forest. Also in the Shoshone National Forest, New Frontier Exploration Co. conducted seismic tests near Bennett Creek. Both companies were exploring for base and precious metals.

In the Black Hills, TRYCCO Inc. of Alberta, Canada, initiated an exploration program of placer and lode deposits in the Mineral Hill district. The placers were evaluated for gold, magnetite, tantalite, tin, and other heavy minerals. The GSW and TRYCCO encountered high gold and silver values from lode deposits along the flank of the Mineral Hill complex. In the Bear Lodge Mountains, north of Sundance, mining companies continued to search for large-tonnage, low-grade gold mineralizations. International Curator Resources Ltd. intersected widespread disseminated gold mineralization during its drilling program of an elongated intrusive breccia.

In the South Pass area of the Wind River Range, Consolidated McKinney Resources of Vancouver, British Columbia, Canada, drilled the Carissa and Alpine properties along the northern margin of the greenstone belt. Reportedly, the company intersected a wide mineralized shear that contained gold mineralization on the Carissa property. Mapping in the Seminoe Mountains district by the GSW led to the discovery of several mineralized zones containing anomalous copper, gold, and silver and a zone with anomalous lead and zinc.

In regard to industrial minerals, ongoing exploration for construction aggregate, bentonite, gypsum, limestone, and trona continued. There was also exploration aimed at finding decorative aggregate, silica rock, zeolites, nonbentonitic clay, mineral pigments, and vermiculite.

LEGISLATION AND GOVERNMENT PROGRAMS

Motivated by reports that the State was losing millions of dollars in unpaid mineral taxes, the newly created Department of Audits' mineral division began auditing out-of-State companies operating in Wyoming.

Soda ash producers in Sweetwater County asked State legislators not to approve a Wyoming Department of Revenue proposal that would raise their taxes. Wyoming calculates its trona tax on a formula of revenue minus production costs. The proposal would lower estimated production costs, resulting in increased taxes to soda ash producers. The Republic of China on Taiwan reduced the tariff on Wyoming soda ash from 12.5% to 10%. The lower tariff could translate into increased sales.

Bridger-Teton National Forest officials proposed allowing mining claims to be staked on about 25 sites previously closed to exploration for and development of hardrock minerals. Based on past interest in this area, the U.S. Forest Service did not expect much activity. The changes would not apply to leasable minerals.

The Mining and Mineral Resources Institute of the University of Wyoming in Laramie received an allotment of $138,000 from the Bureau of Mines in 1989. The school had received a total of $1,799,400 since inception of the Mineral Institute program in 1978.

REVIEW BY NONFUEL MINERAL COMMODITIES

Industrial Minerals

Cement.—Lone Star Industries Inc. completed a joint-venture agreement with Centex Corp. to form Mountain Cement Co. Mountain Cement owned and operated the only cement manufacturing plant in Wyoming. The plant, previously owned by Centex, is south of Laramie, Albany County. The company completed its plant renovation and conversion from a wet- to a dry-process operation, including a mechanical upgrade of the clinker cooler as well as the kiln drive.

The quantity of cement produced in 1989 increased by one-third, but value rose only by 5%. Most of the cement produced was general use, moderate heat Types I and II gray portland cement. Lesser quantities of high-sulfate-resistant Type V portland cement, oil-well cement, Type III high-early-strength portland cement, and masonry cement also were produced. Finished portland cement was used by the following: ready-mixed concrete companies (36%), highway contractors (28%), other contractors (21%), concrete product manufacturers (10%), and building material dealers and miscellaneous customers (5%). The plant used gypsum, limestone, and shale quarried nearby.

Clays.—Wyoming ranked second in the Nation for 1989 in the value of total clay production and fifth in quantity. The State, the Nation's largest bentonite producer, accounted for 70% of the total bentonite mined in the United States and 91% of the swelling bentonite sold or used by producers nationally. Five companies produced bentonite in six counties. American Colloid Co. was the State's largest producer; others included Baroid Drilling Fluids Inc. (a subsidiary of NL Industries), Kaycee Bentonite Partnership, M-1 Drilling Fluids Co., and Wyo-Ben Inc. The bulk of the bentonite was produced in Big Horn and Crook Counties; other producing counties included Hot Springs, Johnson, Washakie, and Weston.

Bentonite has been one of Wyoming's major exports. Wyoming bentonite is the high-swelling sodium type, and when water is added, it increases from 15 to 20 times its dry volume. In 1989, the three major uses of swelling bentonite from Wyoming were drilling mud (41%), iron ore pelletizing (25%), and foundry sand (24%).

Advanced Chemical Technologies Co. (ACT) was doing a feasibility study on the possibility of building a bentonite clay refining plant in Gillette. ACT was working on a process to use refined bentonite in pharmaceuticals. Although there were no bentonite mines in Campbell County, there were some as near as Upton in Weston County.

Common clay was mined by Mountain Cement in Albany County for use in cement manufacturing and by Interstate Brick Co. in Unita County for manufacturing building bricks.

Gem Stones.—The value of Wyoming gem stone production in 1989 increased slightly over that of 1988. Wyoming nephrite, commonly called jade, is a calcium-magnesium-aluminum silicate. Much of the jade occurs in the Granite Mountains in the center of the State. Jade also occurs as veins in Precambrian metamorphic rocks in the southern Wind River Mountains. Boulders and pebbles of jade occur around the southern end of the Wind River Mountains and on the north end of the Laramie Mountains to the east. Although the Wyoming jade industry is small, it is well known throughout the world.

The GSW continued exploring for diamond deposits in the central Laramie Mountains. They were searching for indications of diamondiferous kimberlite and lamproite. The project was expanded into the Medicine Bow Mountains in the vicinity of Mullison Park where two diamonds were found in 1977. Diamond exploration by a major company was also reported in the Bighorn Mountains of northern Wyoming.

Gypsum.—Gypsum production in Wyoming dropped 5% in quantity, but increased 6% in value from that of 1988. Gypsum was quarried at three locations. Mountain Cement mined gypsum at Red Mountain and other locations in Albany County for use at its cement manufacturing plant south of Laramie. Georgia-Pacific Corp., south of Lovell, Big Horn County, and the Celotex Div. of Jim Walter Corp., at Cody, Park County, mined and calcined gypsum to manufacture wallboard for the construction industry.

Helium (Grade-A).—Grade-A helium production increased more than 13% in quantity and value from that of 1988. Wyoming ranked second in the Nation in both production and value. Grade-A helium has been Wyoming's third most important nonfuel mineral commodity since 1987.

Exxon Co. U.S.A. was the only producer of helium in Wyoming; it was extracted from natural gas production at Shute Creek, in the Riley Ridge gasfield, Lincoln County. The southwestern Wyoming gasfield began helium production in 1986.

Lime.—Lime production in Wyoming increased slightly, but the value dropped a little from that of 1988. Limestone from Montana and South Dakota was used to make quicklime for refining sugar at three sugar beet processing plants. The Great Western Sugar Co. used the sugar rock in its plant at Lovell, Big Horn County, and Holly Sugar Corp. used it in its plants at Worland, Washakie County, and at Torrington, Goshen County. All lime produced by these companies was used internally.

Perlite (Expanded).—Harborlite Corp. produced expanded perlite at its processing plant near Green River, Sweetwater County. The company supplied perlite to the trona industry for use in filters at soda ash plants.

Phosphate.—The phosphate calcining plant formerly at Leefe, west of Kemmerer, Lincoln County, has been dismantled. There is currently no phosphate mined in Wyoming. Utah-mined phosphate was transported to Chevron Chemical Co.'s fertilizer plant at Rock Springs, Sweetwater County, by slurry pipeline and reacted with sulfuric acid produced from sulfur from Wyoming to make phosphoric acid and diammonium phosphate.

Sand and Gravel.—Construction sand and gravel production is surveyed by the 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 estimates for 1987 and 1989.

Estimated production for 1989 rose 32% from what was reported in 1988 and 73% from the 1987 estimate. Estimated value jumped 36% from what was reported in 1988 and 71% from the 1987 estimate. Sand and gravel was produced in 21 counties; Laramie, Johnson, Fremont, and Campbell were the leading counties.

Fisher Sand & Gravel Co., a unit of Fisher Industries, acquired the Sundance and Newcastle limestone quarries, including associated permits and machinery, from Summit Materials. In addition to the two eastern Wyoming quarries, Fisher also bought the mining rights to the Gibb Sand & Gravel pit in Douglas, Converse County.

Sodium Carbonate.—Soda ash production in 1989 increased 3% in quantity and 19% in value from that of 1988. The world's largest known resource of trona, a natural sodium carbonate-bicarbonate, was in the Green River Trona District in southwestern Wyoming. With five of the Nation's six major trona mines and soda

WYOMING

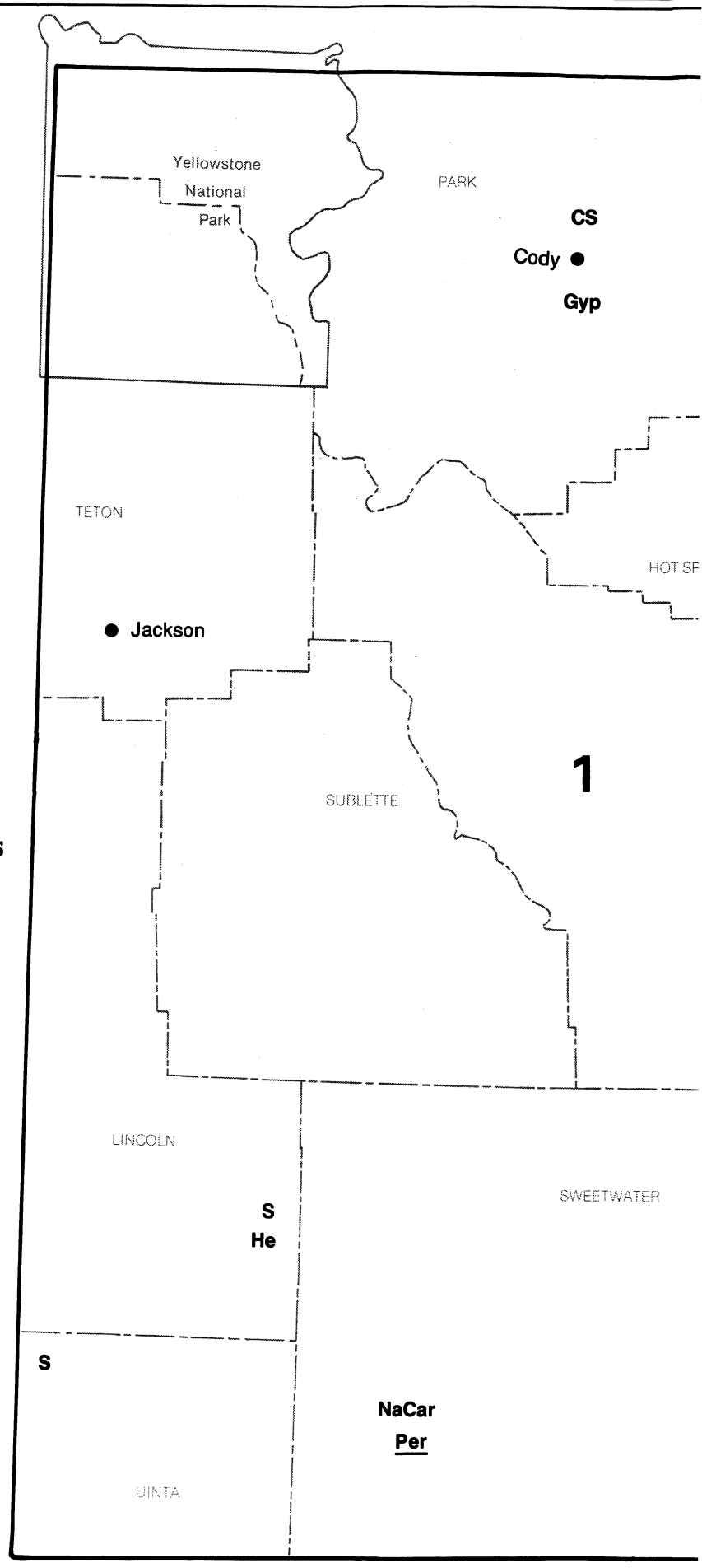
LEGEND

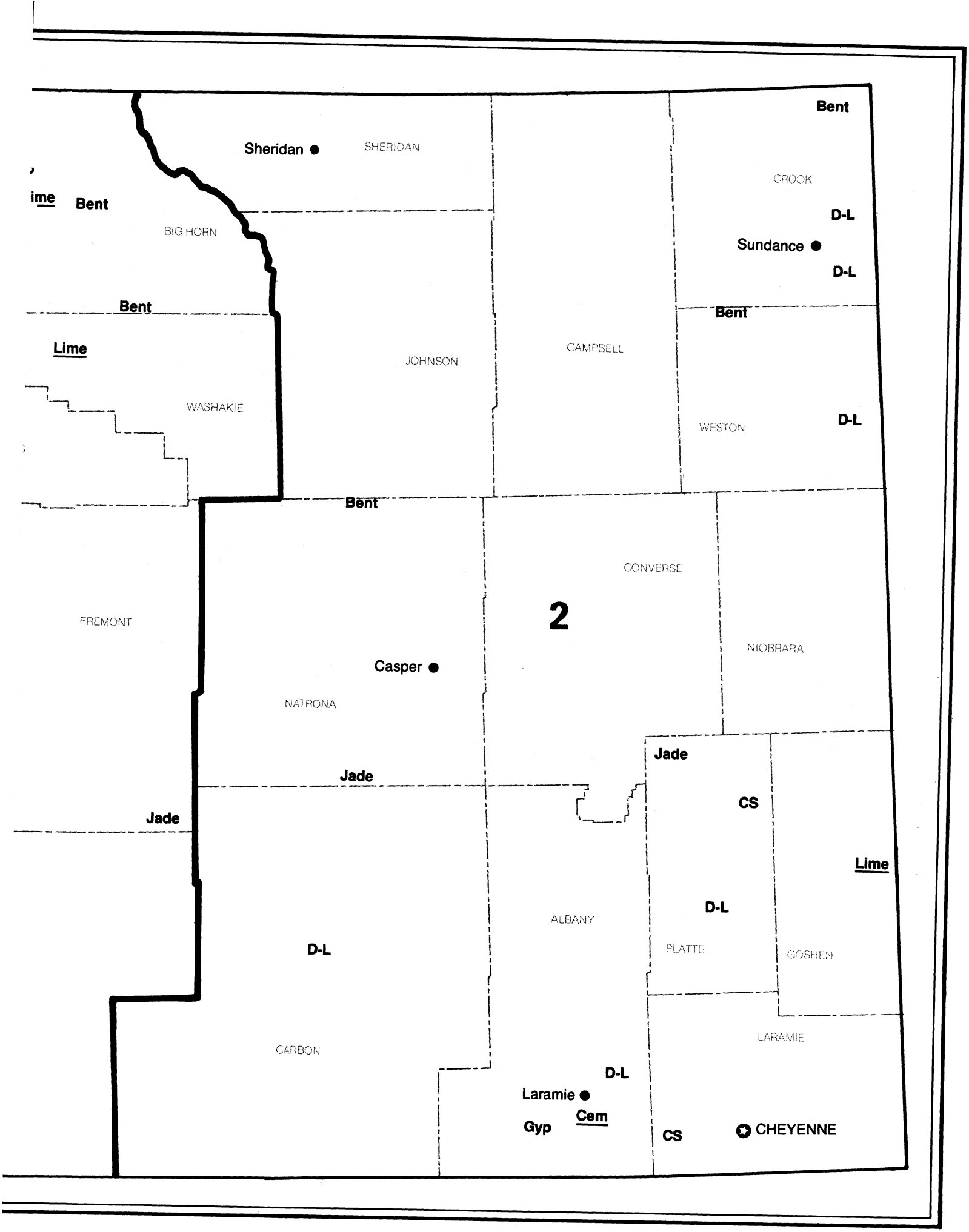
- State boundary
- County boundary
- Capital
- City
- Crushed stone/sand & gravel districts

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




Sheridan
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WESTON
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Bent
CONVERSE
2
FREMONT
Casper
NATRONA
NIOBRARA
Jade
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Lime
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ALBANY
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PLATTE
GOSHEN
LARAMIE
CARBON
D-L
Laramie
Gyp
Cem
CS
CHEYENNE

ash processing facilities within a few miles of Green River, Sweetwater County, Wyoming has been the source of the bulk of the Nation's output of soda ash. Soda ash's primary use was in glassmaking, followed by the chemical industry, soap and detergent production, pulp and paper manufacturing, water treatment, and various other applications.

FMC Wyoming Corp. was the largest soda ash producer in the State, and in 1989, the company led the Nation in soda ash production and capacity. In 1989, the FMC Wyoming trona mine in Green River began using a giant, new 92-ton Eickhoff longwall shearing machine. The mine was the only noncoal longwall operation in the United States and the only trona mine in the Green River Basin not using a mobile continuous conveyor to carry ore out of the mine. Also in Green River, FMC Wyoming broke ground for a new sodium bicarbonate processing facility that will make baking soda for use in food processing and in carpet fresheners. The new plant would compete with Church & Dwight's Green River bicarbonate plant, which has been the only Wyoming facility converting the sodium carbonate to sodium bicarbonate. FMC Wyoming planned to have a caustic soda plant in operation in 1990. The plant was expected to produce caustic soda for use in a new sodium cyanide plant. The company's interest in sodium cyanide was a direct result of the gold-mining boom in Nevada. Sodium cyanide is used in the heap-leaching process to remove gold from ore. The only other U.S. producer of sodium cyanide was E. I. du Pont de Nemours & Co. Inc. FMC officials announced that for technical reasons, the company's experimental solution mining operation was temporarily closed.

General Chemical Co. ranked second in the State in soda ash production. During 1989, the company was modernizing and debottlenecking its Green River operation. Rhone-Poulenc of Wyoming, which purchased the former Stauffer Chemical Co. operation, was the State's third largest soda ash producer. The trona mine, owned 51% by Rhone-Poulenc S.A. and 49% by Union Pacific Corp., used a continuous miner that automatically installed roofbolts as it cut trona.

Tg Soda Ash Operations, a unit of Texasgulf Inc., was Wyoming's fourth largest soda ash producer. The company used a short-wall mining system and a mobile continuous conveyor system in its mine. Tg Soda Ash announced plans to expand its soda ash plant at Green River by 100,000 short tons per year to 1.3 million tons by mid-1990. The planned expansion would take the plant up to the limit of the company's air quality permit. Employment at the underground trona mine and soda ash plant was expected to remain the same.

Tenneco Minerals Co. continued construction of a new caustic soda facility and a new anhydrous sodium sulfite plant. The company also said it planned to expand production of "Alkaten," a rumen buffer or antiacid that assisted beef and dairy cattle on high-grain diets to digest their food better. To improve efficiency at its mine, the company continued to phase out its drum miners and added two more bore-mining machines to supplement the two already working in the mine. A continuous conveyor was used to haul mined ore to the surface. As it has since 1987, Tenneco put its tailings underground. By burying the tailings, the company delayed the need to build a new surface tailings pond and avoided the environmental problem of wildlife, particularly ducks, getting into the tailings pond.

Stone.—Stone production is surveyed by the Bureau of Mines for odd-numbered years only; data for even-numbered years are based on annual company estimates. This chapter contains estimates for 1988 and actual data for 1987 and 1989. Wyoming crushed stone production in 1989 increased almost 20% in quantity and more than 6% in value from that estimated in 1988.

In 1989, crushed and broken stone was mined in nine counties. The counties of Albany, Laramie, and Sweetwater accounted for more than 70% of the total State production. The State's three largest crushed stone producers—Meridian Aggregate Co., Centex Corp., and Monolith Portland Cement Co.—operated four quarries and accounted for better than 69% of Wyoming's total production. Limestone accounted for almost 46% of the State's crushed stone production.

Major specified uses of Wyoming's crushed stone, in order of quantity sold or used, included railroad ballast, stone sand (bituminous mix or seal), cement manufacture, bituminous and concrete aggregate, unpaved road surfacing, and graded road base or subbase.

Hanson Stone Inc. of Salt Lake City, UT, quarried a small amount of Rawlins Grey sandstone from a quarry south of Rawlins in Carbon County. This stone was used to repair and restore a part of the historic prison in Rawlins. The quarry had been closed for a number of years, although in the past the stone was used on a number of important buildings throughout the West. The rise in popularity of dimension stone as exterior and interior wall facing may offer additional demand for Wyoming granite, limestone, marble, onyx, sandstone, travertine, and other dimension stone found in quantity in Wyoming. The State also produced decorative rock products, including Georgia Marble's white marble, quarried west of Wheatland, Platte County. Red clinker (baked and fused), grey marble, and small amounts of red granite also were shipped.

Sulfur.—Wyoming ranked second in the Nation in quantity and fourth in value of elemental sulfur recovered in 1989. The State accounted for 17% of the total U.S. production. In Wyoming, all of the sulfur was produced as a byproduct of natural gas and petroleum processing. Six companies in seven counties produced elemental sulfur, primarily in the Overthrust Belt of southwestern Wyoming.

Other Industrial Minerals.—A zoning change, required before U.S. Zeolite could build a new zeolite plant, was unanimously approved by the Sweetwater County Planning Commission. The mine, also in Sweetwater County, would only be operated in the summer when road conditions are favorable.

Metals

No significant gold production was reported in Wyoming in 1989. Some nuggets and flake gold have been recovered at several stream placers in recent years. American Mining and Milling Co. of Gillette was in the permitting stage of seeking approval for a small placer gold mine on the east bank of Clark's Fork River, near Clark, Park County.

Four historic gold districts lie at the southern tip of the Wind River Mountains: (1) South Pass-Atlantic City, (2) Lewiston, (3) McGraw Flats, and (4) Oregon Buttes. The entire 150- to 200-square-mile South Pass gold-belt area has been mapped by the GSW. In addition to the South Pass-Atlantic City area, the Medicine Bow, Sierra Madre, and Laramie

TABLE 2

WYOMING: CRUSHED STONE[1] SOLD OR USED BY PRODUCERS IN 1989, BY USE

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregates (+1 1/2 inch): Riprap and jetty stone	23	127
Coarse aggregate, graded:		
Concrete aggregate, coarse	133	624
Railroad ballast	660	3,036
Coarse and fine aggregates:		
Graded road base or subbase	243	774
Unpaved road surfacing	259	326
Other construction materials[2]	641	3,015
Other miscellaneous uses[3]	400	2,018
Unspecified:[4]		
Actual	632	2,200
Total	[5]2,990	9,920

[1]Includes limestone, dolomite, volcanic cinder and scoria, granite, marble, and miscellaneous stone.
[2]Includes stone used in macadam, terrazzo and exposed aggregate, and crusher run or fill or waste.
[3]Includes stone used in poultry grit and mineral food, cement and lime manufacture, whiting or whiting substitute, and other fillers or extenders.
[4]Includes production reported without a breakdown by end use.
[5]Data do not add to totals shown because of independent rounding.

Mountain ranges in southeastern Wyoming and the Bear Lodge Mountains in northeastern Wyoming were believed to have potential for gold production. A summary on these regions was published by the GSW in 1989 in a bulletin entitled, "The Geology of Wyoming's Precious Metal Lode and Placer Deposits."[4]

Strategic metals, such as chromium, cobalt, manganese, and platinum, are in Wyoming, but their economic potential was still being investigated.

[1]State Mineral Officer, Bureau of Mines, Spokane, WA. He has covered the mineral activities in Wyoming for 2 years. Assistance in the preparation of the chapter was given by W. A. Lyons, editorial assistant.
[2]Deputy Director and Head, Metals and Precious Stones Division, Geological Survey of Wyoming, Laramie, WY.
[3]Head, Industrial Minerals and Uranium Division, Geological Survey of Wyoming, Laramie, WY.
[4]Geological Survey of Wyoming. The Geology of Wyoming's Precious Metal Lode and Placer Deposits. Bull. 68, 1989, 248 pp.

TABLE 3

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.	5100 Suffield Court Skokie, IL 60076	Pits and plants	Big Horn, Crook, Weston.
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.
Bariod Drilling Fluids Inc.	Box 1675 Houston, TX 77251	Pits and plants	Big Horn and Crook.
Wyo-Ben Inc.	Box 1979 Billings, MT 59103	do.	Big Horn.
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.
Sand and Gravel:			
Casper Concrete Co.	Box 561 Casper, WY 82601	Pits	Natrona.
Rissler-McMurry Co. Inc.	Box 2499 Casper, WY 82602	do.	Various.
Teton Construction Co.	Box 3243 Cheyenne, WY 82003	do.	Laramie.
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.
Stone (crushed):			
Centex Corp.	Box 339 Laramie, WY 82070	Quarries	Do.
Meridian Aggregate Co.	Box 5239 Cheyenne, WY 82003	Quarry	Laramie.
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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