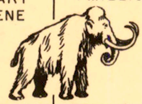
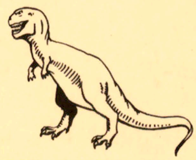
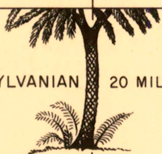
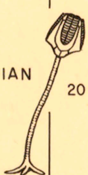
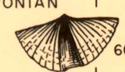
Let's Look at Some Rocks

by
William J. Wayne

Circular
No. 5

Indiana Department of Conservation
GEOLOGICAL SURVEY

1958

ERAS	PERIODS	APPROXIMATE LENGTH IN YEARS	ROCK TYPES IN INDIANA	PRINCIPAL MINERAL PRODUCTS
CENOZOIC	QUATERNARY (PLEISTOCENE EPOCH) 	1 MILLION	*Glacial drift: till, gravel, sand, silt (including loess), clay, marl, and peat (Till and gravel contain boulders of many kinds of sedimentary, igneous, and metamorphic rocks)* Thickness 0 - 500 ft.	*Sand and gravel Clay Marl Peat Ground water*
CENOZOIC	TERTIARY	60 MILLION	*Cherty gravels, Sand and clay* } *Scattered deposits* 0-80 ft.	*Glass sand*
MESOZOIC	CRETACEOUS JURASSIC TRIASSIC	70 MILLION 35 MILLION 30 MILLION	No deposits in Indiana 	
PALEOZOIC	PERMIAN	25 MILLION	No deposits in Indiana	
PALEOZOIC	PENNSYLVANIAN 	20 MILLION	*Shale (including carbonaceous shale), mudstone, sandstone, coal, clay, limestone, and conglomerate* 1,500 ft.	*Coal Ceramic clay, shale Oil and gas Crushed stone Building sandstone Refractory gravel*
PALEOZOIC	MISSISSIPPIAN 	20 MILLION	Upper Part: *alternating beds of shale, sandstone, and limestone* 500 ft. Middle Part: *limestone, dolomite; beds of chert and gypsum* 300 ft. Lower Part: *shale, mudstone, sandstone; and some limestone* 600 ft.	*Oil and gas Building limestone Crushed stone Gypsum Ceramic shale*
PALEOZOIC	DEVONIAN 	60 MILLION	Upper Part: *carbonaceous shale* 100 ft. Lower Part: *limestone, dolomite; a few sandstone beds* 40 - 80 ft.	*Oil and gas Crushed stone*
PALEOZOIC	SILURIAN 	40 MILLION	*Dolomite, limestone, chert, siltstone, and shale* 100 - 300 ft.	*Crushed stone*
PALEOZOIC	ORDOVICIAN 	70 MILLION 	*Shale, limestone, and dolomite* 700 ft. *Limestone, dolomite, and sandstone* } Not exposed at the surface in Indiana	*Crushed stone Oil and gas*
PALEOZOIC	CAMBRIAN	80 MILLION	*Sandstone and dolomite* } Not exposed at the surface in Indiana	
PRECAMBRIAN ERAS		3 BILLION	*Granite, marble, gneiss, and other igneous and metamorphic rock types* } Not exposed at the surface in Indiana	

GEOLOGIC TIMESCALE AND INDIANA ROCK CHART

STATE OF INDIANA
Harold W. Handley, Governor

DEPARTMENT OF CONSERVATION
E. Kenneth Marlin, Director

GEOLOGICAL SURVEY
Charles F. Deiss, State Geologist
Bloomington

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LET'S LOOK AT SOME ROCKS

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William J. Wayne

Illustrated by Robert E. Judah

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PREFACE

Rocks are made up of a mixture of minerals. Therefore you need to know what minerals and how much of each mineral are in a rock before you can give that rock a name. This has been an obstacle for the student of nature and natural science who just wants to give a rock he has collected a fairly accurate name without having first to study mineralogy.

Simple ways of identifying common species of birds, trees, flowers, and many other living creatures have long been available, but most geologists have not provided similar guides for identifying rocks. To help fill this need I have prepared this brief handbook as an aid in identifying most of the common rocks of Indiana. It does not mention the rarer Indiana rock types. My purpose is to help the beginning student of rocks take his first steps into the subject with a little more confidence. I hope the satisfaction that he may get from being able to identify most rocks he is likely to find in Indiana may awaken in the student of natural history an interest in more serious study of rocks, minerals, and fossils.

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FROM ROCKS TO SOIL

If you scrape up a handful of soil and look at it under a magnifying glass, you will see that it is made up of small grains of minerals and some bits of organic material. The plant material, of course, has been mixed into the soil from the top, where plants and animals live and die. But what about the mineral grains that you see? Where did they come from and how do they happen to be in the soil?

Perhaps you have seen an old iron or steel tool that has been left outside in the weather, unprotected, for many years. What does the surface look like? It is covered with a layer of rust. One of the materials in the air and in rainwater, the element oxygen, has combined very slowly with the iron at the surface of the tool and has changed it from the hard gray metal to powdery brown rust. But beneath this rust coating, the iron is just as sound as it was when the tool was new.

A similar thing has happened to the rocks that lie beneath the surface of the ground. Many times, during thousands of years, these rocks have been soaked by rainwater and have then dried. In the same way that the iron on the surface of the discarded tool changed to rust, the rocks at the surface have changed. They have been broken and some parts of them have dissolved and been carried away in the water; the material left behind we call soil. Because some rocks soak up water faster than others, and because some rocks crumble or dissolve faster than others, the thickness and character of the many different soils depend on the kinds of rock from which the soils were formed.

Just as you have to scrape away the layer of rust to see the fresh, unaltered iron of a rusty tool, you have to find a place where the soil layer has been scraped away to see fresh, unaltered rock. Places where streams have cut into their banks often provide good exposures of rocks. Road and railroad cuts, quarries, and pits are places where man has done the scraping. These are all good places for you to look for rocks.

When you are looking for rocks to collect and identify, you want to remember that some things you can find among the pebbles along a stream really are not rocks at all: worn bricks, concrete, slag from a steel mill, and broken glass will roll along in the water and after a while can get to look very much like natural pebbles. You should take your rock samples from fresh cuts along roads, creeks, pits, or quarries, or from large boulders.

Always be sure to ask the owner for permission to enter the property where you want to collect rocks. In active quarries, there is some danger from falling rock, especially during blasting. If the quarry manager knows you are in the quarry, he can warn you to get out before the blast.

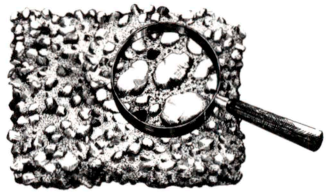
In southern Indiana you will see that solid rock is reached only a few feet beneath the surface in most places. In northern Indiana the solid, bedded rock is buried deeply beneath a thick blanket of ground-up rocks and boulders left by Ice Age glaciers that came out of Canada. So glacial mud, gravel, and sand lie beneath the soil in northern and central Indiana.

WHAT ARE ROCKS?

All materials that lie beneath the surface of the earth can be called rocks in the broadest meaning of the word. Many persons would rather use the word "rock" for only the hard materials, and not call the loose deposits rocks. Because this is so, we will use the words "rocks and rock materials" for the specimens, both solid and loose, that you are likely to find in Indiana.

Rocks and rock materials are mixtures of many mineral crystals, fragments, or grains. Nearly all rocks are composed of more than one substance. To separate rock types and to find out what to call them, you have to look at the particles that make up each rock and see what they are and how they fit together. The way the individual mineral crystals or fragments fit together is called "texture." The kinds of minerals that make up the rock are its "composition."

The individual mineral grains of all rocks fit together in one of two ways. Some rocks (most sedimentary rocks) were originally loose fragments or grains, such as sand or mud, that have been packed together and then cemented with some mineral like lime to become solid. Rocks in which the grains fit together like this generally can be broken rather easily and the grains separated. If you look at the rock through a magnifying glass, you can see spaces between some of the grains.



Other rocks are made up of mineral crystals that formed in a liquid (such as sea water or melted rock) until their edges became interlocked with the edges of other crystals. Rocks with this kind of texture generally are tough and hard to break. When you break a rock of this type, you will see that most of the individual mineral grains have split. A similar pattern can often be seen on the surface of of galvanized steel.

KINDS OF ROCKS

Because not all rocks were formed in the same way, geologists have grouped rocks into three broad classes based on their origin: sedimentary, igneous, and metamorphic. *Sedimentary rocks* are formed by the accumulation and burial of gravel, sand, mud, lime, and plant and animal remains. All rocks at the surface in Indiana except some of the boulders in the glaciated part of the State are sedimentary rocks. *Igneous rocks* are formed when melted rock material from deep beneath the earth's surface cools and becomes solid. *Metamorphic rocks* are formed by the alteration of other rocks deep within the earth.

SEDIMENTARY ROCKS

Everywhere that rocks are exposed at the surface of the earth, the forces of nature break them down into small pieces, and eventually they become soil. Streams that flow across the rocks pick up loose pieces and carry them along. These pieces of rocks serve as grinding tools in the stream bed to wear away more of the rocks that they roll across.

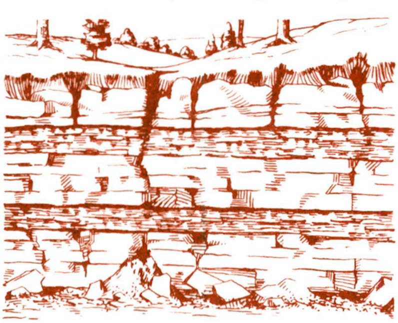
You will find that the largest and heaviest rock fragments are dropped where the stream current slows down. As the current flows slower, only the finer particles are carried along. Eventually the stream reaches a lake or bay where the water is so quiet that even the smallest particles settle out. These fragments of rocks that are carried and deposited are called *sediments*. Sediments may be deposited by water, wind, or ice.

Sediments are piled up in layers or strata. As the deposit grows thicker by the addition of more layers on top, the loose grains are packed tighter together. Water that contains dissolved minerals moves slowly through the open pore spaces of a loose sediment. Some of these dissolved minerals are left behind as a cement that binds the loose grains together. In this way sediments that were once soft and loose become hard and solid.

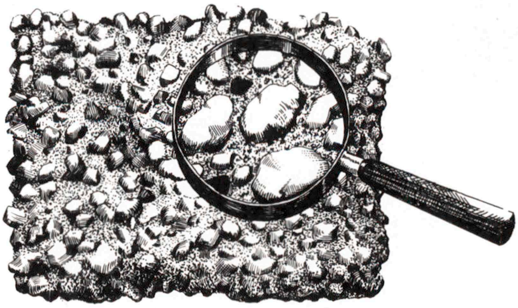
Sedimentary rocks can be separated into three main groups: fragmental, chemical, and organic. Fragmental rocks are made up of the broken pieces of other rocks that have been transported and redeposited. The name given to a particular fragmental rock depends on the size of the fragments that make it up.

Rocks and rock materials that are made up mostly of worn, rounded pebbles with smaller grains filling the spaces between the pebbles are called *gravel* if they are loose and *conglomerate* if they are cemented. Gravel is used in road construction and in making concrete. Almost all the gravel in Indiana was left by Ice Age rivers.

Sand is a sediment made up of grains about the size of granulated sugar. The largest sand grains are about as big as the lead in an ordinary pencil (2 millimeters). The smallest sand grains are just big enough to see without using a magnifying glass (0.05 millimeter). Quartz is the most common mineral found as a grain of sand. Sand that is solid or hard is called *sandstone*. Sand-



stone with lime for a cement to bind the grains together is called a limy (calcareous) sandstone. Sand is used in mortar, concrete, and plaster, and special kinds of sand are the raw material used in manufacturing glass. Sandstone is also quarried for building stone.

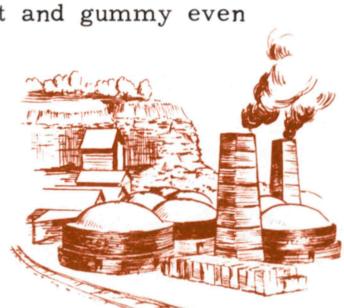


FRAGMENTAL TEXTURE (CONGLOMERATE)

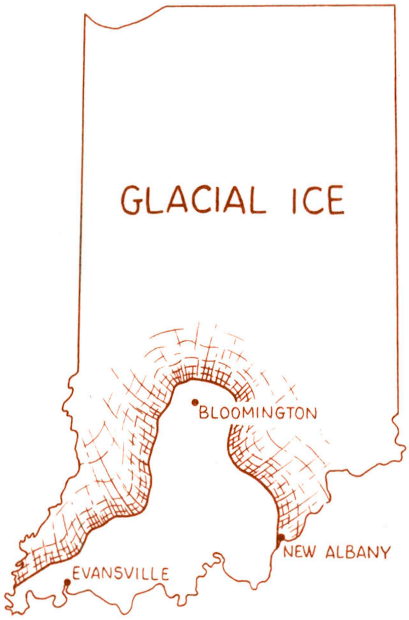
Silt and *mudstone (siltstone)* are made up of very small (dust size) particles. You probably will not be able to see the individual grains without a magnifying glass. Most silt grains are the mineral quartz. Quartz is hard; therefore, a piece of mudstone or a chunk of silt will be very gritty if you touch it to the edge of your teeth. If silt grains become cemented together they form mudstone. Mudstone and very fine-grained sandstone have been used to make whetstones and grindstones. Thick layers of silt were deposited by the wind on the bluffs along the Wabash and Ohio Valleys during the Ice Age. These silt deposits (called "loess") are rich in lime and contain fossil snail shells.

Clay and *shale* are made up of extremely small particles. Clay is ordinarily soft and gummy when it is wet, but when it is dry it is hard enough for you to confuse it with shale. Clays and clay shales are slippery or "soapy" to the touch and do not grit if you rub them against the edge of your teeth. You can find a complete gradation of grain sizes in all fragmental sediments, though, so many clays and shales are likely to have a little gritty material in them. Rocks that have clay in them will smell "earthy" if they are moistened slightly. You can moisten the rock enough to get this odor by breathing on it and then quickly lifting it to your nose. Both mudstone and shale ordinarily have enough clay in them to give this "earthy" odor.

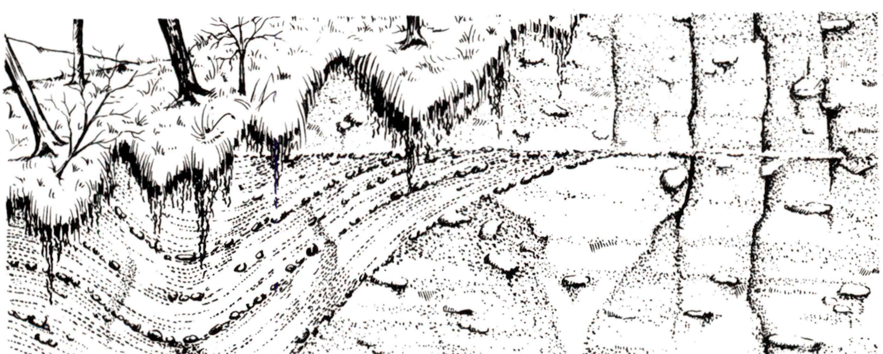
On a surface exposed to the weather, mudstone (siltstone) generally breaks off in large slabs or chunks that stay solid for a long time, but shale splits into thin layers and flakes and, after a few rains, turns into mud. Clay becomes soft and gummy even more quickly than shale if it is wet. Both clay and shale are used in Indiana as raw material for making brick and tile.



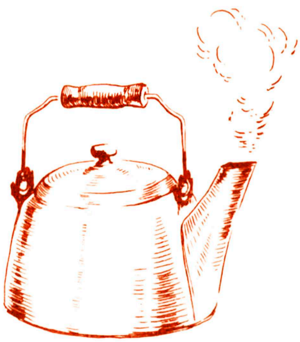
During the Ice Age, glaciers covered about five-sixths of Indiana. When the glaciers melted, they dropped the boulders and ground-up rocks (rock flour) that they had picked up and carried. This mixture of boulders, pebbles, sand, silt, and clay is called *till;* it is the rock material that lies beneath the soil over most of northern and central Indiana. Where it has not been changed by exposure to air and water, it is a gray to brown rock flour that is studded with sand and pebbles and contains scattered boulders. Because some of the rock flour is ground-up limestone, till effervesces (foams) if acid is dropped on it.



Almost all bedrock formations in Indiana are made up of layers that are uniform in thickness and character. In many places these individual rock beds can be followed from one outcrop to the next without any really great change. Glacial sediments, though, are much less regular. A till or gravel bed may be 10 feet or more thick at one end of a stream bluff but pinch out completely at the other end a few hundred feet away.



Some sedimentary deposits are formed by chemical processes. If water in the sea or a lake contains dissolved lime (calcium carbonate), some of this material may be deposited as lime mud on the bottom. A similar process takes place when hard water is boiled in a teakettle. Lime mud on the bottom of a shallow sea eventually hardens to become *limestone*.

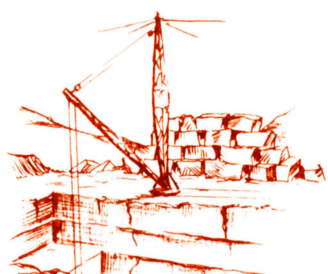


Some limestones are made up mostly of shells of fossil animals. These are called fossiliferous limestones. Other limestones are made of small rounded grains of lime (called *oolites*, because they look like fish eggs) that have been cemented together. These are oolitic limestones. Many lakes in northern Indiana are now being filled with *marl*, a soft white lime mud formed by millions of tiny plants in the water that cause lime to be deposited where they grow.

Limestone is a soft rock (you can scratch it with a knife). It can be almost any color, even black, or brown, or white, but usually it is some shade of gray. It foams (effervesces) rapidly when a drop of dilute muriatic acid is placed on it. *Dolomite* is a rock formed in much the same way. Dolomite can be distinguished from limestone because it effervesces very slowly in acid. Most dolomites effervesce a little faster, though, if you put a drop of acid on a small piece of the rock that you have crushed to powder. Some of the lime rocks in Indiana are partly limestone and partly dolomite. These you can call *dolomitic limestone*.

FOSSILIFEROUS LIMESTONE

Limestone is a most useful rock. It is a basic ingredient of cement and is crushed and mixed with cement to make concrete. Crushed limestone also has been used to surface thousands of miles of roads. Of course, one of the most important uses of crushed limestone is to "sweeten" an acid soil. Limestone is very important as a building stone. Indiana is world-famous for its excellent building limestone.



Some sandstones, mudstones, and shales

effervesce a little with a drop of acid because they have a lime cement between the grains. If you find a rock like this, you can call it a "limy sandstone" or "limy shale."

Another rock that is formed as a chemical deposit from sea water is *gypsum*. Gypsum is even softer than limestone (you may be able to scratch it with your fingernail) and looks much like limestone, but it does not effervesce in acid. Gypsum is not common in Indiana at the surface, but it is being mined in southern Indiana. It is used in manufacturing plaster and plasterboard.

Chert (or *flint*) is the common fine-grained sedimentary rock in Indiana that is harder than a knife blade. Chert is brittle and almost always breaks with square, sharp edges. Because of this quality of breaking or flaking with sharp edges, it was a favorite material used by Indians to make scrapers and arrowpoints. Most chert is gray, but it can be brown, or black, or even red. Some chert may contain parts of fossil animals. You may find chert as layers, as knot-shaped masses in limestone, or as loose chunks in glacial drift. It is a common rock and can be found nearly everywhere in the State.

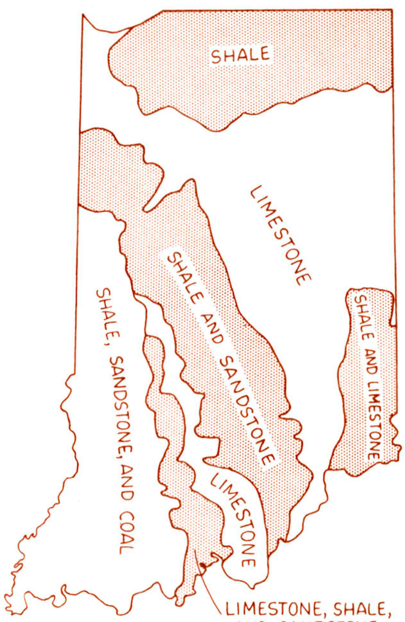
Some of the most attractive rocks that a collector can pick up in Indiana are also hard, like chert. These are knobby or rough-surfaced balls, called *geodes*, that form in small cavities in some limestones and shales. Many geodes never get completely filled but remain hollow at the center. Hollow geodes may contain beautiful crystals. Quartz and calcite are the most abundant minerals in geodes, but many other minerals have been found. In southern Indiana, geodes can be found in Mississippian rocks.

Whole or broken geodes are found in many places in glacial drift in northern Indiana. Because geodes are hard and do not wear away quickly, stream beds and gravel banks are good places to look for them.

Some sedimentary rocks can be burned. These rocks are soft and normally are dark brown or black. They are made up of plant remains and may or may not have some clay or silt in them.

Coal is a soft black rock that contains bands of shiny and dull material and is found in layers a few feet thick or less in southwestern Indiana. The coal mined in Indiana has a greater value than any other mineral commodity in this State, but it is not an important soil-forming rock. *Peat,* found in many of the bogs of northern Indiana, is the matted remains of plants and is the first stage in the formation of coal. *Muck* is a black sediment made of small particles of plant debris. It may contain some silt or clay. Both peat and muck are soil-forming materials in Indiana. *Bituminous shale* is a clayey or silty rock that contains enough plant material to burn slowly. It is ordinarily black and, when fresh, can resemble slate. It weathers into small flakes much more quickly than slate, however.

Except for some boulders in glacial drift, all the rocks and rock materials you will find at the surface in Indiana were deposited as sediments. The bedrock formations in southern Indiana were all sands and muds deposited in a shallow sea. These sediments became thicker and thicker. About 200 million years ago they rose above sea level. Since that time streams have been flowing over these sedimentary rocks and have eroded them.



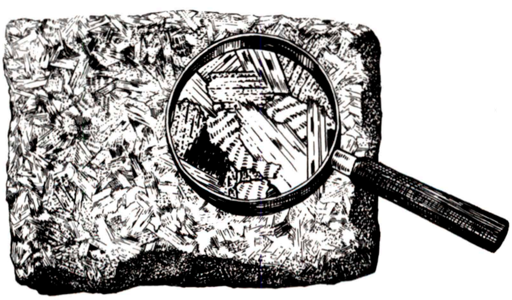
The rocks in Indiana lie so nearly flat that you probably will not see that the layers are tilted ever so slightly toward the southwest. They dip about 30 feet lower in every mile. Because of this dip, each kind of rock crops out in a belt that runs from northwest to southeast. The oldest rocks are at the east edge of the State, and the youngest rocks are in southwestern Indiana.

North of the glacial boundary, though, this bedrock is covered in many places by a thick blanket of glacial drift. For this part of the State a bedrock geologic map shows the kind of rock that a well driller finds directly below the deposits of the Ice Age. Large, detailed geologic maps of Indiana that show where the bedrock formations and glacial sediments are found can be obtained from the State Geological Survey.

IGNEOUS ROCKS

Igneous rocks were originally hot, molten material but have cooled and become solid. Because of the way they were formed, igneous rocks are made up of crystals of different minerals that have grown together and become interlocked, much like the pieces of a jig-saw puzzle. They are generally heavier, harder, and tougher to break than most sedimentary rocks. Igneous rocks lie below several thousand feet of sedimentary rocks in Indiana. The only igneous rocks at the surface are found as boulders in the glacial drift. They were brought here from Canada by glacial ice.

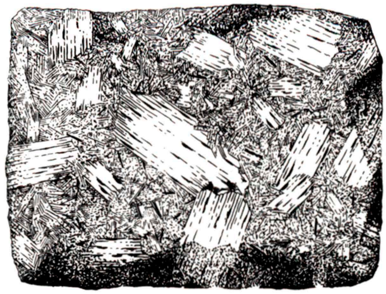
When igneous rocks cool and become solid, crystals of minerals begin to form in the hot, molten rock material. As the material continues to cool, the individual mineral crystals become larger until the edges of crystals meet and interlock with one another. The crystals eventually fill all the space that was fluid rock material, and a solid igneous rock is formed. The arrangement of the individual crystals that results when a rock forms in this manner is called "crystalline texture."



CRYSTALLINE TEXTURE (GRANITE)

Some igneous rocks were still deep within the earth when they began to cool and become solid. Because these rocks cooled slowly, the individual crystals in the rock had a chance to grow large. Other igneous rocks cooled quickly because they were much nearer the surface of the earth. When molten rock solidifies rapidly, many more crystals are formed than when it cools slowly. These mineral grains are so tiny that they cannot be seen without a microscope. The rocks that cooled slowly are "coarsely crystalline," and the igneous rocks that cooled quickly are "finely crystalline" ("microcrystalline").

Some igneous rocks contain a few large crystals scattered through the mass of much smaller crystals. A rock of this kind is said to be porphyritic. Many microcrystalline rocks are porphyritic and contain some scattered crystals barely large enough to see and identify, but the spaces between these visible crystals are filled with dull-looking rock.



PORPHYRITIC TEXTURE

Most of the igneous rocks you will find in the glacial drift of Indiana are made up entirely of crystal grains that are big enough to see easily. If you look at a freshly broken rock surface, you can see that most of the minerals have broken or split with a smooth surface and reflect light easily.

Identification of igneous rocks becomes scientifically accurate if a few diagnostic minerals are learned. Most of the references at the end of this brochure will help you in learning to recognize minerals.

The most common of the coarse-grained igneous rocks is granite. *Granite* is made up of the minerals feldspar and quartz, and most granites contain a few grains of dark minerals. The quartz and feldspar are light-colored minerals; as a result granites are generally light-colored rocks. Many monuments and grave markers are made of granite, and polished granite facing is used on many buildings.

Diorite looks like granite in many ways but ordinarily is a darker colored rock. Diorite is made up mostly of lime-rich feldspar and contains almost no quartz. Usually about a fifth to almost half of the rock will be dark iron-rich minerals.

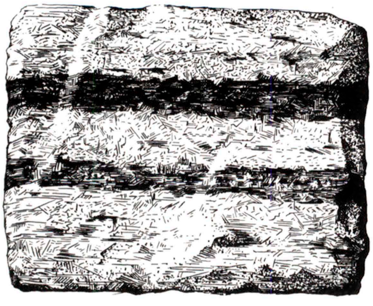
Gabbro is a dark-colored coarse-grained igneous rock that is made up mostly of dark minerals such as hornblende or augite. The lime-rich feldspar makes up less than half the rock. Even the feldspars in gabbro are darker in color than the feldspars in diorite. Gabbro is fairly common in the glacial drift in Indiana. The iron- and lime-rich minerals weather more quickly than quartz, so gabbros break up into soil particles faster than granites.

The finely crystalline (microcrystalline) igneous rocks are made up of crystals too small to see. Geologists have given names to many varieties of these microcrystalline igneous rocks. For our purpose, color can serve to separate the microcrystalline rocks found in Indiana. Dark-colored microcrystalline igneous rocks are called *basalt*, and light-colored microcrystalline igneous rocks are called *felsite*. Both felsite and basalt are found in some places in the glacial drift, but neither is a really common rock in Indiana.

Glass is formed by cooling melted rock materials very quickly. The cooling is so rapid that crystals do not form. Igneous rocks that are poured out on the surface, like some volcanic rocks, cool quickly and are natural glass. Although no glassy igneous rocks are found in Indiana, and none are included in the key, obsidian and pumice, relatively common in some parts of western United States, are rocks of this type.

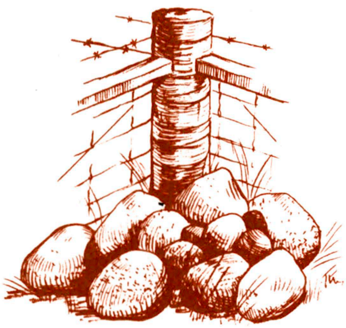
METAMORPHIC ROCKS

Metamorphic rocks are rocks (originally either sedimentary or igneous) that have become buried deep within the earth and then have been altered, chiefly by heat and pressure, while they were buried. Some metamorphic rocks (such as quartzite and tillite) have been changed only a little, and their original form can still be recognized. Others (for example, gneiss and schist) have been changed so much that their original characteristics are completely destroyed. Individual mineral crystals of metamorphic rocks fit together tightly, and many of them develop interlocking crystals such as the igneous rocks have. Many metamorphic rocks appear to have "grain"; that is, the mineral grains are lined up parallel to each other. Some metamorphic rocks are tougher to break than any other kind of rock you will find, but others break up rather easily. In Indiana, metamorphic rocks are fairly abundant as boulders in glacial drift, but they are not found elsewhere at the surface in the State.



BANDING OR "GRAIN" (GNEISS)

Among the glacial boulders in Indiana, *quartzite* probably is more abundant than any other metamorphic rock. Quartzite is a hard, dense rock that has formed from fusing the grains of a sandstone. Quartzites are harder and tougher than sandstones. If you break a piece of sandstone, the cement that binds the grains together cracks and the fracture goes around the sand grains. In quartzites, the bond between the grains is so hard that a fracture goes through the grains rather than between them. The surface of a piece of freshly broken quartzite looks much like broken glass. If you look closely, though, you should be able to make out the individual grains that are in the rock.



Some quartzites are made up almost entirely of the mineral quartz, and many of the quartzite boulders in Indiana are this kind. Other quartzites are impure and contain other minerals. The lime, clay, iron oxides, and other minerals that are in sandstones have become recrystallized during metamorphism and result in such minerals as feldspar, mica, hematite, and many others. If one of these minerals is abundant enough to be noticeable, it can be used in the name of the rock--for example, micaceous quartzite or feldspathic quartzite.

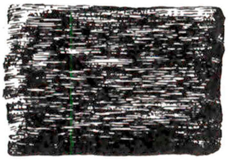
Quartzites are extremely resistant to weathering and break down slowly. For this reason quartzite boulders are found in the upper parts of the soil where nearly all other rock types have disappeared.

A fairly common metamorphic rock in the glacial drift in Indiana is *tillite*. Tillite is heavy and very tough, very fine grained, and dark greenish gray. Most tillite contains pebble-sized chunks of granite or some other igneous or metamorphic rock. A pebble of tillite that does not contain fragments of other kinds of rocks may look so much like basalt that even a person experienced in identifying rocks may have trouble telling them apart.

Slate is a fine-grained metamorphic rock that is formed when pressure changes some of the clay minerals in shale to microscopic flakes of mica. It is the first stage in the conversion of a shale to some coarse-grained rock like schist. The flakes of mica are all arranged parallel to each other and make it

possible for slate to be split into thin sheets. They also give it a toughness and durability that shale does not have. The slate used for blackboards and for roofing in Indiana has been brought from quarries in the eastern part of the United States. Slate is not found in the bedrock formations of southern Indiana and is rare among boulders in the glacial drift.

Schists are fairly common among glacial boulders in Indiana. Most of the individual mineral grains in a schist are large enough to be visible. The rock has a banded or "foliated" appearance because it is made up of platy, cleavable minerals arranged parallel to each other. Usually only one platy mineral is abundant in any schist, but others may be present. The most common platy minerals you are likely to find are mica and hornblende. Nonplaty minerals such as quartz and garnet also are found in schists but are not as abundant as the platy minerals. The name of the most abundant mineral is used in naming a schist. So we may have a mica schist, a hornblende schist, or a garnet schist.



SCHIST

The platy minerals in schists split easily, and their arrangement permits the rock to be broken into smaller fragments. Because of this weakness, boulders of schist do not make good stone for building, and schist pebbles in gravel may make the gravel undesirable for concrete.

Gneiss (pronounced "nice") is a metamorphic rock that is made up of bands of granitelike rock separated from each other by bands of rock that are distinctly different. The individual bands may be thick or very thin. Many gneisses have thick, light-colored bands of quartz and feldspar that are separated from each other by thinner parallel schistose bands of dark platy minerals. In some gneisses the bands may be irregular and twisted.

Gneiss is one of the common kinds of rock found in Canada, and the gneisses in the glacial drift in Indiana came from there. Most of the boulders of gneiss in Indiana contain quartz and feldspar in the light-colored granular bands and black mica (biotite) or hornblende in the dark bands. Both mica and hornblende are platy minerals that split easily in one direction. This direction of splitting is parallel with the bands, so gneisses break easily along the bands of platy minerals. Names for the different kinds of gneisses depend on the main minerals that make up the rock. For example, a gneiss with abundant hornblende is called a hornblende gneiss.

There is a complete gradation between gneiss and schist, and it is possible that you will find rocks on the borderline between a gneiss and a schist. For such a rock, either name is acceptable.

Feldspars and the dark minerals biotite and hornblende weather much more quickly than quartz. Even though gneiss is a resistant, hard, dense rock, it does break up more rapidly than quartzite. Gneiss is an attractive rock that is often used for headstones in cemeteries.

When limestone is placed under the kind of heat and pressure that form gneiss and schist, the calcite (calcium carbonate) crystals become larger. The rock becomes granular like a granite, but it is made mostly of one mineral, calcite. Such a recrystallized, metamorphosed lime rock is called *marble*. Marble is rare in the glacial drift in Indiana. It is quarried for building stone in many eastern states.

KEY TO THE COMMON ROCKS OF INDIANA

A key is a series of clues that are intended to guide you through some of the things you must observe before you can give a name to an unknown rock or rock material. The following key is constructed in the form of an outline. In it you will find descriptive statements about some of the more obvious properties of rock structure, texture, and color, along with a few simple tests on the physical properties of rocks and the minerals in them. A list of the equipment you will need to make these tests is on page 30.

This key has three main parts: Part I, the Coarse-grained Rocks; Part II, the Fine-grained Rocks; and Part III, the Organic Rocks. First you have to examine your unknown rock and decide which of the statements in the outline key fits your rock best. Then turn to that part.

To use the key, you choose between contrasting statements that describe some feature or property of the rock. Each set of contrasting statements begins the same distance from the left margin of the page and is numbered or lettered. Read both statements in order to make your choice (no straddling allowed). Inset beneath one or both of this first pair of statements is another pair of contrasting statements. This plan is repeated until the accumulated descriptions fit a rock type. When you reach a name for your unknown rock, you will also be referred to the page where that rock is described more completely so you can check it.

Because rock types grade into one another, completely clear distinctions are not always possible. This gradation between rock types makes it extremely difficult, practically impossible, to construct a perfect key. The effort here has been to keep the key as brief and simple as possible, yet to include most of the common rocks and rock materials found in Indiana.

OUTLINE KEY

Rocks or rock materials made up partly or entirely of plant remains; will burn; black to brown color - Part III (Organic rocks)

Rocks or rock materials with little or no plant remains; will not burn; any color, rarely black

Individual rock particles (grains, crystals, fragments) large enough to be seen - - - - - Part I (Coarse-grained rocks)

Individual rock particles (grains, crystals, fragments) too small to be seen - - - - - - - - - - Part II (Fine-grained rocks)

KEY

PART I (COARSE-GRAINED ROCKS)

I. Individual rock particles (grains, crystals, fragments) soft enough to be scratched by a knife blade

A. Does not fizz in dilute muriatic acid (HCl); can be scratched with your fingernail; does not contain fossils - - - - - - - Gypsum (p. 14)

B. Fizzes in dilute acid; cannot be scratched with your fingernail; may contain fossils

1. Fizzes very slowly in dilute acid, but a little faster if a piece of rock is powdered - - - - - - - - - - - - - - - - - Dolomite (p. 13)

2. Fizzes quickly in dilute acid - - - - - - - - - - - - - Limestone (p. 13)

II. Individual rock particles too hard to be scratched by a knife blade (instead, the grains will scratch the steel blade or a piece of glass)

A. Rock composed of particles (crystals) that interlock (crystalline texture, p. 16)

1. Crystals or particles oriented in one direction (like the "grain" of wood)

a. Nearly all crystals or grains have parallel arrangement or orientation - Schist (p. 20)

b. Some crystals arranged in bands - - - - - - - - - - Gneiss (p. 20)

2. Crystals or grains not oriented in any particular direction

a. Color light gray, pink, or tan (only a few dark-colored grains) - Granite (p. 17)

b. Color medium gray - - - - - - - - - - - - - - - - - - Diorite (p. 17)

c. Color dark (green to nearly black) - - - - - - - - Gabbro (p. 17)

B. Rock or rock materials composed of particles that do not interlock (fragmental texture, p. 10)

1. Particles not uniform in size; a mixture of pebbles and smaller particles

a. Solid rock; particles cemented together - Conglomerate (p. 10)

b. Rock material; compact but not cemented - - - - - - Till (p. 12)

c. Loose rock material; neither cemented nor compacted - Gravel (p. 10)

2. Particles fairly uniform in size: smaller than 2 mm (0.08 in.) but larger than 0.05 mm (0.002 in.), or about the size of grains of sugar

a. Loose rock material; not cemented - - - - - - - - - - Sand (p. 10)

b. Solid rock; cemented

(1.) Rock breaks around grains - - - - - - - - Sandstone (p. 10)

(2.) Rock breaks across grains - - - - - - - - Quartzite (p. 19)

PART II (FINE-GRAINED ROCKS)

I. Rock hard, cannot be scratched with a knife blade (instead, the rock will scratch the steel blade or a piece of glass)

A. Brittle, very sharp corners and edges left when broken or chipped - Chert (p. 14)

B. Tough and difficult to break; no knife-sharp edges formed when broken (may contain scattered crystals or fragments large enough to see)

1. Color light (gray, pink, or tan) - - - - - - - - - - - - - Felsite (p. 18)

2. Color dark (greenish gray to greenish black)

a. Contains fragments of other kinds of rocks - - - Tillite (p. 19)

b. Does not contain fragments of other kinds of rocks -Basalt (p. 18)

II. Rock or rock material soft enough to be scratched or cut with a knife blade

A. Smells "earthy" when moistened with the vapor from your breath

1. Rock material not entirely fine grained, but contains scattered pebbles and sand - Till (p. 12)

2. Rock or rock material uniformly fine grained

a. Rock material does not feel gritty when rubbed against the edge of your teeth - - - - - - - - - - - - - Clay (p. 11)

b. Rock or rock material does feel gritty when rubbed against the edge of your teeth

(1.) Loose; not cemented; powdery when dry - - - Silt (p. 11)

(2.) Solid; breaks into thin platy fragments - - - Shale (p. 11)

(3.) Solid; does not break into thin platy fragments - - - - - - - - - - - - - - - - - - - Mudstone (p. 11)

B. Does not smell "earthy" when moistened with vapor from your breath

1. Soft; not solid; gummy when wet and chalky when dry - Marl (p. 13)

2. Solid; makes a ringing sound if tapped with a hammer

a. Will split into thin sheets or slabs; does not fizz under a drop of muriatic acid (rare in Indiana) - - - - - - Slate (p. 19)

b. Will not split into thin sheets or slabs; fizzes under a drop of muriatic acid

(1.) Fizzes freely in acid - - - - - - - - - - - Limestone (p. 13)

(2.) Fizzes very slowly in acid, but a little faster if a piece of rock is powdered - - - - - - Dolomite (p. 13)

PART III (ORGANIC ROCKS)

I. Soft; not solid; very light in weight when dry

A. Plant fragments coarse; large enough to be recognized - - -Peat (p. 15)

B. Plant fragments small; not recognizable - - - - - - - - - - - - Muck (p. 15)

II. Hard; solid; fairly heavy

A. Contains bands of shiny and dull material; burns well - Coal (p. 15)

B. Does not contain shiny bands; burns slowly and poorly - Bituminous shale (p. 15)

HOW TO MAKE A ROCK COLLECTION

Rock collections are made for many different purposes. The size and arrangement of the specimens in any particular collection depend greatly on the purpose for which the collection is made. Large samples (trimmed to about 3 x 4 x 1 inches) are desirable for collections that will be studied in a classroom or mounted for museum display. Specimens this size are too large for use in a portable exhibit and generally require a cabinet and trays for storage. Small specimens (not larger than 1 x 2 x 1/2 inches) are often used in portable collections or displays because they require less space for storage and are not so heavy.

Small display collections can be mounted on a piece of stiff cardboard, plywood, or masonite with wire or glue (such as Duco cement or iron glue). The main disadvantages of this kind of collection are: (1) new materials cannot be added readily and (2) the specimens cannot be removed easily for detailed examination once they are fastened to the board. It serves well, however, to develop interest in the study of rocks and makes an attractive classroom exhibit in science and natural history for elementary or secondary school work and for scouting organizations and similar groups.

If you make a collection, you will want to identify and label the specimens. This will give you some practice in recognizing the characteristics of the common rocks and also can provide you with a set of some of the common rocks that you can display. Names for most of the rocks you will be able to collect in Indiana can be found in the key here. A list of reference books that may be helpful in identifying rock specimens is given at the end of this brochure. You can find some of these books in most local libraries.

For convenience, you can mount a small collection by gluing the specimens to a sheet of heavy cardboard. The label can be glued directly beneath each rock specimen. A collection of twelve 1 x 2 x 1/2 inch specimens, with labels, can be mounted on a piece of heavy cardboard 8 1/2 x 11 inches in size. Neatly trimmed rock specimens make a most attractive display.

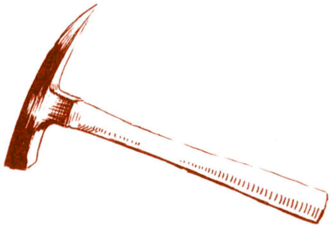
In order to have value as a geological collection, every specimen must have a label that carries essential information about the specimen. Ordinarily, this includes: (1) a name identifying the rock, mineral, or fossil, (2) the location from which it was collected, (3) the rock unit or formation from which it was collected, and (4) the name of the collector and date. The more accurately and completely these data are recorded, the more useful the specimen will be in a collection.

Several methods of labeling have been used successfully. In the field, each sample can be wrapped separately with its label, or a number can be written on adhesive tape and stuck to the sample and a description written beside the corresponding number in a notebook. In a large collection, a small white enamel circle or square is usually painted on a corner of each specimen; then either the necessary note or a number is lettered on it with india ink. Additional information is recorded in a catalog or on a card file. A coat of shellac or clear fingernail polish will prevent the painted label from chipping and becoming illegible. A small mounted collection can be labeled adequately by printing the pertinent information on a card and pasting it beneath each specimen. An example of such a label might look like this one:

FOSSILIFEROUS SHALY LIMESTONE
UPPER ORDOVICIAN (CINCINNATIAN) ROCKS
LAUGHERY CR. BANK, VERSAILLES, INDIANA
COLL. BY J. I. JONES, 6-12-57

EQUIPMENT YOU WILL NEED

Hammer

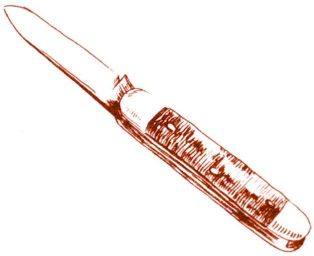


A prospector's pick or a mason's or bricklayer's hammer with a square face and either a pick or a chisel will be most useful. Any hammer will do if this kind is not available, though. The pick end is helpful in prying or digging chunks of rock (or fossils), but should not be used to strike a hard rock. You can trim rock samples by striking around the edges with a hammer.

Chisel

An ordinary cold chisel about 6 inches long with an edge about one-half to three-quarters of an inch wide is frequently a handy tool to use when collecting rocks, fossils, or minerals.

Knife



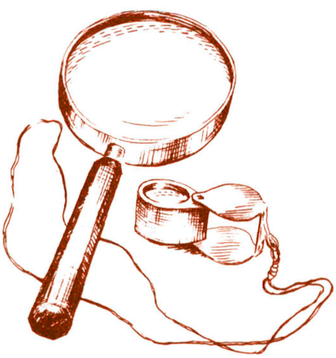
A pocket knife is necessary to test the hardness of the rocks and minerals. A knife is also helpful in digging fossils or mineral crystals out of soft rocks.

Acid

A small dropper-bottle filled with dilute hydrochloric acid (HCl) is needed to test certain rocks for the presence of lime (calcium carbonate). Empty dropper bottles, 1- or 2-ounce size, cost from 10 to to 25 cents at most drug stores. You can also purchase *dilute (10 percent) muriatic acid* from a druggist. Keep the acid in a well-marked storage bottle out of reach of small children and refill your small dropper bottle from it when necessary. Just a single drop of acid is all that you need each time you test a rock to see if it contains lime.

WARNING: Muriatic (hydrochloric) acid is one of the strong acids and can be dangerous if it is used or handled carelessly. Be sure all bottles of this acid are plainly marked so that no one is likely to mistake it for something else. NEVER leave it where small children might touch it. If you should get any on your skin or clothes, rinse it off with clean water as soon as possible.

Lens



A hand lens or magnifying glass is necessary for examining small mineral grains in rocks. Lenses which have a magnifying power between 8X and 12X are most useful, but a lens which has a lower magnification will often prove adequate.

Collecting bag	A large cloth bag, such as a musette bag, is most useful to carry specimens in the field. To prevent breakage or mixing of specimens, small paper bags or sheets of newspaper make handy wrapping material for field use.
Notebook	Some type of notebook for recording observations and other pertinent information should be carried in the field on a geological excursion. A fairly hard pencil (H or 2H) stays sharp reasonably well and will not smear as readily as softer pencils.
Labels	All specimens should be labeled at the time they are collected; for convenience, the label can be a piece of paper wrapped with the specimen, or it can be a piece of adhesive tape stuck to the rock, mineral, or fossil.

SOME USEFUL REFERENCES ON ROCKS AND MINERALS

Boy Scouts of America Merit Badge Series pamphlet on "Geology." Can be purchased from local Boy Scout Supply Store or Council Headquarters office. (25 cents)

This pamphlet is brief, but it is written at a level easily understood by Junior High students. It includes rock and mineral charts, but without additional help it will not be adequate for identification purposes. A good list of books is included at the end.

Cormack, M. B., 1950, The first book of stones: 93 p., illus., New York, Franklin Watts, Inc.; republished by D. C. Heath and Co., Boston.

Written especially for young people, this small book includes interesting details on a few of the more common rocks and minerals. This is a good introduction to collecting.

Greenberg, S. S., Bundy, W. M., and McGregor, D. J., 1958, Guide to some minerals and rocks in Indiana: Ind. Geol. Survey Circ. 4, 60 p., 6 figs., 5 tables. (25 cents)

This semitechnical guide to minerals and rocks of Indiana includes a diagnosis of the physical and chemical properties of minerals a collector is most likely to find in Indiana, as well as some of the more unusual and rare ones. One hundred and ten localities where minerals can be collected from the bedrock formations are listed by counties and indexed by minerals. The key to 30 minerals will be helpful to the amateur mineralogist. Tables provide handy guides to rock identification, and the text includes a brief description of each rock type.

Hawkins, A. C., 1935, The book of minerals: 161 p., 5 pls., 62 figs., New York, John Wiley & Sons, Inc.

Written for amateur mineralogists, this book contains a good section on how and where to collect. Most of the mineral descriptions are concise. Perhaps some are a little too brief, although really common minerals are given somewhat longer discussion.

Loomis, F. B., 1923, Field book of common rocks and minerals: 352 p., 73 pls., New York, G. P. Putnam's Sons.

This is a good summary of common minerals and rocks for collectors. The mineral section contains fewer minerals and somewhat less information regarding just what to look for to identify a mineral than the section in Pough (Field Guide to Rocks and Minerals, Peterson Guide Series) but more space is devoted to rocks and rock types. It is a good guide for a beginning rock collector, though, and for many years was the only good book of its kind available. Many local libraries have copies.

Marple, M. F., and Brown, W. C., 1955, Handbook for teachers of earth science: Ohio Geol. Survey Inf. Circ. 15, 61 p., 15 pls. (50 cents)

This guide, which can be purchased from the Ohio Geological Survey, The Ohio State University, Columbus 10, Ohio, was prepared primarily to introduce elementary and secondary school teachers to some of the fundamentals of geology and to suggest means of adding it to the science courses they teach. A brief summary on how to identify minerals is combined with a key to about 25 common minerals. Sections are included on rocks, fossils, earth history, landscape, mineral wealth, how to set up a field trip, and an outline of six geological field projects for class use. A useful list of references can be found at the end.

Pearl, R. M., 1955, How to know the minerals and rocks: 192 p., 8 pls. of minerals in color, 29 figs., unnumbered text figs., New York, McGraw-Hill Book Co., Inc. ($3.75); reprinted by The New American Library of World Literature, Inc., as Signet Key Book KD 346. (50 cents)

This is an elementary field guide to the recognition of minerals and rocks. Twenty-one pages of this handbook are devoted to a general discussion of the occurrence of rocks and 10 pages on how to make a mineral collection. Keys and brief descriptions to assist in identifying 105 minerals and 22 rocks make up the body of the book. The descriptions include all the important rock-forming minerals and many of the gems and ore minerals likely to interest a collector.

Pough, F. H., 1953, rev. 1955, A field guide to rocks and minerals: 33 p., 44 pls., 34 figs., Boston, Houghton Mifflin Co. ($3.95)

Issued as one volume in the Peterson Field Guide Series, this well-illustrated handbook is intended for the serious collector. It may be a little advanced for one who has not had the opportunity to get some training in science. Sections of the book are devoted to how to collect and how to identify by fairly simple field and laboratory tests used regularly by geologists; it also discusses the classification of rocks and tells where to find rocks and minerals. The book contains a glossary and an index. It is an excellent comprehensive reference manual for any library, one which will increase in usefulness to the individual as he gains experience.

Travis, R. B., 1955, Classification of rocks: Colo. School of Mines Quart., v. 50, no. 1, 98 p., 66 pls., 4 figs. ($1.00)

This text was designed to aid the professional or advanced amateur in identifying rocks. Charts for each of the major rock groups are comprehensive, and full-page black and white photographs are used to illustrate nearly all variations in rock texture that one is likely to encounter. It is written in technical language, but it is good. This publication is available from the Colorado School of Mines, Golden, Colo.

Weaver, Dolla, 1955, For pebble pups--a collecting guide for junior geologists: 95 p., 27 illus., Chicago, Chicago Natural History Museum. (Prepared to accompany a small collection of rocks and minerals, both items $1.25.)

The 4 junior geologists illustrated on the cover of this pocket-sized discussion of rocks and minerals look as if they are between 9 and 14 years old. The book is an interesting introduction to the subject especially for geologists in this age group. The small collection of 18 rocks and minerals is an excellent way to illustrate the rocks and minerals discussed in the text.

Zim, H. S., and Shaffer, P. R., 1957, Rocks and minerals (Golden Nature Guide Series: 160 p., illus., New York, Simon and Schuster. ($2.50 clothbound; $1.00 paper) ($6\frac{1}{4}$ x $4\frac{1}{4}$ inches)

This guide to familiar minerals, gems, ores, and rocks is illustrated with hundreds of accurate colored drawings of minerals and rocks. A brief but good section on how to collect minerals and rocks begins the book and is followed by a clear presentation of the many properties of minerals used in identification and how to test for them. The mineral descriptions include 68 metallic and at least 47 nonmetallic minerals, as well as sections on gem stones and rocks. The descriptions are brief, but with the excellent illustrations, they are probably adequate. A remarkably large amount of information on rocks, minerals, and ores and their uses is packed into this small book; it should be a welcomed addition to the reference shelf of any high school general science laboratory.

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