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Wisconsin Geological and Natural History Survey
W. O. Hotchkiss, Director and State Geologist

BULLETIN No. 63 EDUCATIONAL SERIES No. 7

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—OF—

# Wisconsin Rocks

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# EDUCATIONAL COLLECTION OF WISCONSIN ROCKS AND ORES.

## INTRODUCTION

*Purpose of the collection.* The Educational Collection of Wisconsin Rocks and Ores is designed for use in high schools and other institutions in which general science, elementary geology, physical geography, or geography of Wisconsin is taught. The collection was made by a cooperative agreement between the Wisconsin Geological and Natural History Survey and the Department of Geology of the University of Wisconsin. Although it alone will not give students a complete knowledge of rocks, it is hoped that it will stimulate interest in the study of rocks and geology. Rocks lie all about us and are the ultimate source of the soil from which we derive our living. From the ores we derive the metals without which our civilization would be impossible.

The treatment of the subject has been made so simple that students should be able to get something out of its study even if no preliminary work has been done on minerals and rocks. Teachers who wish to give such work can secure copies of the laboratory exercises used in the University elementary classes by writing to the Department of Geology. Thorough work in the laboratory cannot be undertaken without having one specimen of each rock or mineral for every three to five students. It is only by drill in the laboratory that students learn to distinguish rocks in a systematic manner. This collection cannot be used for a complete laboratory course since only one set can be furnished to each institution. Either the Geological Survey or the Department of Geology will be glad to determine any specimens of rocks or minerals provided the transportation charges are paid both ways by the sender. Small broken chips of fresh rock are best. Badly weathered specimens cannot be determined readily.

The geological map mentioned in this booklet is that published by the State Geological Survey in 1911. A copy of this was at one time furnished to every school in the state. If this copy has been lost or destroyed it will be replaced free of charge to institutions which order this collection.

The rocks were collected mainly by F. T. Thwaites, curator of the museum in the Department of Geology of the University of Wisconsin. The specimens of red granite from Montello were presented by the Montello Granite Company and those of hematite from Hurley by the Montreal Mining Company. Lost specimens can be replaced if still in stock for 50 cents postpaid.

## LIST OF SPECIMENS.

| IGNEOUS ROCKS. | SOURCE. |
|---|---|
| 1. Granite, red | Montello, Marquette Co. |
| 2. Granite, pink or gray | Granite Heights, Marathon Co. |
| 3. Gabbro | Mellen, Ashland Co. |
| 4. Basalt | Hurley, Iron Co. |
| 5. Quartz porphyry | Saxon, Iron Co. |

SEDIMENTARY ROCKS AND THEIR METAMORPHIC EQUIVALENTS.

| | |
|---|---|
| 6. Loess | Middle Ridge, LaCrosse Co. |
| Red clay | Friendship, Adams Co. |
| Marl | Lake Wingra, Madison, Dane Co. |
| 7. Conglomerate | Montreal River, Saxon, Iron Co. |
| 8. Sandstone, white or yellow | Baraboo, Sauk Co. |
| 9. Sandstone, calcareous | Black Earth, Dane Co. |
| 10. Sandstone, green | Black Earth, Dane Co. |
| 11. Quartzite | Baraboo, Sauk Co. |
| 12. Mica schist | Baraboo, Sauk Co. |
| 13. Shale, green | Baraboo, Sauk Co. |
| 14. Shale, red | Montreal River, Saxon, Iron Co. |
| 15. Slate | Upson, Iron Co. |
| 16. Mica schist | Rib River, Athens, Marathon Co. |
| 17. Limestone, calcite | Mount Horeb, Dane Co. |
| 18. Limestone, buff, dolomite | East Middleton, Dane Co. |
| 19. Limestone, white, dolomite | Mayville, Dodge Co. |
| 20. Marble, dolomite | Foster, Ashland Co. |
| 21. Chert | Mount Horeb, Dane Co. |
| 22. Iron formation | Pence, Iron Co. |

METAMORPHIC ROCKS, UNKNOWN ORIGIN.

| | |
|---|---|
| 23. Gneiss | Wisconsin Rapids, Wood Co. |
| 24. Hornblende schist | Pittsville, Wood Co. |

PRODUCTS OF WEATHERING.

| | |
|---|---|
| 25. Series showing weathering of granite | Marathon, Marathon Co. |
| 26. Series showing weathering of limestone | Mount Horeb, Dane Co. |

ORES.

| | |
|---|---|
| 27. Hematite | Hurley, Iron Co. |
| 28. Hematite, oolitic | Mayville, Dodge Co. |
| 29. Galena | Platteville, Grant Co. |
| 30. Sphalerite | Platteville, Grant Co. |

## DESCRIPTION OF SPECIMENS.

*General.* This collection includes both rocks and ores found in Wisconsin. These are fairly typical of the rocks of the entire country. A *rock* is a material which forms some appreciable portion of the earth's crust and which is firm enough to be broken into pieces which will withstand handling. An *ore* is a substance from which a metal can be profitably extracted. Rocks and ores are both made up of component particles called *minerals.* A *mineral* is a definite chemical compound and is the same material all the way through. Most rocks are made up of several kinds of minerals mixed in no definite manner, just as a wall might be built of several kinds of bricks, but with no definite arrangement of the different kinds. Some ores are composed of a single mineral, while others contain more than one mineral.

The principal minerals mentioned in the text are: *Feldspar* (color pink or gray, cannot be scratched by knife, breaks in smooth faces); *quartz* (color gray or white, cannot be scratched by knife, breaks like glass); *hornblende* (color black, can be scratched with difficulty with a knife, breaks in needle-like forms); *mica* (color either black or gray, can be scratched with finger nail, splits in thin sheets); *calcite* (color gray to blue, readily scratched by knife, breaks in smooth faces, effervesces when treated with hydrochloric acid); *dolomite* (like calcite but often yellow in color and does not effervesce with acid unless powdered); *kaolin* (chief constitutent of clay, a very soft, generally light colored mineral with an earthy odor); *hematite* (a fairly soft mineral, red when scratched).

*Rocks.* The way in which rocks are formed is a very interesting subject to which many men have given long years of study. Some of the general principles, however, are very simple and easy to comprehend.

Rocks may be formed in two ways. One of them is by the cooling and solidifying of melted rock material such as the molten lava that flows from volcanoes. When this cools a very hard solid rock is formed. When the volcano is no longer active, the molten rock below it also cools and solidifies.

The effect of the rate of cooling is very striking. If one melts some sugar to make candy and cools it quickly on ice or snow, it solidifies in a clear glassy mass like butterscotch. If one cools it slowly, it becomes granular. In the quickly cooled candy, the sugar crystals do not have time to form, while in that cooled more slowly they have plenty of time and so the candy is granular. The rate of cooling of molten rock has the same effect. The lavas that flow out on the surface cool quickly and are glassy or very fine grained. Those that do not get to the surface but solidify deep within the earth, cool very slowly and so are almost always much more coarsely crystallized. Compare specimens 2 and 4 and tell which was cooled deep within the earth and which cooled at the surface.

Rocks that solidify from a molten condition are called *Igneous Rocks.* Look at the first five specimens and contrast them with specimens 7 to 15.

Igneous rocks and all other rocks are broken up by the weather, by streams, and by waves along the sea shore, into more or less fine grains, and parts of them are dissolved by water. Thus all the rocks exposed at the surface are being worn away slowly and carried by streams into the lakes and the sea. The mud in the streams and the sand and gravel which they roll along their bottoms are thus carried along with the current. When the current stops on reaching a large body of water, the material can no longer be carried and so is deposited. Coarse particles like sand and gravel settle quickly. The fine particles which make up the mud settle more slowly. The material which the water had dissolved from the rocks does not settle at all, but part of it is used by animals and plants living in the water and so eventually gets to the bottom. The sediment carried and deposited by water and the dust carried by the wind form what are called sedimentary deposits, and when they are later cemented so they are solid, we call them *Sedimentary Rocks.* This is the second way in which rocks may be formed.

Look over the specimens numbered from 6 to 22 and see how they differ from the igneous rocks.

When either kind of rocks—igneous or sedimentary—are subjected to great pressure and heat deep within the earth, the mineral particles that make the rocks are likely to suffer marked changes. These changes result in what we call *Metamorphic Rocks.*

The most common effect is to develop large quantities of mica, and in this manner a shale becomes a slate and with still more pressure a mica schist. Compare specimens 13 and 16. Sometimes this alteration becomes so great that it is impossible to tell whether the resulting rock was originally sedimentary or igneous. Examine specimens 23 and 24.

## SEDIMENTARY ROCKS.

*Origin of sedimentary rocks.* Sedimentary rocks are discussed first because they are simplest in composition and because they cover most of Wisconsin. (See geological map of Wisconsin.) All of these rocks were once in a loose incoherent state, being material such as sand or clay which was deposited by water, or more rarely, by the wind. Since this deposition took place, the sand, clay, or other material has been changed into solid rock. (See below.) All sedimentary rocks are composed of material derived from the weathering and destruction of still older rocks.

*Strata or beds.* The rate of deposition by water or wind is subject to variation as is also the kind of material. Such changes cause the formation of distinct layers. The partings between the layers are called *bedding planes* while the layers themselves are spoken of as *beds* or *strata.* Sedimentary rocks are often called *stratified rocks,* though they do not in all cases show well marked layers, especially in small specimens.

*Change into rock.* The loose material which is deposited to form rocks may be gravel, sand, clay, or finely divided calcite (marl). The change of these various substances to the state of solid rock is due in part to pressure and in part to the deposition of cementing substances from water which works its way through the material. The weight of overlying deposits is a large factor in consolidating clay into shale, but most sedimentary rocks are hardened mainly by the process of cementing. Almost all underground water carries small amounts of quartz, calcite, dolomite, and oxide of iron in solution. Under favorable conditions these waters deposit a part of their dissolved minerals, thus gradually cementing the material into rock. In this discussion metamorphosed sedimentary rocks which are so little altered that the nature of the original rock is recognizable are considered with the other sedimentary rocks. These rocks whose original state is in doubt are classed as *metamorphic rocks of unknown origin.* (pp. 24, 25.)

*Classification of sedimentary rocks.* Sedimentary rocks may be classed as to (1) kind of material and (2) changes which they have undergone since deposition. The following table shows a convenient classification of sedimentary rocks.

| | | Unconsolidated | Consolidated | Metamorphosed |
|---|---|---|---|---|
| Groups | Material washed or blown | Gravel<br>Sand<br>Clay | Conglomerate<br>Sandstone<br>Shale | Conglomerate<br>Quartzite<br>Slate |
| | Material carried in solution | Marl<br>--------------<br>-------------- | Limestone<br>Iron formation<br>Chert | Marble<br>Iron formation<br>Chert |

## GRAVEL GROUP.

### UNCONSOLIDATED GRAVEL.

*Description.* No specimen of gravel has been included in the collection since it is so common. The pebbles in gravel are usually rounded. They may be of any kind of rock.

*Distribution.* Gravel is widely distributed in Wisconsin where streams flow now or flowed in the past. Most of it was deposited by the waters which came from the melting glacier.

*Uses.* Gravel is used for concrete, roads, roofing, railroad ballast, and filters. See table of production on p. 10.

### CONSOLIDATED GRAVEL.

*Specimen No. 7. Conglomerate, Montreal River near Saxon, Iron Co.*

*Description.* This rock was once loose gravel, made up of pebbles of several kinds of rocks mixed with coarse red sand. The cement is calcite and oxide of iron.

*Distribution.* This conglomerate comes from the bed of Montreal River. The gravel which was cemented into this rock was probably deposited by streams which flowed into the basin of Lake Superior. As originally laid down the strata were undoubtedly inclined at a low angle. Subsequent movements of the earth's crust have made them vertical.

*Other Conglomerates.* Conglomerates of different kinds occur throughout the state. An especially good place to study them is near Devils Lake and Ableman in Sauk County. Here there were once mountains of quartzite which were gradually submerged by the sea. The waves beat against them breaking off bowlders and rounding them on the beach. Sand accumulated between the pebbles and bowlders, and the whole mass was cemented into conglomerate.

*Uses.* Conglomerate with firm pebbles can be crushed and used for the same purposes as gravel. This is done near Ableman, Sauk County. The production is included with that of gravel.

#### METAMORPHOSED GRAVEL.

Metamorphosed conglomerates are not common in Wisconsin.

### SAND GROUP.

#### UNCONSOLIDATED SAND.

*Description.* No specimen of sand has been included in the collection. Most sands consist largely of quartz grains.

*Uses.* Sand is used for making mortar, plaster, and concrete, also for moulds used in casting metal, for sand lime brick, for the sand blast, and on slippery rails as an aid in giving better traction to locomotives and street cars.

*Distribution.* Sands are very common in Wisconsin along the courses and in the beds of existing and extinct streams and lakes. Much sand was deposited along the courses followed by the waters from the melting glacier.

**PRODUCTION OF SAND AND GRAVEL IN WISCONSIN 1910—1917.**

| Year | Sand | | Gravel | | Total | |
|---|---|---|---|---|---|---|
| | tons | value | tons | value | tons | value |
| 1910 | 810,999 | $ 333,812 | 640,759 | $ 92,751 | 1,451,758 | $ 425,563 |
| 1911 | 1,020,303 | 345,996 | 2,659,552 | 385,696 | 3,679,855 | 731,692 |
| 1912 | 1,746,804 | 383,416 | 1,305,015 | 270,911 | 3,051,819 | 664,327 |
| 1913 | 1,432,734 | 409,685 | 2,612,020 | 362,440 | 4,044,754 | 772,125 |
| 1914 | 2,299,443 | 425,766 | 1,294,893 | 343,230 | 3,594,336 | 768,996 |
| 1915 | 1,294,196 | 286,551 | 1,567,840 | 349,941 | 2,862,036 | 636,492 |
| 1916 | 1,912,071 | 507,187 | 1,632,695 | 387,015 | 3,544,766 | 894,202 |
| 1917 | 1,688,483 | 523,944 | 1,921,386 | 556,916 | 3,609,869 | 1,080,860 |

The increase of production of sand and gravel is related to the growth of the use of concrete which has to a large extent displaced stone and brick. The values vary with building conditions.

## CONSOLIDATED SANDS.

### *Specimen No. 8. Sandstone, Baraboo, Sauk Co.*

*Description.* This sandstone is composed of clean, well-worn, quartz grains, cemented by quartz. The yellow color seen in some specimens is due to a minute quantity of iron oxide.

*Distribution.* This specimen comes from the lower portion of the Upper Cambrian ("Potsdam" of old maps and reports) sandstone formation which was deposited in a shallow sea as is testified to by abundant *ripple marks* like those found on modern lake bottoms near shore. Note the distribution of the Cambrian sandstone on the geological map. This particular sandstone forms the cliffs of the castle-like rocks near Camp Douglas, Friendship, and many other places in central Wisconsin.

*Uses.* This sandstone, on account of its porous character, is an important reservoir of underground water. It is called the "Potsdam sand" by well drillers. The rock itself is used to some extent for building. It is quarried at Ableman, Sauk County, where it is firm enough to make paving blocks.

### *Specimen No. 9. Sandstone, calcareous, Black Earth, Dane Co.*

*Description.* This rock is composed of fine sand mixed with a large proportion of dolomite. It may be called a mixture of sandstone and limestone.

*Distribution.* This specimen is taken from the upper or younger part of the Cambrian sandstone. This kind of rock is found in the bluffs from near La Crosse to the Wisconsin River.

*Uses.* The layers from which the specimen was taken are quarried considerably for building stone, as the beds split apart readily. This use is, however, rapidly declining. At places where the strata are thin, portions are excavated for road surfacing. The material is left to be packed by the travel thus making a cheap but short-lived road.

### *Specimen No. 10. Sandstone with greensand, Black Earth, Dane Co.*

*Description.* Examine this rock with a magnifying glass. The greenish color is due to grains of a dark green mineral called "greensand" or "glauconite" (contains iron, potassium, silicon, and oxygen).

*Distribution.* This rock lies immediately beneath the formation represented by Specimen No. 9. It is part of the Cambrian sandstone ("Potsdam"). In western Wisconsin green sandstone of the same kind is found in great abundance.

*Uses.* Greensand has no use at present, but if a way is ever discovered to extract its potash cheaply it will supply a much needed fertilizer for the soils of the state. It is of fair value as a fertilizer without any chemical treatment.

*Other sandstones.* A formation in Wisconsin not represented in the collection is the Lake Superior sandstone. Much of this formation is of a brownish red color on account of the presence of red iron oxide which coats the sand grains. The dark red, firm sandstone was once quarried extensively for building purposes under the name "Lake Superior brownstone."

The St. Peter sandstone is also an important formation. Although soft, it forms occasional buttes and crags like the "Three Chimneys" near Viroqua.

The distribution of these sandstones should be studied on the geological map.

PRODUCTION OF SANDSTONE IN WISCONSIN 1910–1917

| Year | Paving | Total |
|---|---|---|
| 1910 | ---------- | $ 81,607 |
| 1911 | $ 7,541 | 85,807 |
| 1912 | 37,100 | 101,592 |
| 1913 | 60,287 | 121,586 |
| 1914 | 37,000 | 101,425 |
| 1915 | 55,492 | 110,804 |
| 1916 | 23,266 | 78,419 |
| 1917 | 44,711 | 98,393 |

One-third to one-half the value of sandstone quarried in Wisconsin is used for paving. In 1892 the value of sandstone was $417,000. The great shrinkage to the present production is due to the abandonment of the Lake Superior quarries and to the competition of concrete.

METAMORPHOSED SANDS.

### *Specimen No. 11. Quartzite, Baraboo, Sauk Co.*

*Description.* This rock is over 99 per cent quartz. The remainder is clay and iron oxide. Compare this specimen with sandstone. Quartzite is distinguished from sandstone by the fact that it breaks through the original sand grains instead of around them. It was changed from sandstone by cementation with quartz rather than by pressure.

*Distribution.* This specimen is from the Baraboo Bluffs in Sauk County. The extent of the quartzite is shown on the geological map. Quartzite is very hard and resistant so that it does not weather as readily as the surrounding rocks. For this reason it is nearly always found standing out in the form of hills. The Baraboo Bluffs, Rib Hill near Wausau, Powers Bluff near Wisconsin Rapids, Flambeau Ridge, and a number of other high hills in Wisconsin are composed of quartzite.

*Uses.* Quartzite is (a) crushed and burned with a small amount of lime to make fire brick, (b) used for road surfacing, (c) used for concrete, and (d) used for abrasives (sandpaper, etc.).

PRODUCTION OF QUARTZITE IN WISCONSIN 1910–1917

| Year | Fire brick or Ganister | Total |
|---|---|---|
| 1910 | $66,138 | $130,676 |
| 1911 | 40,598 | 82,266 |
| 1912 | 47,384 | 79,118 |
| 1913 | 63,384 | 126,478 |
| 1914 | 34,170 | 96,854 |
| 1915 | 40,082 | 100,782 |
| 1916 | 79,643 | 159,682 |
| 1917 | 167,385 | 238,851 |

### *Specimen No. 12. Mica schist, Baraboo, Sauk Co.*

*Description.* Examine this rock under the magnifying glass. Note that the specimen is in layers. (In some specimens these layers are bent into little wave-like forms.) Note that the mica flakes are parallel to the layers. This rock occurs in beds a few feet thick between thick strata of the Baraboo quartzite. In past ages the whole Baraboo region was compressed by a movement of the earth's crust bending the rocks into great folds miles across. This process caused slipping between the different layers or strata (See p. 7.), which took place mainly along layers which were softer than the rest of the rock. This schist represents the layers which originally had more clay in them than did the adjacent strata. The clay was changed into mica by pressure.

*Distribution.* Schist like the specimen is found throughout the Baraboo Bluffs in Sauk County and at a number of points in northern Wisconsin.

*Uses.* Schist splits too easily to be used as building stone. It can be used for road surfacing but there is no commercial production.

**Note:** The word schist is also applied to rocks differing from this specimen. It is usually qualified by the name of the most conspicuous mineral present, such as "mica schist," "hornblende schist," etc. See p. 24.

## CLAY GROUP.

*General.* Clay is the name applied to the fine material which is slowest to settle from water or air. Clay is composed mainly of kaolin, mixed with finely powdered quartz and various other minerals such as mica, feldspar, calcite, and dolomite. The consolidation of clay into rocks is, in large part, simply the result of pressure. Clay may, however, be cemented the same as sand. Clay which is sufficiently firm to be classed as a rock is called *shale*. Earth movements may compress shale into *slate* which no longer splits along the bedding planes, but in a direction fixed by the process of folding. If the earth movements were very intense new minerals, especially mica, may have been developed. The rock is then called a *schist*.

### UNCONSOLIDATED CLAY.

*Specimen No. 6A. Loess, Middle Ridge, La Crosse Co.*

*Description.* This brownish clay is known to be wind-deposited because it contains no large particles such as are readily carried by streams, and is unlike the material left from the weathering of the underlying rocks. It shows no bedding planes as do water deposits.

*Distribution.* Much of the soil of western Wisconsin in both the glaciated and unglaciated region is loess. It is especially well shown on the bluffs of Grant, Crawford, Vernon, and LaCrosse counties. To the east, the loess deposit is thinner but has a great extent.

*Uses.* Loess has sometimes been used to make bricks but at present few brick yards of large size are using loess. It has been used in some places as a surfacing on sandy roads.

*Specimen No. 6B. Red Clay, Friendship, Adams Co.*

*Description.* This clay contains some calcite or dolomite and fine sand. The red color is due to the presence of a small amount of iron oxide. In the bank from which this specimen was taken thin layers of red clay, gray clay, and fine sand alternate. These strata are very even and level due to the fact that these sediments were deposited in quiet water.

*Distribution.* Red clays of this type underlie much of western Adams Co. When the glacier was at its greatest extent it blocked the Wisconsin River at Kilbourn and formed an extensive lake, into the quiet water of which flowed the streams formed by the melting of the ice. The clay and iron oxide were carried farthest out from shore before settling to the bottom. The finely divided limestone in this clay came from limestone ground up by the glacier. This specimen was taken near a sandstone hill which formed an island in the lake. There is less sand in the clay far from islands.

Red clay forms much of the soil along the shores of Lake Michigan (north of Milwaukee), of Green Bay, and of Lake Superior. This clay was deposited in the Great Lakes when they were held at higher levels by the glacier during its retreat.

*Uses.* Red clay is widely used for brick. The pulverized limestone it contains combines with the iron on burning so that the bricks are not red but cream colored. Milwaukee was once called "The Cream City" because so many buildings were constructed of brick of this kind.

CONSOLIDATED CLAYS.

*Specimen No. 13. Shale, green, Baraboo, Sauk Co.*

*Description.* The green shale consists of a clay containing a minute percentage of iron compounds of greenish color. There are bands and spots of red iron oxide. This rock was once soft clay deposited on the sea bottom. Since then the strata have been bent and the clay compressed into hard shale. Many persons call any hard shale a slate. Except in a small part of the area where this specimen was secured the rock still splits along the original bedding planes and hence is not a true slate.

*Distribution.* Shale of this type is known only near Baraboo. It does not come to the surface at any place, but the specimens were obtained from the shaft of an iron mine.

*Specimen No. 14. Shale, red, Montreal River, Iron Co.*

*Description.* The red color is due to red iron oxide. Mica can be seen in some specimens.

*Distribution.* This specimen was collected near the mouth of Montreal River. Red shales of this type are found in great quantity throughout the area underlain by rocks of Upper Keweenawan age (see geological map). At many places mud cracks are found just like those seen in dried-up puddles today.

*Other shales.* Only one other large shale formation is found in Wisconsin, the "Cincinnati" shale. This occurs in the eastern and southwestern parts of the state. It is exposed at the surface in but few places. The shale is of bluish, or greenish-gray color and contains much dolomite.

*Uses.* Shale as well as clay can be used to make brick and other clay products. Shale is used in sandy areas for surfacing roads. The clay of which it is composed mixes with the sand and makes a very good easily maintained road for light traffic.

PRODUCTION OF CLAY PRODUCTS IN WISCONSIN—1910-1917.

| Year | Value |
|---|---|
| 1910 | $1,176,883 |
| 1911 | 1,158,139 |
| 1912 | 1,044,486 |
| 1913 | 1,020,728 |
| 1914 | 950,999 |
| 1915 | 910,558 |
| 1916 | 905,910 |
| 1917 | 1,114,121 |

The competition of concrete and of brick manufactured in Illinois has kept the value of clay products in Wisconsin stationary for many years. The product is mainly common brick, though some drain tile is made.

### METAMORPHOSED CLAYS.

*Specimen No. 15. Slate, Upson, Iron Co.*

*Description.* Slate is much harder and splits better than shale. It does not split along the original bedding planes. This slate occurs as a thin band between vertical layers of stronger rock on either side.

*Distribution.* Slate like the specimen is abundant in northern Wisconsin. It is well exposed in Iron, Ashland, and Florence counties.

*Use.* No slate suitable for roofing or blackboards has been found in Wisconsin. Broken-up slate is sometimes used for road surfacing. If it has a pleasing color, such as a pronounced green or red, or a light gray, it is sometimes crushed to small particles and used to cover asphalt shingles.

*Specimen No. 16. Mica schist, Rib River, near Athens, Marathon Co.*

*Description.* Some of the specimens of No. 16 show large crystals. These are *staurolite,* a silicate of aluminum and iron, formed as a result of pressure. Note that this specimen splits well. This is a result of the intense pressure which formed the rock and made mica out of the original clay.

*Distribution.* Similar schists which were once shale are found throughout northern Wisconsin. Good exposures may be seen in the bed of the Wisconsin River near Merrill.

*Uses.* Schists split too readily to be used for building stone. Rock like this could be used for road surfacing. Yellow mica in schist is sometimes mistaken for gold, but can be readily distinguished because the mica can be pounded to a powder, while gold can not.

### LIMESTONE GROUP.

*General.* We now turn to a group of rocks made up of calcite and dolomite. See p. 6. Calcite is pure calcium carbonate, and dolomite is a chemical mixture of calcium and magnesium carbonates. The origin of such rocks is evidently not the same as those studied up to this point. Little calcite and dolomite is carried by water in the way that sand and clay are transported. These minerals are readily soluble in water containing dissolved carbon dioxide (sometimes called carbonic acid gas). Such waters are called hard waters. The total amount of these minerals present, however, in few cases exceeds 3/100 of 1% of the water. In lakes and the ocean various organisms ranging from microscopic bacteria to shell-encased animals several feet in length remove calcite from the water and use it for their skeletons or shells. These shells and skeletons of animals and plants accumulate on the bottom and in long periods of time build up limestone deposits. Certain chemical changes in the water also cause the deposition of either calcite or dolomite. The origin of limestones composed of dolomite is not as yet very well known. These are called "magnesian limestones" or "dolomites". Freshly deposited material containing much calcite not yet hardened into rock is called "marl". Most marls are not pure but contain more or less clay or sand.

### UNCONSOLIDATED LIMESTONE.

*Specimen No. 6C. Marl, Lake Wingra, Madison, Dane Co.*

*Description.* Note the shells in your specimen. Not all the calcite can be accounted for by animal shells alone. Most of it was taken from solution by plants. The clay was washed from the adjacent highlands. This marl contains a large percentage of clay. If hardened into rock we would call it shaly limestone or limy shale.

*Distribution.* Marl like the specimen is found in a large number of lakes in Wisconsin. In deep water shells are less common but there is less sand or clay. The thickness of the deposit in Lake Mendota at Madison is about 40 feet. This has all formed since the glacier disappeared.

*Uses.* Marl can be used (a) in making cement if sufficiently pure, and (b) to put on soils as a fertilizer. For both of these purposes, however, limestone is more commonly used.

### CONSOLIDATED LIMESTONE.

*Specimen No. 17. Limestone, calcite, Mt. Horeb, Dane Co.*

*Description.* The brownish spots are composed of dolomite with a little iron oxide. The bulk of the rock is calcite. In some specimens crystals of calcite are present filling what were once holes.

*Distribution.* Calcite limestone is not very common in Wisconsin. One formation composed of this material, the Platteville limestone, is found in the southwestern part of the state.

*Uses.* Calcite limestone is valuable for flux, used in blast furnaces where the iron is extracted from iron ore, and for cement which is made by burning it (or marl which has little or no magnesium), together with clay, and grinding the burned material very fine. Other uses are the same as those of dolomite limestone. The Wisconsin deposits of pure limestone are too far from iron and cement making districts to be of use. They are also too far from the main lime consuming regions to be used extensively.

*Specimen No. 18. Limestone, buff, dolomite, East Middleton, Dane Co.*

*Description.* Contrast this specimen with the gray portion of the last. It shows a somewhat sandy appearance, due to the minute crystals of dolomite. This specimen owes its yellowish color to weathering. See if there are any evidences of shells or other remains of life. Few original shells are ever preserved in dolomite limestone (as they often are in calcite limestone). Only their impressions remain.

*Distribution.* Dolomite or magnesian limestones are found in many parts of the state. Rock similar to the specimen makes up much of the Trenton and Galena formations. The weathered portions of these formations are buff or yellow. Where unweathered the rock is gray or blue.

*Specimen No. 19. Limestone, white, dolomite, Mayville, Dodge Co.*

*Description.* Note the small size of the dolomite crystals which make up this rock. This rock is extremely pure dolomite.

*Distribution.* Limestone more or less similar to the last specimen makes up the Niagara and Lower Magnesian formations. This specimen is from the Niagara. Note the distribution of these formations on the geological map.

*Uses.* Limestone of any kind—if hard enough—is used for (1) building, (2) crushed rock for concrete or roads, (3) lime, (4) flux, and either hard or soft for (5) fertilizer.

As noted before, the use of stone for building is decreasing while that of crushed rock is increasing, as shown by the following table. Lime is made from the very pure Niagara dolomite limestone and is largely used in the paper and pulp industry of the Fox River Valley. Any kind of limestone can be ground to use on sour soils to neutralize their acid condition. Portland cement, the only kind made in these days, cannot be made successfully from limestone containing very much dolomite. At one time a shaly dolomite limestone found near Milwaukee was used to make natural cement, but the better quality of Portland cement has caused it to be used to the exclusion of the former.

PRODUCTION OF LIMESTONE IN WISCONSIN 1910–1917

| Year | Crushed rock | Other purposes | Total |
|---|---|---|---|
| 1910 | $668,102 | $311,420 | $ 979,522 |
| 1911 | 525,[illegible]45 | 323,118 | 84[illegible],36[illegible] |
| 1912 | 600,503 | 242,974 | 8[illegible],477 |
| 1913 | 759,670 | 257,455 | 1,017,135 |
| 1914 | 762,444 | 244,662 | 1,007,106 |
| 1915 | 673,363 | 220,795 | 894,158 |
| 1916 | 794,820 | 294,291 | 1,089,111 |
| 1917 | 861,873 | 310,694 | 1,172,567 |

**The most notable feature of limestone production is the large proportion used as crushed rock for concrete and road making. Competion with gravel has, however, kept the value of limestone production from making any large increase.**

PRODUCTION OF LIME IN WISCONSIN 1910–1917

| Year | Short tons | Value |
|---|---|---|
| 1910 | 248,232 | $ 959,405 |
| 1911 | 250,638 | 961,558 |
| 1912 | 263,052 | 825,551 |
| 1913 | 243,006 | 1,005,496 |
| 1914 | 227,469 | 871,820 |
| 1915 | 221,147 | 755,986 |
| 1916 | 266,805 | 1,207,059 |
| 1917 | 169,650 | 1,037,578 |

METAMORPHOSED LIMESTONE.

*Specimen No. 20. Marble, dolomite, near Foster, Ashland Co.*

*Description.* Contrast the size of crystals of dolomite in the marble with those in the limestones. Note that there is no difference in hardness with respect to scratching. The pressure which made limestone into marble (p. 7) formed larger crystals than were present in the original limestone. Some of the marble specimens show needles of a silicate of calcium and magnesium called tremolite; other specimens show some chert. (See specimen No. 21.)

*Distribution.* Marble is not common in Wisconsin. The specimen is from a discontinuous belt (not shown separately on geological map) which runs along the southeastern side of the Penokee-Gogebic Iron Range in Ashland and Iron counties.

*Uses.* No Wisconsin marble has ever been exploited for ornamental stone. Marble can be used for the same purposes as limestone.

### MISCELLANEOUS GROUP.

*General.* The miscellaneous group comprises chert, iron formation, and oolitic hematite (See below for definition of oolitic). Chert, or flint as it is often called, is silica (the same material as quartz) deposited from sea water in small amounts along with calcite or dolomite. This deposit was more or less scattered throughout the limestone formations, but during the hardening of the rock underground water dissolved and redeposited it to a large extent. Thus it has been concentrated into nodules and bands which vary from a fraction of an inch to a few feet thick. That these nodules and bands were originally not all chert is made clear by the presence in them of the impressions of shells which were once calcite.

The iron formation such as occurs in the Baraboo and Penokee-Gogebic iron ranges consists of iron oxides, iron carbonate, and chert. It was deposited from solution on the sea bottom in somewhat the same way as limestone. Bodies of iron ore pure enough to mine are formed in the great mass of the iron formation only where the chief impurity—chert—is leached out by weathering. (See Specimen No. 27.)

Oolitic hematite occurs in patches between the Cincinnati shale and the overlying Niagara limestone. Its origin is not well understood but it is known that it was deposited on the sea bottom. The term *"oolitic"* refers to the small spheres which resemble fish eggs. They are not the product of wear, but of deposition.

*Specimen No. 21. Chert, Mt. Horeb, Dane Co.*

*Description.* Chert, being a form of quartz, is harder than steel. In some specimens portions can, however, be scratched; this is due to weathering. It can be distinguished from limestone by the fact that it does not effervesce with hydrochloric acid. (See p. 6). The color of chert varies widely. Some is black, while other kinds are red, pink, or yellow, the colors sometimes being arranged in bands. Many cherts have cavities lined with quartz crystals. Others have a sand-like appearance due to the occurence of the chert in little spheres (oolitic).

*Distribution.* Chert is found in nearly all the dolomite limestones, marbles, and iron formations of Wisconsin, although it is not found in the calcite limestones of this state. The cherts of different formations vary in appearance.

*Uses.* Chert is used in this state only for road surfacing. In a number of places in the valley of Sugar River there are deposits of weathered chert which are excavated for that purpose.

*Specimen No. 22. Iron formation, Pence, Iron Co.*

*Description.* Scarcely two specimens of iron formation, or "jasper" as it is frequently called by miners, are the same. It is a mixture of iron oxide (hematite or magnetite), iron carbonate, and chert. The metallic iron seldom reaches 35%. Examine your specimen and see of what it consists.

*Distribution.* Iron formation varies much in different localities. Along the Penokee-Gogebic Range the rock is in large part like the specimen. Farther south, iron formation has been found in a few places.

*Uses.* Iron formation is used for road surfacing as the hematite forms a good binder although it makes a disagreeable red dust. No figures on production are available. In this rock are found bodies of merchantable iron ore (See Specimen No. 27).

*Specimen No. 28. Hematite, oolitic, Mayville, Dodge Co.*

*Description.* Such grains as these were built up and not worn into their present shape. They consist of layers of iron and silica so that on the average there is only about 40 to 45 per cent metallic iron. The material between the grains is largely hematite and calcite.

*Distribution.* Oolitic hematite occurs in patches from a few inches to 55 feet in thickness and from a few square rods to several square miles in extent. These are found between the Cincinnati shale and the Niagara limestone. (See geological map.)

*Uses.* Oolitic hematite similar to this specimen is mined for iron ore in Alabama and New York, but in Wisconsin its low grade as compared with the Lake Superior iron ores and its distance from coal prevents exploitation on a large scale. Another disadvantage is that too much of the ore breaks up readily into fine dust which is blown out of the blast furnace by the forced draft. The only large mine is near Mayville, the ore being smelted at that place. To lessen the dust loss the local product is made into small bricks before being put in the furnace. The production is included with that of other iron ore (p. 32).

## SUMMARY OF SEDIMENTARY ROCKS.

Sedimentary rocks were made from the weathered fragments of older rocks transported by wind or water, deposited, and then hardened by pressure or by the work of ground water. They are classified into five groups depending on the nature of the material. Rocks of the *gravel* group can readily be distinguished by the rounded pebbles. In the *sand* group sandstone can be told since one can usually rub off the grains of sand. Quartzite is so hard that one cannot do this; it breaks right through the original sand grains. The change from sandstone to quartzite is more the result of cementation than of pressure. *Slate* is much harder than shale. *Limestone* can be distinguished from sandstone because it can be readily powdered with a knife without finding any grit. Marble is firmer and harder than limestone though no more difficult to scratch with a knife. *Chert* looks like limestone but will not effervesce when treated with hydrochloric acid and in most cases cannot be scratched with a knife. Iron formation contains chert and red oxide of iron. A chemical analysis is sometimes needed to tell whether or not it has enough iron to be considered an ore. When rocks were deposited the different kinds of material were not always cleanly sorted out. Therefore we have sandy limestone, limy sandstone, limy shale, and other combinations which may trouble a beginner.

### METAMORPHIC ROCKS OF UNKNOWN ORIGIN.

*General.* It very frequently happened that the process of metamorphism went so far that it cannot even be definitely decided whether or not the original rock was igneous or sedimentary. Out of a considerable variety of rocks of this class found in the state two have been selected. The first belongs to the class *gneiss,* rocks with schist-like parting, but with minerals of different colors arranged in more or less distinct bands, while the second is a *schist* made up almost exclusively of the mineral hornblende. These rocks were far below the surface when they were metamorphosed. The state must have been mountainous at that time. Ages of erosion have destroyed the mountains. (See p. 27 for other evidence on this point.)

*Specimen No. 23. Gneiss, Wisconsin River, below Wisconsin Rapids, Wood Co.*

*Description.* The minerals in this rock are feldspar, quartz, and hornblende. Note how they are arranged and compare this arrangement with that of schists. Compare with the bedding of a sedimentary rock. Compare with the minerals common in sedimentary rocks.

*Distribution.* Gneiss is widely distributed throughout northern Wisconsin.

*Uses.* Gneiss could be used for building or crushed stone, but owing to the difficulty and expense of quarrying there is no commercial production in Wisconsin.

*Specimen No. 24. Hornblende schist, near Pittsville, Wood Co.*

*Description.* Note the well developed splitting and the arrangement of hornblende crystals. Hornblende is a black mineral which forms needle-like particles. Compare this rock with the dark bands of the preceding specimen. The gneiss contains the light colored mineral, feldspar, which is not present in the schist. The feldspar and some of the quartz were either injected in a molten state into the seams of the schist or carried in and deposited there by hot water solutions, thus making it into gneiss. Not all gneisses were made in this way; many are probably metamorphosed igneous rocks.

*Distribution.* Schists like the specimen are not very common in exposures because their ready cleavage makes them weather away rapidly. Similar schists, many of them clearly derived from igneous rocks, are common throughout the northern part of the state. Others were possibly once sedimentary rocks which contained much hornblende or feldspar. Schists derived from iron formation are very magnetic, but rarely contain enough iron to be called ore.

*Uses.* There is no commercial production of schist at present, although some could be used for road surfacing.

### SUMMARY OF METAMORPHIC ROCKS OF UNKNOWN ORIGIN.

Metamorphic rocks of unknown origin may have originally been either sedimentary or igneous rocks. They show the effects of the intense pressure and heat to which they have been subjected in the great abundance of mica and hornblende and in the parallel arrangement of the particles. Gneiss looks much like granite, but is made of alternating light and dark colored bands. It can be told from stratified sedimentary rocks because the minerals are not like those of the sediments, but like those in granite. Schist splits more readily than gneiss and is the same material all the way through with no banding.

## IGNEOUS ROCKS.

*Definition.* Igneous rocks are those which were once molten.

*Characteristics.* Igneous rocks vary in composition, that is in kind of minerals present and the relative proportions of the minerals, in the way those minerals occur, and in size of the mineral particles.

*Color.* The first character to be considered is the color of the rock. The lighter colored rocks have a high percentage of feldspar and quartz. In the dark rocks there is much dark feldspar and hornblende.

*Texture.* Another scheme of classification is based on the size of the mineral particles. The following groups may be distinguished: (1) those in which the mineral particles are plainly visible (coarse grained); (2) those with only scattering minerals which can be seen in a ground mass of fine-grained material ("porphyries"); (3) those in which the minerals are very small or undistinguishable (fine grained); (4) those which are glassy or porous. Very few examples of the last group are found in Wisconsin.

These differences are due to the rate at which the rocks cooled. It takes a long time for mineral particles to form or "crystallize", as it is called, so that the more rapidly a rock cooled the smaller the mineral particles or crystals (See p. 6). Some lavas were chilled so rapidly that they become natural glass or obsidian, while others were blown out as a froth which cooled as pumice. Pumice is a glass and should not be confused with crystalline rocks.

*Table.* We can now connect color or composition with size of particles (texture) in a way to enable us to identify the common igneous rocks.

TABLE OF CLASSIFICATION OF IGNEOUS ROCKS.

| Texture | Light Color | Dark Color |
|---|---|---|
| Coarse | Granite | Gabbro |
| Porphyritic | Porphyry | Porphyry |
| Fine | Felsite | Basalt |
| Glassy | Glasses and Pumice | Glasses and Pumice |

It can be readily appreciated that there are all gradations of color and of texture because there are all possible variations in the proportions of minerals and in the rate of cooling. This explains the great variety of names which have been applied to igneous rocks. Some felsite is found in the northern part of the state; it is like the porphyry but without the visible crystals.

A kind of rock which a beginner might readily mistake for porphyry is basalt in which volcanic gasses left holes on cooling. Various light colored minerals have been deposited by underground waters in these holes. These minerals, unlike those in true porphyry, are usually softer than steel and the holes they fill are always rounded in outline. These filled cavities are called "amygdules" and the rocks in which they occur are called "amygdaloids". It is in the amygdaloidal rocks in northern Michigan that some of the world's greatest copper mines are found.

*Specimen No. 1. Granite, red, Montello, Marquette Co.*

*Specimen No. 2. Granite, pink or gray, Granite Heights near Wausau, Marathon Co.*

*Description.* Compare these rocks as to kinds of materials, size of minerals, and the rate of cooling. These rocks cooled far beneath the surface. (See p. 6.)

*Specimen No. 3. Gabbro, Mellen, Ashland Co.*

*Description.* This rock is made of hornblende and very dark feldspar. It must have cooled slowly far below the surface of the ground.

*Specimen No. 4. Basalt, Hurley, Iron Co.*

*Description.* Study the table to determine whether or not this rock cooled more rapidly than gabbro. Do not be confused by the reddish yellow weathered faces which are found on many of the specimens. These were cracks in which water discolored the rock. The minerals in this rock are in too small crystals to be seen by the naked eye.

*Specimen No. 5. Porphyry, Saxon, Iron Co.*

*Description.* Small crystals of feldspar and quartz can be seen in this rock. They are set in a ground mass of microscopic crystals. If no mineral were large enough to distinguish, we would call the rock felsite. Compare the probable rate of cooling with the other rocks of the collection.

*Distribution of igneous rocks.* The igneous rocks of Wisconsin are among the oldest rocks of the state, that is they cooled long ages before most of the sedimentary rocks were formed. Evidence of their great age may be found in the occurrence at the surface of slowly cooled rocks, like granite, showing that a great thickness of overlying rocks has been worn away since they hardened. The metamorphic rocks of the same area also must have been deeply buried when altered. (See p. 24.) The remaining specimens of igneous rocks cooled either on the surface (lava) or in cracks in the older rocks.

*Uses of igneous rocks.* The outstanding feature of igneous rocks from the standpoint of human use is their strength or resistance to breaking. This is because they are made up of interlocking crystals of different minerals. Great breaking strength in a rock is not so necessary in a building as it is for paving blocks, or for crushed rock for roads. Many igneous rocks resist weathering very well (heating and cooling, freezing and thawing of water, etc.). Slow rate of weathering makes certain igneous rocks useful for monuments and buildings. Examine your specimens and see if any show any weathered or discolored surfaces. The black rocks discolor more readily because some of the iron they contain becomes iron rust. They also absorb more heat and are in that way broken up. Granite, as it contains much quartz, is best suited for monuments and buildings, but is so hard that quarrying and working is expensive. The granites from Montello (Marquette Co.), Red Granite (Waushara Co.), Wausau, and Marinette are most used. These rocks are made into monuments because they take a very fine polish and show lettering well. They are also used for paving blocks. The production for building purposes is negligible. Porphyry with a black groundmass is quarried at Berlin and Utley. (Look up all these places on the geological map.) Basalt is quarried for crushed rock in Polk and Douglas counties. It is called "traprock" in the stone trade.

PRODUCTION OF IGNEOUS ROCKS IN WISCONSIN, 1910-17.

| Year | Monuments | Paving blocks | All other purposes | Total |
|---|---|---|---|---|
| 1910 | $ 403,553 | $ 939,020 | $ 232,769 | $ 1,475,342 |
| 1911 | 379,227 | 872,878 | 230,204 | 1,382,309 |
| 1912 | 513,253 | 497,307 | 168,458 | 1,179,018 |
| 1913 | 505,756 | 279,465 | 142,395 | 927,616 |
| 1914 | 520,774 | 548,100 | 272,581 | 1,341,455 |
| 1915 | 491,113 | 577,758 | 187,980 | 1,256,851 |
| 1916 | 504,598 | 658,622 | 227,748 | 1,390,968 |
| 1917 | 538,370 | 564,466 | 145,276 | 1,248.112 |

The above table shows clearly the two main uses of granite. The total value has been practically stationary for a number of years, because the increase in monumental stone is offset by the reduced use of stone block pavements.

**Note:** The student should remember that the term "granite" is often used by quarrymen for almost any kind of hard rock such as porphyry, gabbro, or quartzite.

## SUMMARY OF IGNEOUS ROCKS.

The student should learn to identify igenous rocks by means of the table rather than by similarity to the rocks of this collection.

To decide whether or not an unknown rock belongs to the igneous class note its hardness with respect to breaking. Igneous rocks do not split readily along parallel planes as do sedimentary and metamorphic rocks; they do not contain a high percentage of mica as do many metamorphic rocks; they consist of interlocking crystals of such minerals as feldspar, quartz, and hornblende. The fine grained group has crystals so small that they cannot be seen with the naked eye. Rocks of this group are sometimes readily confused with shale, but are harder and have less of the clay odor than does shale. The hardness of igneous rocks enables them to resist weathering better than do other rocks. Therefore they are valuable for monuments and buildings which are expected to last a long time. A disadvantage is that they are expensive to work.

## WEATHERING.

All substances which are exposed to the open air are subject to the process known as weathering. The agents of weathering are summarized below.

*Mechanical.* (1) Heating and cooling; (2) freezing and thawing; (3) work of roots and animals.

*Chemical.* (1) Solution by water especially when carrying dissolved substances such as carbon dioxide; (2) mineral changes due to chemical reactions with above substances or gasses of the air such as oxygen and water vapor.

The result of the action of the mechanical agents of weathering is the breaking up of a rock into smaller parts like the original rock. The chemical agents change the kinds of minerals which are present.

### *Specimen No. 25. Series Showing Weathering of Granite, Marathon, Marathon Co.*

*Description.* Examine Specimen 25A and compare with specimens of unweathered granite. Specimen 25B was taken somewhat nearer the surface and 25C just below the grass roots. As weathering advanced, the rock was broken up and the feldspar changed to kaolin. This weathering of feldspar formed the clay seen in 25C. Quartz is very resistant both to solution and chemical change and so was little affected by chemical action. The principal products left behind after weathering are (1) quartz, (2) clay, largely composed of kaolin, a residue from the weathering of feldspar, and (3) oxide of iron. All these substances are resistant to further change. Quartz, since it is hard and resistant to weathering, makes up most sand grains.

*Distribution.* Soils due to the weathering of granite are found in Marathon, Clark, and Wood counties. Although some of this district may have been glaciated, it was by an earlier ice advance than that which affected the area to the north and east. Residual soil has therefore had time to develop.

*Uses.* Residual soil from granite is a sandy clay and is of good quality. Disintegrated granite from below the soil is widely used for road surfacing in northern Wisconsin.

*Weathering of other rocks.* The manner of weathering of sandstone may be contrasted with that of limestone. Sandstone is mainly composed of grains of quartz loosely held together by some cement. It therefore weathers mostly by the grains breaking apart into sand, since the quartz is difficult to dissolve. Limestone is made of crystals of calcite or dolomite firmly fastened together, but those minerals are readily soluble in water which contains carbon dioxide. Therefore limestone weathers mainly by chemical means. If there were no impurities such as clay or chert in a limestone, no soil would be formed by weathering. However, such impurities are found in most of the limestones of Wisconsin so that areas underlain by limestones have a clay soil in most places containing many chert pebbles. Sandstone forms a sandy soil and shale a clay soil. Chert is like quartz in resisting solution.

### *Specimen No. 26. Series Showing Weathering of Limestone, Mount Horeb, Dane Co.*

*Description.* Specimens 26A, 26B and 26C show the process of the formation of soil from limestone and are arranged in order from the solid rock to the surface. Note the abrupt change between 26B and 26C. This is the depth to which the limestone has been entirely dissolved, leaving only clay and chert at the surface.

*Distribution.* Soils formed by weathering are called residual soils. There is little residual soil in the glaciated parts of the state since the glacier scraped it off. Even in the unglaciated area the residual soils are in many places covered up by material transported by the wind or by streams.

*Uses.* Residual soil from limestone is a heavy clay of good quality.

*Specimen No. 27. Hematite, Hurley, Iron Co.*

*Description.* The iron formations in the state are all very ancient (pre-Cambrian) rocks and have been much displaced by earth movements. This has resulted in tilting up and cracking the layers so that water can penetrate to great depths and cause chemical weathering. These rocks originally consisted largely of iron oxide, iron carbonate, and chert. Of these minerals the chert and iron carbonate are readily attacked by underground water, the iron minerals becoming iron oxide or hematite and the silica being carried away in solution. This process is very slow since silica is not readily soluble (although the form present is more soluble than quartz) but in places where much water has flowed for many ages little is left but hematite. When pure, hematite contains 70% of metallic iron, the remaining 30% being oxygen. Little hematite is found which is absolutely pure and only that containing over 50% metallic iron is considered a usable ore in the Lake Superior district.

*Distribution.* Iron ore of the type shown by this specimen is mined along the Gogebic Range in Iron County, and in Florence County. Similar ore was formerly mined in Sauk County.

*Uses.* Iron ore is used to make iron. It is heated with coke or charcoal and limestone. The fuel furnishes the heat and also burns out the oxygen from the ore. Forced draft is used. The limestone serves as a "flux" which unites with the impurities and floats on top of the molten iron. This is drawn off as slag. Iron ore is also used for red paint and to surface roads.

PRODUCTION OF IRON ORE IN WISCONSIN, 1910-1917.

| Year | Long tons | Value |
|---|---|---|
| 1910 | 1,149,551 | $3,610,349 |
| 1911 | 698,660 | 1,623,677 |
| 1912 | 860,600 | 2,039,622 |
| 1913 | 1,018,272 | 2,504,949 |
| 1914 | 886,512 | 1,764,159 |
| 1915 | 1,095,388 | 2,125,053 |
| 1916 | 1,304,518 | 3,104,753 |
| 1917 | 1,202,235 | 3,991,420 |

This table does not include a comparatively small amount of ore sold for its value in containing manganese nor ore sold for paint.

## ORES.

*Definition.* An ore is a mineral which contains a metal which can be profitably extracted for human use.

*Iron Ores.* We have already considered the two kinds of iron ore mined in the state (Specimens 27 and 28).

All this ore is used for iron, except a very little which goes into paint and is not included in the table. Most of the ore is not smelted near the mines since it is cheaper to carry the ore to the coal which is needed to smelt it than to carry the coal to the iron ore. The only iron furnaces in Wisconsin are at Milwaukee, Mayville, and Ashland, and the last uses charcoal as fuel.

### LEAD ORE.

*Specimen No. 29. Galena, Platteville, Grant Co.*

*Description.* The only mineral mined in the state for lead is galena or lead sulphide. Note the way in which it breaks into cubes.

*Distribution.* Galena is found in the Galena limestone where it was deposited by underground waters. The largest deposits were long ago discovered in Grant, Lafayette, and Iowa counties and have been for the most part worked out.

*Uses.* Lead is extracted from galena by heating to drive off the sulphur. Lead is used for weights, pipes, bullets, shot, type, acid-resisting vessels, paint, etc.

## ZINC ORE.

### *Specimen No. 30. Sphalerite, Platteville, Grant Co.*

*Description.* The minerals mined in this state for zinc are sphalerite or zinc sulphide and "drybone" or zinc carbonate. Compare the color and cleavage of sphalerite with galena.

*Distribution.* Sphalerite occurs associated with galena, but usually at greater depths below the surface. The carbonate of zinc is mined at shallow depths near Highland.

*Uses.* The mining of zinc now greatly surpasses that of lead in Southwestern Wisconsin. Sphalerite is smelted in much the same way as galena. At Mineral Point and near Benton the sulphur is driven off and converted into sulphuric acid. At Mineral Point zinc carbonate is burned and zinc oxide is made which is used for paint and in making automobile tires. Metallic zinc is used chiefly for covering iron to make galvanized iron, and for mixing with copper to make brass.

PRODUCTION OF LEAD AND ZINC ORES IN WISCONSIN, 1910-1916.

| Year | Lead | | Zinc | |
|---|---|---|---|---|
| | Tons | Value | Tons | Value |
| 1910 | 5,608 | $286,493 | 98,998 | $2,003,266 |
| 1911 | 4,359 | 229,465 | 94,501 | 1,820,162 |
| 1912 | 3,373 | 180,661 | 70,551 | 1,569,355 |
| 1913 | 2,532 | 125,197 | 51,361 | 1,035,313 |
| 1914 | 2,028 | 85,196 | 50,316 | 1,037,549 |
| 1915 | 3,175 | 171,091 | 141,575 | 5,381,539 |
| 1916 | 4.187 | 291,397 | 205,481 | 7,464,153 |