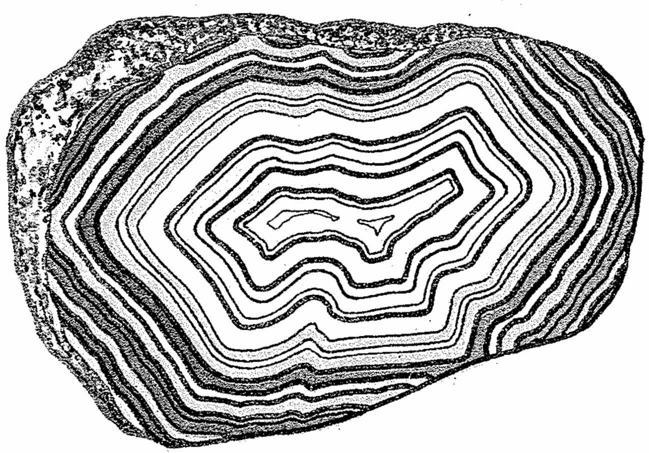
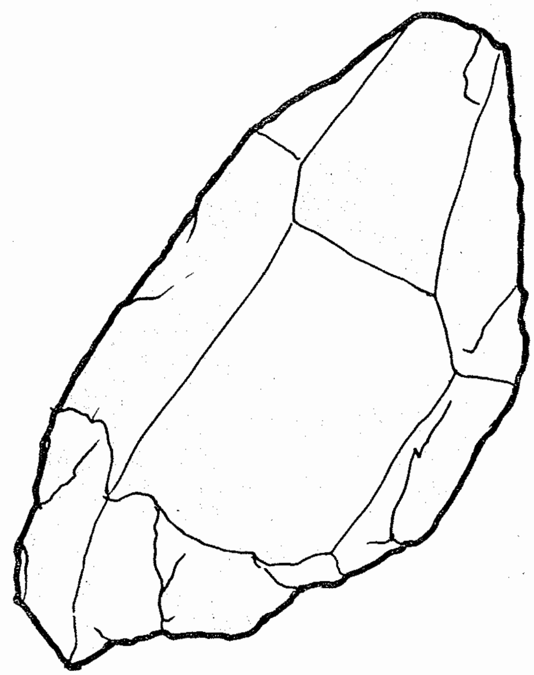
Educational Series No. 5

MINERALS AND ROCKS OF SOUTH DAKOTA





by Bruno C. Petsch
and Duncan J. McGregor

DEPARTMENT OF
NATURAL RESOURCE DEVELOPMENT
SOUTH DAKOTA GEOLOGICAL SURVEY
VERMILLION, SOUTH DAKOTA
1973

STATE OF SOUTH DAKOTA
Richard Kneip, Governor

DEPARTMENT OF NATURAL RESOURCE DEVELOPMENT
Joe Grimes, Secretary

GEOLOGICAL SURVEY
Duncan J. McGregor, State Geologist

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Science Center
University of South Dakota
Vermillion, South Dakota
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INTRODUCTION

Stop! Don't kick that "stone." Stoop down, pick it up, and observe your find. You may be surprised at what you see. Does it sparkle in the sunlight? Does it have pretty colors? Does it have an interesting shape? Instead of throwing your find at a tin can or tree, save it and start a collection. Soon you will have many different kinds of stones: shiny ones, dull ones, sparkly ones, hard ones, and soft ones. There will also be many colors--red, brown, gray, black, yellow, and green. Suddenly you become curious and wonder why these stones are different. How many different kinds are there? How are they made? Let us begin by first talking about the language of geology and some of its major concepts that relate to minerals and rocks.

THE LANGUAGE OF GEOLOGY

The study of minerals (mineralogy) and rocks (petrology) requires a few simple tools and often times painstaking patience because skill in mineral identification comes with experience. More importantly, however, the study of rocks and minerals requires a keen awareness of the earth around us. One must enjoy the outdoors and the search for interesting and often times beautiful specimens.

If you want to learn about rocks and minerals, you will have to study to make it worthwhile. Some of the concepts presented in this booklet must be learned. To begin, you must learn to be precise. The study of rocks and minerals is a science and as such it requires a specific language so that people interested in minerals and rocks can avoid confusion by communicating their thoughts in clear and accurate terms. Let us look at a good example. In the beginning of this booklet we used the word stone. This word is used by many people, but generally is avoided by geologists in their scientific endeavors because it is ambiguous; its meaning is not clear because it has different meanings for different people. Some use the word stone to mean any earth material that is hard; others use it to mean the same thing as rock; while still others use it to denote any rock that is broken into small pieces. If a geologist uses such an ambiguous term in his writings, you may have a different idea than someone else about what is being said. For this reason the geologist uses more precise terms such as *minerals* and *rocks*. These words have more explicit definitions; let's show you how to use them.

MINERALS

What is a mineral? We define minerals as natural inorganic substances that have a definite chemical composition and definite physical properties. That is quite a definition, isn't it? Let us break it down and see what it means.

Natural means that man did not make the mineral. Steel, glass, and cement are not minerals because man made them. Native copper, gold, native silver, and diamonds are minerals because they occur naturally in nature.

Inorganic means that neither animal nor plant life formed the mineral. Thus, coal, oil, amber, pearls, and bones are not minerals because they are the products of plant and animal life.

Definite chemical composition means that no matter where a mineral is found, it will always be made up of the same building blocks we call *chemical elements*.

Definite physical properties mean that the same mineral no matter where it is found will have the same hardness, specific gravity, luster, cleavage, streak, and crystal form.

Chemical Properties

In order to understand what is meant by definite chemical composition and why every mineral within certain limits has a definite chemical composition, we must first understand some very simple chemical concepts. To begin with, scientists believe the world is built from tiny particles called *atoms* or *elements*. You know some elements are so small that we cannot see them even with the most powerful microscope, but by scientific experiment we know there are at least 103 different elements of which 34 are shown in table 1.

TABLE 1. List of elements and their symbols used in this booklet

Al	Aluminum	Mg	Magnesium
As	Arsenic	Nb	Niobium
Ba	Barium	O	Oxygen
Be	Beryllium	P	Phosphorus
B	Boron	K	Potassium
Ca	Calcium	Si	Silicon
C	Carbon	Ag	Silver
Cl	Chlorine	Na	Sodium
Cr	Chromium	Sr	Strontium
Cu	Copper	S	Sulfur
F	Fluorine	Ta	Tantalum
Au	Gold	Ti	Titanium
H	Hydrogen	Sn	Tin
Fe	Iron	W	Tungsten
Pb	Lead	U	Uranium
Li	Lithium	V	Vanadium
Mn	Manganese	Zn	Zinc

Elements join together or combine in definite proportions to form minerals. Some minerals are composed of only one element; others are a combination of two or more elements. For example, the mineral gold contains only one element, gold; while the mineral quartz is made up of two elements, silicon and oxygen. When we say a mineral has a definite chemical composition we mean that the chemical composition of the mineral gold will always be composed of the element gold, and the chemical composition of the mineral quartz will always be composed of the elements silicon and oxygen. Some minerals are much more complex involving a combination of many elements; but in general, if a mineral is made up of five specific elements, it will always be made up of these particular five elements. An example is the mineral, muscovite, in which the elements potassium, aluminum, silicon, oxygen, and hydrogen are always present. Exceptions do occur because other elements, not usually present, sometimes appear in a mineral, but they are considered impurities.

Before going further, our study will be easier if you learn some chemical "shortcuts." Abbreviations called *symbols* are used for elements. When you write them down, you are writing a chemical formula. "Au" is the chemical abbreviation or symbol for gold; "Ag" is the chemical symbol for silver. "Au" is also the chemical formula for gold; "Ag" is also the chemical formula for silver.

Now let us study the composition of a mineral. Remember, a mineral is always made up of the same elements and these elements generally occur in the same ratio. For example, quartz, as already mentioned, is a common mineral made up of the elements silicon and oxygen. The chemical symbol for silicon is "Si"; the chemical symbol for oxygen is "O." It takes one silicon element to combine with two oxygen elements to form the mineral quartz. This ratio never varies. Silicon attracts oxygen, but it can only hang on to two of them; thus, we write the formula as SiO_2. The two oxygen elements are designated by the subscript "2." Numbers above 1 are always written this way. The number "1" for the amount of silicon is understood and is never shown. To illustrate:

$$Si + OO = SiO_2 = \text{quartz}$$

Let us take a short quiz. FeS_2 is the chemical formula for the mineral pyrite. Fe is the chemical symbol for the element iron; S is the chemical symbol for the element sulfur. What does FeS_2 mean? You are right if you said it takes one element of iron to combine with two elements of sulfur to form the mineral pyrite.

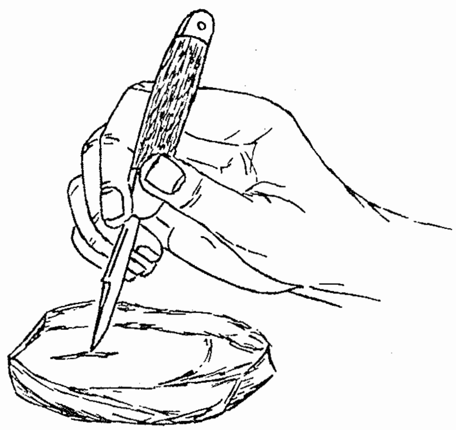
$$Fe + SS = FeS_2 = \text{pyrite}$$

Physical Properties

Our definitions of minerals stated that minerals have definite physical properties; that is a mineral of one particular type will always exhibit the same color or colors, hardness, specific gravity, luster, cleavage, streak, and crystal form. The reason this is true takes us back to chemistry once again. Remember that minerals are either elements or a combination of elements, but ultimately all matter is made from elements; they are the building blocks. Each mineral is made up of elements of a specific kind in specific proportions; i.e., a definite chemical composition. We can go one step further: minerals have a characteristic way in which elements are combined. This means that when elements come together to form a mineral, they combine in a very specific way such that their architecture is distinctive from that of every other kind of mineral. Every mineral of the same type has the same characteristic internal structure. It is this characteristic structure that gives minerals their physical properties. For example, if you find a specimen of the mineral quartz in the Black Hills of South Dakota, it will have the same hardness as quartz found anywhere else in the world. This holds true for all its physical properties because a mineral, no matter where it is found, will always have the same characteristic structure governing its physical properties.

Now let's discuss important physical properties. You must learn these properties and apply them in identifying your minerals.

Hardness



Hardness is a measure of a mineral's resistance to abrasion. The test for hardness is simple and can be done without fancy equipment; all you need is your fingernail, a copper penny, a knife blade, a piece of glass, and a steel file. Each of these items has a different hardness; to prove it, try scratching the copper penny with your fingernail. It will not work because your fingernail is not hard enough to scratch the penny. Now do it the other way around, and use the penny to scratch the back of your fingernail; this works.

The same principle operates with minerals; some minerals will scratch others because they are harder. Quartz is harder than calcite; therefore, a piece of quartz drawn across the surface of a piece of calcite will scratch the calcite.

In 1882, F. Mohs, an Austrian mineralogist, worked many hours with different kinds of minerals testing the hardness of one against the other. Eventually he was able to devise a scale using certain minerals as models or standards of hardness. The scale uses numbers from one to ten to designate the softest to the hardest mineral. This scale is shown above and you should memorize it.

Mohs Scale of Hardness

1	*Talc*	*6*	*Orthoclase*
2	*Gypsum*	*7*	*Quartz*
3	*Calcite*	*8*	*Topaz*
4	*Fluorite*	*9*	*Corundum*
5	*Apatite*	*10*	*Diamond*

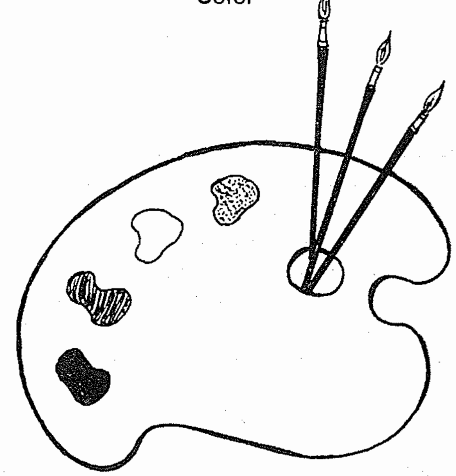
By scratching a mineral of unknown hardness with minerals of known hardness from Mohs Scale, you can determine where the unknown mineral stands in the hardness scale. Suppose you have a mineral before you and you do not know what it is. In performing the hardness test you find that the mineral fluorite (hardness = 4 according to Mohs Scale) will scratch it, but calcite (hardness = 3) will not. This means that the unknown mineral has a hardness somewhere between 3 and 4. This is very helpful information because it narrows the number of minerals the specimen can be.

You may have a set of minerals arranged in order of Mohs Scale of Hardness. If not, you can use the common items we mentioned at the beginning of this discussion. The hardness of each is listed below:

Fingernail – H 2.5
Copper penny – H 3
Knife blade – H 5
Piece of glass – H 5.5
Steel file – H 6.5

Now you know how to test for hardness, but do you understand why a particular mineral is always hard, others always soft? Hardness is a physical property caused by how tightly the elements are held together. The strength of the holding power between elements determines hardness. Graphite and diamond are composed of the same element, carbon; but due to the difference in holding power, a diamond is very hard, while graphite is quite soft.

Color

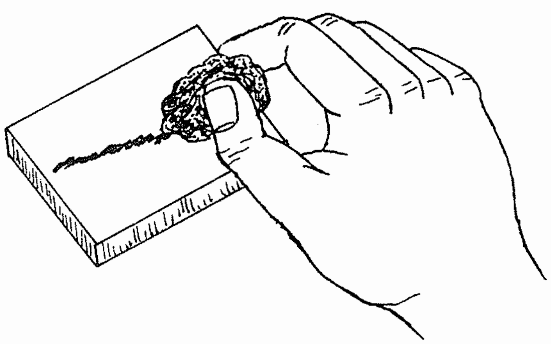


Color is probably the first thing you observe when you pick up a mineral. Often times it is merely this attractive quality that draws your attention to the mineral in the first place. But be careful when using color as a diagnostic property leading to the identification of a mineral because many times a mineral's color is misleading; consequently, it is a property that must be used with caution.

Your first observation of a mineral's color may be incorrect. Chances are the mineral you have picked up has been lying exposed to the weather for a long time; as a result, its surface has been tarnished and it may have changed color. Have you seen a tarnished copper penny? Its surface looks green or black from continued exposure to the atmosphere. Surely you have seen an old iron rake or shovel that has rusted. Its color is red from the rust instead of its true silvery color. You can avoid this problem by chipping the mineral and looking at an unweathered broken surface that will show its true color.

However, knowing the true color of a mineral may not be too helpful in identifying the mineral. Consider the mineral quartz. It can be pink, purple, brown, red, yellow, black, white, or colorless; the same is true for the mineral calcite and a variety of other minerals. Knowing, for example, that the true color of a particular unknown mineral is pink may only eliminate a very few minerals from the list of which it could be.

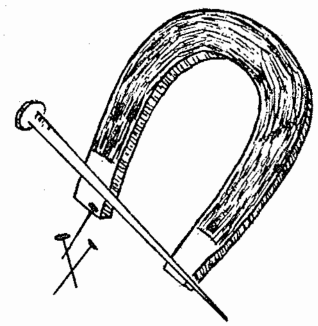
Streak



The color of the powder made by scratching or rubbing a mineral on a hard unglazed porcelain plate is known as its *streak*. Minerals may have several different colors, but the color of the streak of a mineral seldom changes. It may be lighter or darker than the color of the mineral, the same color as the mineral, an entirely different color, or colorless. Most common minerals have a colorless streak.

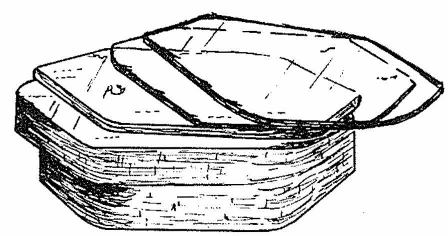
Magnetism

At one time or other in your life you have no doubt seen and used a magnet. Magnets attract and



stick to certain items that contain iron, such as nails, safety pins, etc. Perhaps you have even stuck a decorative magnetized decal on your refrigerator door. Magnetite (chemical formula, Fe_3O_4) is a common mineral that is attracted by magnets. Old miners of the west called certain varieties of magnetite *lodestone* which is a natural magnet capable of attracting small objects that contain iron.

Cleavage



When a mineral is struck a sharp blow, it may break along definite lines to form a flat surface. This is called *cleavage* or *the plane of cleavage*.

Surfaces of a cleavage plane are always parallel to crystal faces. Crystal faces or planes are created naturally when a mineral is formed in the earth. Because the holding power between elements differs in strength in various directions, a mineral will have a tendency to break in planes along which the holding power is weakest. It is rather like a chain that breaks at its weakest link. Breakage of this sort is called *cleavage* and it **NEVER** changes within a mineral species. More simply, you can think of cleavage as the tendency of a mineral to break forming specific flat surfaces. Two pieces of the mineral calcite will break in exactly the same way because they have the same internal structure. In addition, no matter how finely you break a mineral, even if you hammer on it until it is a fine powder, microscopic examination will show that it always breaks the same way.

Here is a test you can try in order to prove this: take a piece of rock salt (the mineral halite), the type your father uses on the icy sidewalk in the winter time. Common table salt will work just as well, but because of its smaller size, its cleavage is hard to see without a microscope. Examine your piece of rock salt closely. Note that it has the shape of a cube. Now carefully try to break the salt crystal into two or three smaller pieces. Again, examine the shapes of the crystal; they are still cubes! Break the mineral into even finer pieces and look at them with the aid of a magnifying glass or microscope; they will still be cubes.

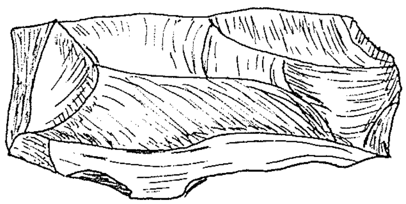
Another mineral that shows its cleavage very well is muscovite. Muscovite is known to many older people as isinglass; its transparent to translucent properties makes it usable in the old wood burner stoves as "window glass." Ask your parents if they are familiar with it.

Muscovite has cleavage that resembles a deck of cards. In one plane the bonds between elements are very, very strong. Try to pull a card in two by grasping both ends and pulling. Chances are you cannot do it; the same is true of a sheet of the mineral muscovite. If, however, you pull two separate cards of a deck apart it is very easy. Muscovite acts similarly; it lies in sheets that can be pulled apart, but the sheets themselves are very, very strong.

It is important for you to understand that not all minerals display cleavage. Some minerals are fine grained and the cleavage cannot be seen without the aid of a microscope. Some minerals have a structure in which no definite planes of weakness exist and thus, these do not exhibit cleavage. When these minerals break, they are said to fracture. Let us now discuss fracture.

Fracture

Fracture as distinguished from cleavage does not occur along distinct planes but can occur in any direction for a variety of reasons. Four kinds of fracture are *conchoidal, hackly, fibrous or splintry*, and *uneven or irregular*.



CONCHOIDAL FRACTURE

Conchoidal fracture means the fractured surface is smooth and curved like an egg shell. Quartz is a mineral that has a conchoical fracture.

Hackly fracture means the fractured surface is jagged. Native copper is a good example of hackly fracture.

Fibrous fracture is exhibited when a mineral breaks and reveals splinters or fibers. An example is the asbestos.

Uneven fracture occurs when a mineral breaks into rough and irregular surfaces. An example is the mineral sulfur.

Specific Gravity

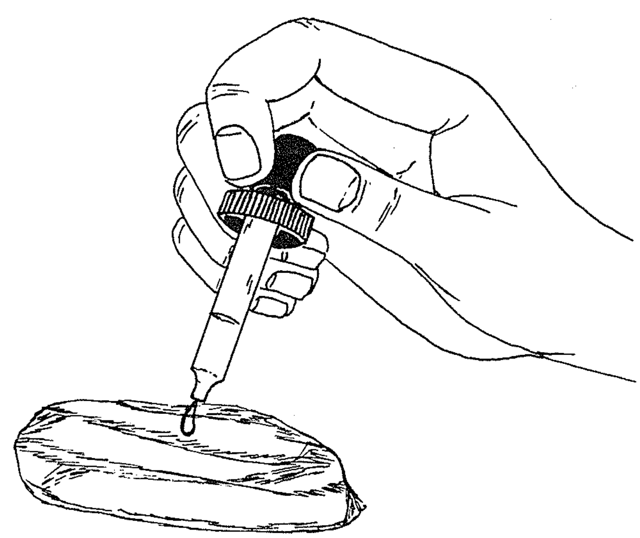
Scientists use specific gravity to compare the relative weight of minerals. Two equal volumes of lead and calcite will not weigh the same because lead has a higher specific gravity than calcite.

Specific gravity of a mineral is a number obtained by measuring the weight of a mineral in air divided by the measured loss of weight of the same mineral in water. Let's assume Wa represents the weight of a mineral in air. Now, immerse the mineral in water and weigh again. It will weigh less because any object immersed in water will be buoyed up by a force equal to the weight of the water displaced by the mineral. Let's assume Ww equals the weight of the displaced water. Then by subtracting Ww from Wa we can get a number that equals the loss of weight caused by immersion of the mineral in water. A formula can now be written:

$$\frac{Wa}{Wa - Ww} = S.\ G.$$

For example, if Wa of a measure is measured as 6 and Ww is measured as 3, then $6 \div (6 - 3 = 3) = 2$. The specific gravity of the mineral is 2. Instruments called a Jolly Balance and a Beam Balance are used to measure the weight of a mineral in air and the amount of water the mineral displaces when immersed in water.

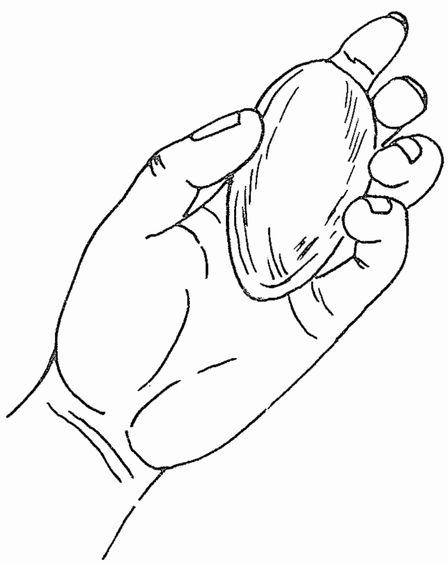
Effervescence in Acid



Dilute hydrochloric acid (1 part acid in 9 parts water) may be used to test for carbonate (CO_3) minerals such as calcite $CaCO_3$ and dolomite $CaMg(CO_3)_2$. Other minerals that contain carbonate may effervesce (bubble), but will be relatively unimportant to you.

A chemical reaction takes place when dilute hydrochloric acid is dropped on a mineral containing carbonate; i.e., carbon-dioxide gas and water are evolved. The CO_2 gas evolves at different rates depending on the impurities in the mineral. Calcite will effervesce very rapidly; the reaction is almost unmistakable. Dolomite, on the other hand, effervesces much more slowly. Most of the time you will be able to distinguish between these two minerals on the basis of this test.

Touch



Some minerals can be identified by touch. The mineral talc, also called *soapstone*, has a slippery feel like soap.

Taste

Some minerals can be identified by taste; for example, the mineral halite can be identified by taste. You eat and taste this mineral every day because it is the ordinary table salt you use to flavor your food.

Solubility

Some minerals dissolve and go into solution when mixed with water. The mineral halite dissolves in water causing the water to have a salty taste. Water is the universal solvent; in time it will dissolve most minerals.

Luster

Luster is a word used to describe the way the surface of a mineral reflects the brilliancy of light. Metallic luster means having the look of a metal such as pyrite and galena. Glassy luster means having the look of glass, such as quartz. Shiny luster means having a very shiny or sparkly surface, such as diamond. Silky means having the look of silk such as fibrous gypsum. Earthy means having a dull or earthlike look such as the mineral kaolin or clay.

CRYSTAL FORMATION

Minerals grow from tiny aggregates of elements called *nuclei*. These nuclei grow as elements continue to add on to each other. Think back to the time you have watched frost feathers spread over a window pane on a chilly evening. Each droplet of water attaches itself to the developing pattern in a very specific way. The ice forms a mineral and shows the way in which most minerals grow. Minerals have a characteristic internal arrangement of elements that form external crystal faces. Note the flat faces and sharp straight edges of the crystals. These are an outward expression of a regular internal arrangement of elements--an observation seen again and again in the mineral kingdom.

Not every mineral displays a crystal form. Often times, a mineral is an aggregate of very tiny, individual crystals. If you had a microscope powerful enough, you would be able to see hundreds of tiny interlocking crystals making up the massive mineral. On the other hand, some mineral crystals grow as large and tall as telephone poles. Whichever is the case, the characteristic regular internal arrangement of elements is always present.

The origin and history of the growth of minerals can be very complex because varying environmental factors play a dominant role in crystal development. Factors such as temperature, pressure, rate of cooling, and impurities all affect the formation of crystals. A crystal which was formed by very, very slow cooling will have time to arrange its elements and build large crystals. Conversely, a crystal formed by very rapid cooling will not have time to arrange its elements and it, therefore, grows small crystals.

CRYSTAL SHAPES

Crystals of a mineral have characteristic outward shapes of which there are a great variety possible. Basically all crystal shapes can be placed into six large groups called *crystal systems*. The names of the crystal systems are *isometric, tetragonal, hexagonal, orthorhombic, monoclinic,* and *triclinic*. Clues to some of the crystal shapes are shown on the following page.

SELECTED MINERALS IN SOUTH DAKOTA

Minerals in the State are numerous and of many kinds and varieties, but a word of caution. Do not expect to find with ease the perfect crystal, the exotic, or the ideal gem mineral because such finds are rare. However you can find excellent specimens of minerals if you devote time and have patience in your effort.

Pegmatite

Pegmatite is a word used for a rock having the same mineral content as granite, but differs in that the size of minerals are very large. During World War II many strategic minerals were mined from the pegmatites in the Black Hills and include feldspars, the micas, beryl, spodumene, columbite-tantalite, and quartz. Many abandoned mines in pegmatites are found in the general region from Custer to Pringle, South Dakota.

Barite

Barite is a common mineral found in the Pierre Shale throughout South Dakota. It forms excellent crystals in cavities in the shale and may be found as concretions (rosettes) or as fibrous masses on shale outcrops.

Sand crystals of barite weather out of sandstone along the Cheyenne River between the mouth of Wildcat and Cedar Canyons. Sand crystals range in size up to 5 inches in length. Crystals commonly are yellow to brown in color, but may be white, bluish-white, dark brown, or reddish.

Barite is a heavy mineral and by weight can easily be distinguished from the lighter mineral calcite.

Bentonite

Bentonite is the term applied to deposits of montmorillonite clays that were derived from the weathering of volcanic ash. The mineral is widespread and abundant in the Graneros and Pierre Shale of upper Cretaceous Age. Some bentonites possess the characteristic of expanding up to five times their natural weight when water is added. This makes the mineral most useful as a sealant.

Bentonite has been produced from open pits in the region around Belle Fourche. A non-swelling bentonite mineral is found in the Ardmore area.

Beryl

Common beryl is a mottled yellow and grayish-white mineral found in pegmatites throughout the Black Hills. Emerald is the green gem variety of beryl. Aquamarine is the deep blue gem variety. Gem varieties are rare in South Dakota.

Beryl is found frequently as crystals showing its six-sided prism shape. The mineral is a source of the element beryllium.

Calcite

Calcite is the most common and widespread mineral in South Dakota. It is the chief mineral in the rock called limestone. The color of calcite ranges from white to brown. A common crystal form of calcite looks like the "eyetooth" of a dog. It is the term "dog-tooth spar" of the miner's vocabulary. Calcite often phosphoresces under ultraviolet light and exhibits shades of red, green, yellow, and blue. This feature of calcite is demonstrated in Wind Cave as part of the tour through the Cave. Calcite frequently is found around spring deposits as tufa, particularly between Hot Springs, South Dakota, and the Cheyenne River. It is found as incrustations and as stalactites and stalagmites in caves.

Interesting crystals of sand calcite are found in the Washabaugh County at a place called Rattlesnake Butte or Devil's Hill. The crystals occur as individuals or in complex arrangements. Sizes of the crystals range from less than 1 inch up to 15 inches.

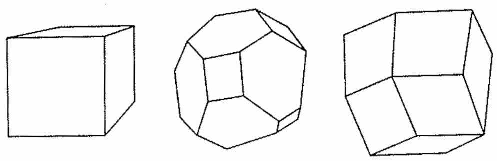
Carnotite

Carnotite, bright yellow to lemon yellow in color, is a radioactive mineral that is associated with sandstone and shale in Butte, Custer, Fall River, and Harding Counties. Sandstones in the general region north of Edgemont and in Craven Canyon have yielded carnotite as have the sandstones near Ludlow in Harding County. Considerable carnotite has been mined from the Dakota Sandstone west of Belle Fourche in Butte County.

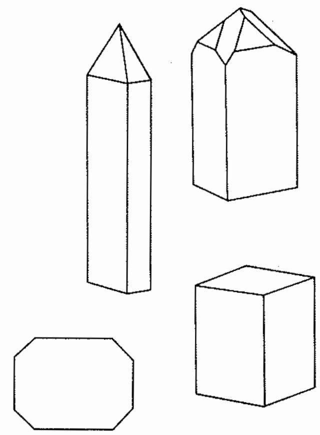
Columbite-tantalite

Columbite and tantalite are two jet-black minerals that always occur together. Discovery of these two minerals in pegmatites southeast of Custer brought considerable recognition to the Black Hills because of excellent specimens found there. Crystals have been found that measure up to 3 feet in length and 2 feet in width. These minerals have been mined also from pegmatites in Lawrence and Pennington Counties.

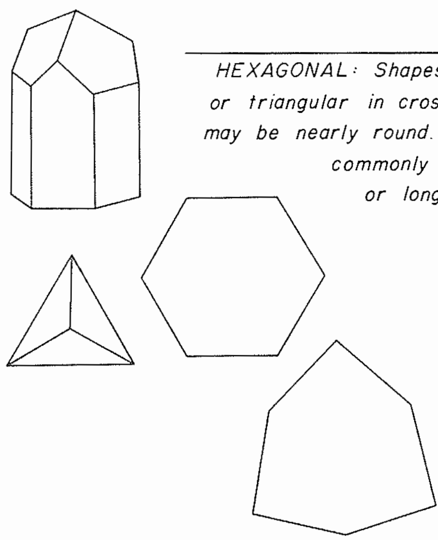
CRYSTAL SHAPES



ISOMETRIC: Shapes are square, blocky, or ball-like in appearance.

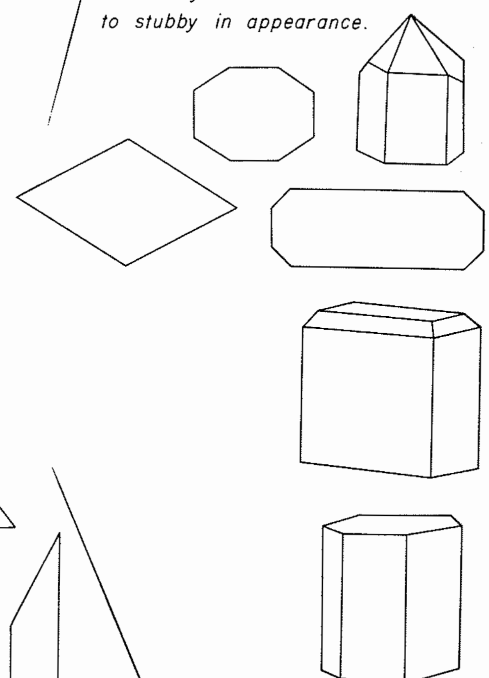


TETRAGONAL: Shapes are squarish in cross-section, commonly slender, elongated, or needle-like in appearance.

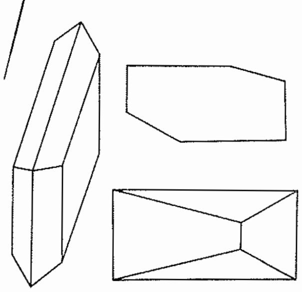


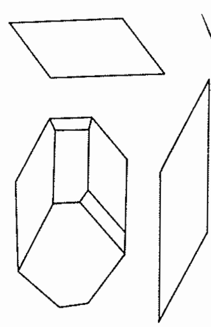
HEXAGONAL: Shapes are hexagonal or triangular in cross-section but may be nearly round. Crystals are commonly found in short or long columns.

ORTHORHOMBIC: Shapes are rectangular to diamond in cross-section. Crystals are commonly tabular and short to stubby in appearance.



MONOCLINIC: Shapes are blocky or stubby with faces on opposite ends that match.





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TRICLINIC: Shapes lack right angles on faces or edges. They may be in wafer-like crystals or they may be blocky in appearance.

Feldspar

Feldspar is a general term applied to a group of minerals that include orthoclase, microcline, and the plagioclase series. Orthoclase is abundant in igneous rocks of the northern Black Hills often occurring in them as large crystals (phenocrysts). Single crystals of orthoclase can be found on old gold mine dumps in Lawrence County, some of which measure up to 4 inches in length.

Microcline is an abundant mineral in pegmatites of the southern Black Hills. Excellent specimens can be found in the many abandoned pegmatites in the Custer-Pringle area.

Of the plagioclase series, albite is the most common and is found also in the pegmatites of the Custer-Pringle area.

Gold

Native gold has wide distribution in the Black Hills. South Dakota leads all other states in the production of this mineral. The Homestake Mine at Lead is the chief active mine producing gold valued at more than $20 million a year.

Gold taken from placer deposits has yielded several gold nuggets in the past, the value of which ranges from $30 to approximately $800. Today you can pan for gold along the several streams of the Black Hills and if patience and time are in your makeup, you might possibly get a show.

Gypsum

White layers of gypsum are easily spotted within the red shale beds of the Spearfish Formation that crop out around the Black Hills. Local names given to the outcrop region are the "Racetrace" or "Red Valley." Layers of gypsum measure up to 25 feet in thickness. The mineral occurs in three varieties: rock gypsum, the massive form; satin spar, the fibrous form; and selenite, the clear transparent form. Rock gypsum used for carving is called alabaster.

Gypsum is abundant in the general region of Hot Springs, South Dakota, and it also occurs extensively throughout the Black Hills. If one uses patience in his search for gypsum, he may find the rock variety that could well be used for carving. Excellent selenite crystals are found in shale outcrops in the Union and Yankton County areas in South Dakota. Along U.S. Highway 12 from Hawarden to Akron, Iowa, exellent selenite crystals can be dug out of the shale outcrops along the road.

Gypsum is the mineral from which plaster of paris is manufactured and with which much of the wallboard for home construction is manufactured.

Hematite

Hematite is found in many places in the Black Hills. Near Nemo on Boulder Creek is an area that has actively been explored for possible commercial production. It is estimated that the deposits may be as much as 800 feet in thickness. Other areas where hematite is known to occur are around Hayward and south of Keystone.

Limonite

Limonite is the name given to a mixture of various hydrous iron oxide minerals chiefly goethite and hematite. Weathering of rock high in iron minerals forms limonite surface deposits known as *gossan* or *iron hat*. An occurrence of limonite near Rochford in the Black Hills was mined at one time for use as mineral pigment ocher.

Mica

Mica is a general term applied to the minerals muscovite, biotite, and lepidolite. Muscovite (white) occurs in great abundance in rocks of many types within the Black Hills area, particularly so in pegmatites. Mica in pegmatites occurs in crystal masses called *books* by the miners. From pegmatites muscovite has been mined in large sheets. *Isinglass*, a familiar term known to older people, is a large layer sheet of the mineral muscovite. Crystals of muscovite have been mined that measure up to 6 feet long, 17 inches wide, and 4 inches thick.

Biotite (black) like muscovite is found as a mineral in many rock types throughout the Black Hills. Crystals of biotite have been found that measure 3 feet long and 2 inches across. Abandoned pegmatites in the Custer-Pringle area contain the minerals muscovite and biotite.

Lepidolite (pink) is not as common as muscovite and biotite. It has been mined from pegmatites in the general area southeast of Custer.

Pyrite

Pyrite (Fool's Gold) is abundant and widespread throughout the State. It is present in many rock types. The mineral can be found on most mine dumps in the Silver City area and is abundant on the eastern flank of Iron Mountain in Custer County. Pyrite is also found as concretionary masses in the Pierre and Chadron Shales in the general region of the Badlands.

Quartz

Quartz is a common mineral in igneous, sedimentary, and metamorphic rocks. Many varieties of quartz exist in the State, among which are clear, milky, smoky, rose, jasper, agate, and chalcedony.

Clear, smoky, rose, and milky quartz can be found in the numerous abandoned pegmatites that are found south and east of Custer, South Dakota, and east and south of Pringle, South Dakota.

Jasper is a massive form of quartz that contains large amounts of iron oxide. Therefore, the color is various shades of red and brown. A conglomerate rock containing jasper occurs in large masses of the Lakota formation and may be found as boulders in the stream beds of Lame Johnny Creek 7 to 8 miles west of Fairburn.

Agates that are banded and may contain amethyst crystals are found in Tepee Canyon a mile or so west of the Jewel Cave Monument boundary and north of U.S. Highway 16.

Chalcedony nodules and surface layers are found in Harding County in the vicinity of the Depco oil well and in tributary stream beds of the Little Missouri River near the Montana border.

By an act of the Legislature, Rose Quartz is the State Mineral and the Fairburn Agate is the State Gem Mineral.

Siderite

Siderite is common in the State particularly in concretions found in the shale of Cretaceous Age. Along the Missouri River from Pierre south to the Nebraska border much of the material called clay ironstone concretions is indeed the mineral siderite.

Spodumene

Spodumene is a mineral found in pegmatites in the Keystone area of the Black Hills. A single crystal of spodumene was found in the Etta Pegmatite near Keystone, South Dakota, that measured 42 feet in length and 3 by 6 feet in cross section. Dirty white is the common color of spodumene. Gem varieties of the mineral are hiddenite (yellow-green), kunzite (lilac pink), and triphane (colorless, transparent). Although these minerals are rare, they have been found in the pegmatites of the Hills. Spodumene is a source of the element of lithium.

Tourmaline

Tourmaline, the black variety known as *schorl*, is found extensively in the Black Hills, particularly in the pegmatites in the Custer-Pringle area. Crystals of tourmaline occur in sizes from less than 1 inch up to 10 inches in diameter. Striations on the prism faces of the crystals readily identify the mineral as tourmaline.

ROCKS

Rocks are formed from various combinations of minerals. For a specific rock there is generally a specific mineral combination; for example, granite is a rock composed chiefly of the minerals quartz, feldspar, and mica (muscovite and biotite). Thus, minerals may be called the "building blocks" of rocks just as elements are the building blocks of minerals.

There are three large groups of rocks and all rocks belong in one of the three categories. These are igneous, sedimentary, and metamorphic. The relationship between these rock groups is illustrated in the rock cycle (fig. 1). Refer to it as you read the following explanation.

IGNEOUS ROCKS

All minerals and rocks start from molten rock called *magma*. Magma exists in large reservoirs called *magma chambers* deep inside the earth. When the hot liquid rock begins to cool and becomes hard, igneous rocks are born.

Intrusive Igneous Versus Extrusive Igneous Rocks

Rocks formed inside the earth by the cooling of magma are called *intrusive igneous rocks*. Intrusive igneous rocks commonly exhibit large crystal texture because they crystallize very slowly deep inside the earth.

Rocks formed on the surface of the earth by the cooling of molten rock, such as in volcanic eruptions, are called *extrusive igneous rocks*. Extrusive igneous rocks exhibit a fine crystalline texture because the crystals form very very quickly and do not have time to grow under the rapid cooling conditions.

Common intrusive ingeous rocks include granite, diorite, and gabbro. Granite is probably the most common igenous rock and most familiar to all. It is composed primarily of the minerals feldspar and quartz which give the rock a light-gray or pink color. In addition, the minerals biotite and hornblende are usually present. These minerals are dark and they give the rock a speckled look.

Diorite is made up of about 30 percent hornblende, augite, and biotite with 55 percent feldspar and up to 15 percent quartz. It is darker than most granites.

Gabbro is quite similar to diorite except there is no quartz, and the percentage of hornblende, augite, and biotite increases.

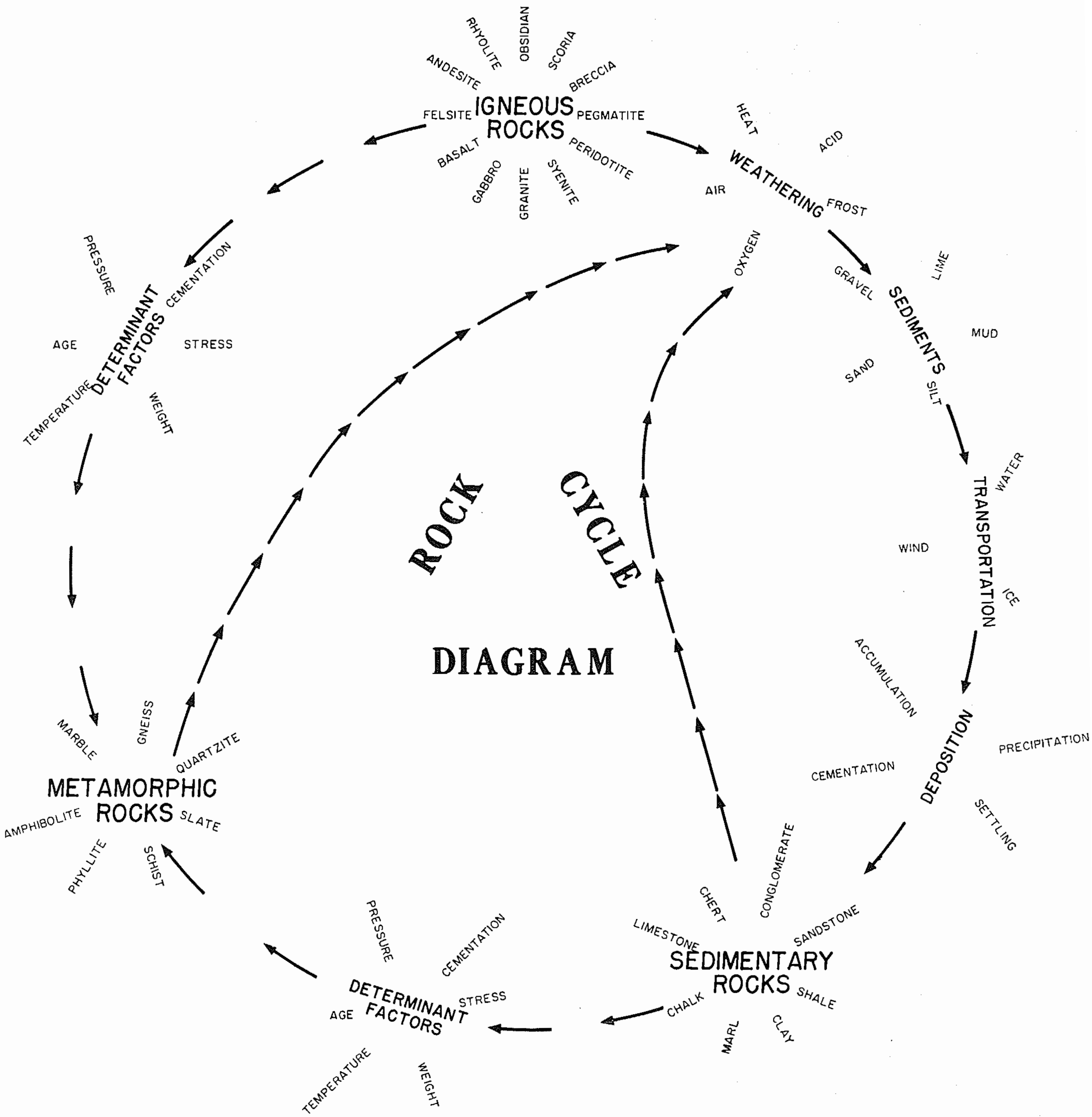


Figure I. Rock cycle.

Lava is an extrusive igneous rock that often flows out of volcanoes. Common extrusive igneous rocks are rhyolite, andesite, basalt, and obsidian.

Rhyolite is a light-colored rock with a composition similar to granite. Its texture is very fine consisting mostly of quartz and feldspar.

Andesite contains a greater proportion of dark ferromagnesian minerals than rhyolite and has little or no quartz.

Basalt is a very dark heavy rock that is very common in volcanic regions. It is composed of hornblende or augite and plagioclase feldspar (approximately in equal proportions). Olivine may also be present.

Obsidian is chemically equivalent to rhyolite. Obsidian is a glass (having no characteristic internal structure) formed when rhyolitic lava is chilled very rapidly. It is shiny and dark-colored, but thin fragments are transparent and look lighter.

Formation of Gem Minerals

When a magma cools, the rock may crack or form large open spaces giving mineral crystals room to grow. This is how gem minerals like garnet are formed. Hot liquids and gases left over when a magma cools may deposit precious metals such as gold or silver in cracks or veins far from the original magma. Volcanoes, gas vents, geysers, and hot springs are formed where the hot liquids and gases reach the surface. These hot gases and liquids when cooled may form minerals.

Classification of igneous rocks is given in table 2.

SELECTED IGNEOUS ROCKS IN SOUTH DAKOTA

Igneous rocks crop out in South Dakota in three areas: near Milbank in Grant County, near Sioux Falls in Minnehaha County, and throughout the Black Hills in western South Dakota. The granite east of Milbank is currently quarried chiefly for monumental and ornamental uses. Originally, granite known as the Milbank Granite was used for building stone. Many existing buildings today in South Dakota contain Milbank Granite. A small outcrop of diabase can be seen northeast of Sioux Falls and 1 mile north of the small town of Corson.

Landforms in the Black Hills, such as Harney Peak, Mount Rushmore, Bear Butte, Custer Peak, Terry Peak, the Needles, are fashioned from igneous rock. Associated with the igneous rock of the Black Hills are localized features called *pegmatites*. From the pegmatites large crystals of feldspar, rose quartz, beryl, and lithium minerals have been found.

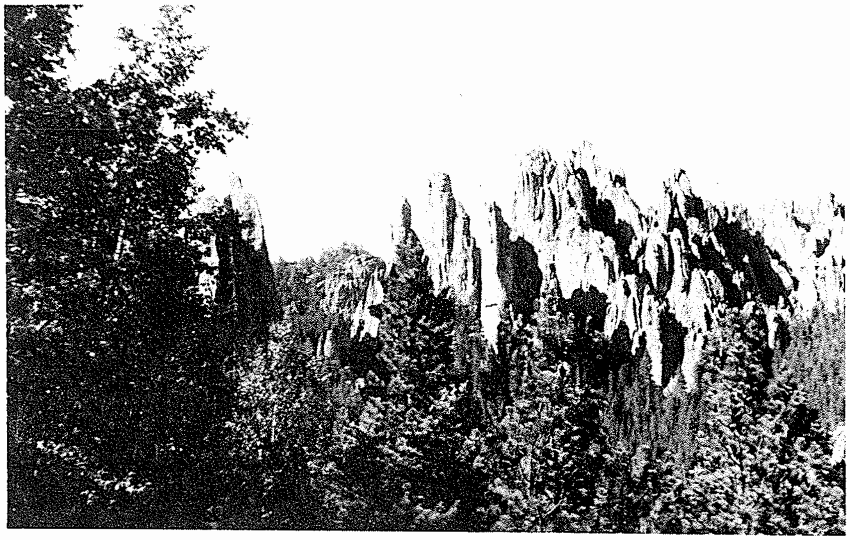
Igneous rocks also are found in material deposited by the ice as it moved southward across the State.

TABLE 2 – Classification of Igneous Rocks

Mineral Composition	Texture	
	Coarse-grained	Fine-grained
Excess of light-colored minerals: Feldspars and quartz abundant; some biotite.	Granite[1] Granodiorite[2]	Rhyolite[1] Dacite[2]
Excess of light-colored minerals; Plagioclase feldspars predominant; no quartz; some biotite; some iron-magnesian minerals.	Diorite	Andesite
Excess of dark-colored minerals: Iron-magnesian minerals abundant; no quartz; feldspars predominant	Diabase Gabbro	Basalt

[1] Feldspar predominantly orthoclase.

[2] Feldspar predominantly plagioclase.

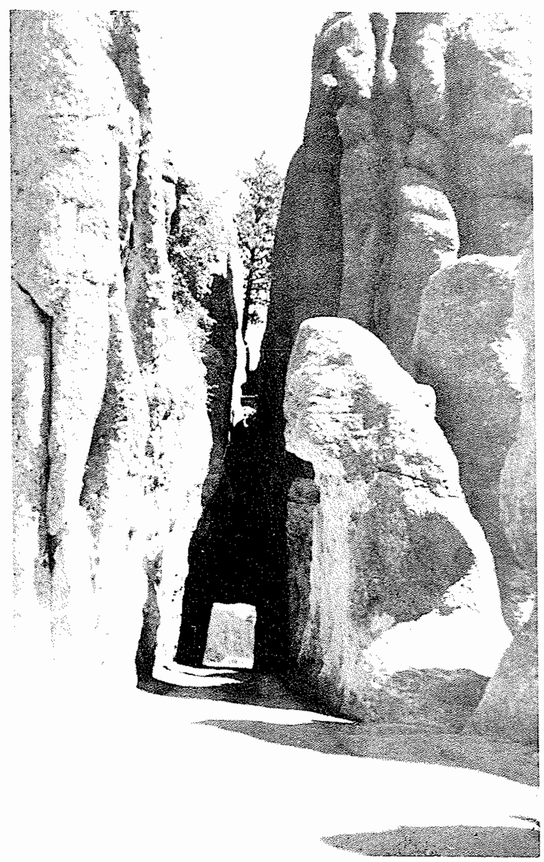


Weathered granite formed "The Needles", Black Hills. ←

Many gravel pits in eastern South Dakota contain igneous rocks of all sizes.

Deposits found in terraces along the major streams that flow from the Black Hills also contain considerable amounts of igneous rock.

Tunnel through granite, highway 87, Black Hills. ↓



Granite

Granite is an intrusive igneous rock found in outcrops in an area east of Milbank, South Dakota, and in the central part of the Black Hills. The chief minerals in granite are quartz, feldspar, and the micas. Granite usually is light in color with the color hue directly related to the color of the feldspar. Near Milbank, the Milbank Granite is mahogany in color because the mineral feldspar exhibits this color.

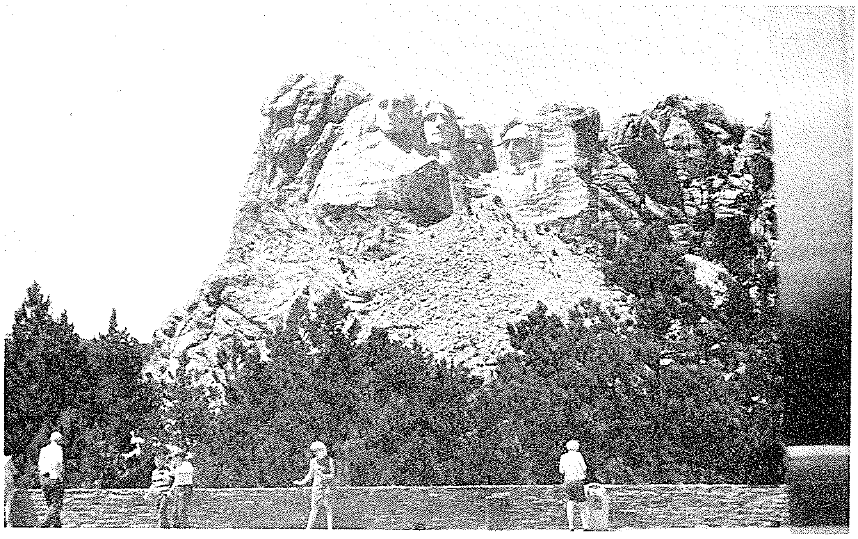
The faces on Mount Rushmore are carved in granite, and nature's sculptured features of Harney Peak and the Needles also are in granite. The light color of the granite is again due to the color of the feldspar.

Granite is found as a rock type in the glacial deposits of eastern South Dakota. Most granite found in the glacial deposits has been transported from northern areas in Canada into the State by action of glacial ice.

Terraced gravels found along many of the streams in western South Dakota may contain abundant granite derived from the Black Hills.

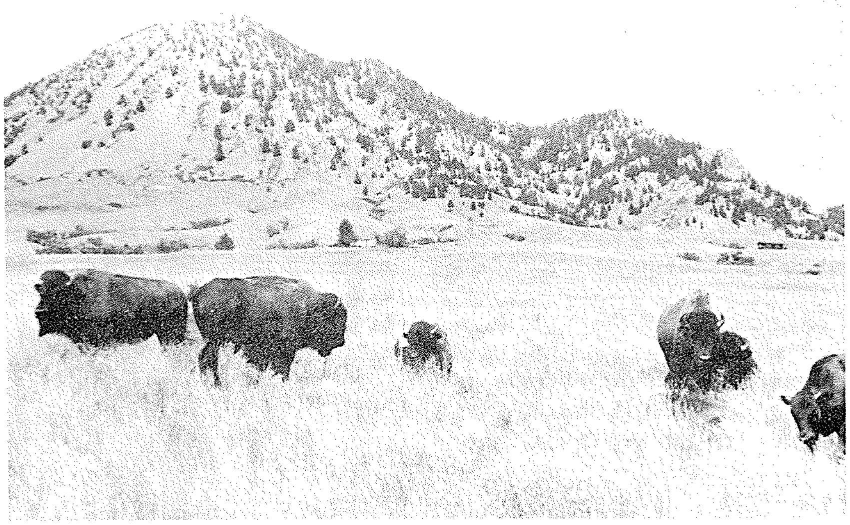
Rhyolite

The extrusive igneous rock, rhyolite, is seen in outcrops in various places in the northern Black Hills and at Bear Butte, a distinctive landform northeast of



Mt. Rushmore faces carved in granite, Black Hills.

Bear Butte formed in Rhyolite, Bear Butte State Park.



Sturgis, South Dakota, which now is in the State Park System.

Open pits that resulted from the excavation for gold ore at Homestake Mine at Lead, South Dakota, are in rhyolite rock. Much rhyolite crops out in the vicinity of Lead and Deadwood, South Dakota. Specimens can usually be picked up from outcrops along the roads that traverse the area.

Diabase

Diabase crops out in an area near Corson in eastern South Dakota. It is limited in extent and referred to structurally in geologic terms as the Corson Dike. Because of its dark color the rock stands out in contrast with the surrounding glacial deposits and soil.

Diorite

A diorite type rock crops out in an area 20 miles northwest of Hill City. The rock is found as narrow dikes that protrude through the surrounding rocks called *schists*. It is difficult to distinguish on outcrops the true identity of these rocks. One might well call these rocks *gabbros*. In diabase the black mineral is chiefly hornblende whereas in the gabbros the black mineral is augite.

SEDIMENTARY ROCKS

Sedimentary rocks are formed from the accumulation of rock fragments, minerals, and fossils which have been transported from their present location by streams, currents, wind, ice, or by precipitation of solid particles from sea, river, or lake waters. Figure 2 shows diagrammatically the step sequences of how sedimentary rocks are formed.

Only a fixed amount of mineral matter can be dissolved in water. Mineral matter in excess of the fixed amount is precipitation. Limestone, rock salt, and gypsum are formed in this way. Limestone, salt, and gypsum are rocks formed on the bottom of shallow oceans. To illustrate, dissolve some table salt in a pan of water and then place the pan of water on the lighted burner of a stove. Watch the water evaporate and see the salt appear.

Water in many streams is not clear. The water is carrying mineral matter in suspension. The mineral matter is made up of muds, sands, and gravel. Somewhere this mineral matter will be deposited, and in time rocks called *shale, sandstone,* and *conglomerate* will be formed.

Limestone is composed almost entirely of the mineral calcite. Most limestones are generally light in color and many contain shells of animals that lived in the water when the limestone was formed.

Dolomite is a rock that resembles limestone but is made up mostly of the mineral dolomite instead of calcite.

Sandstone is a rock that contains small grains of many kinds of minerals. However, the chief mineral in sandstone commonly is quartz.

Conglomerate is like sandstone, but the mineral grains are much larger and have greater variations in

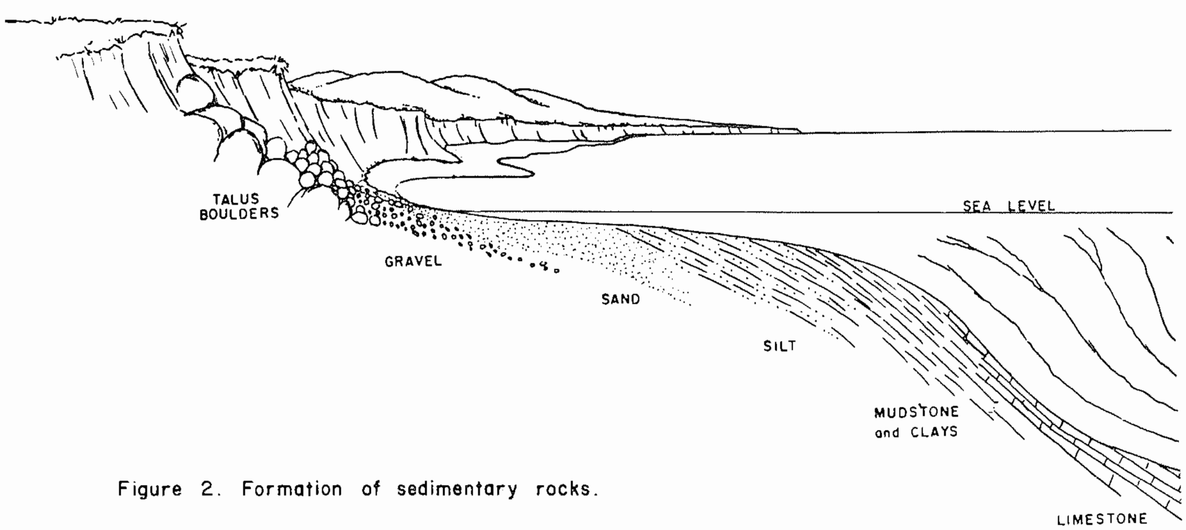


Figure 2. Formation of sedimentary rocks.

size. A good example is the wall of the canyon on the west side of the main street of Hot Springs, South Dakota.

Shale is a rock composed of muds that have become hard. Some shales break. The chief minerals in shale are quartz, mica, and clay minerals. The mineral grains are very small.

Chert is another form of the mineral quartz, but it is made by precipitation from water. Quartz crystals in chert are very very small.

Gypsum and rock salt are formed when sea water is evaporated. Gypsum and barite rosettes are common minerals in many shales.

Coal is the accumulation and ultimate burial of plants that lived on land a long time ago. Lignite, a variety of coal, is found in the northwestern part of the State.

Most rocks are not completely solid because they contain openings or pores. In the ground, water may be found filling the openings. The water from porous rocks may drain into a stream or may come out at the surface as springs. In caves water may appear on the roof and when it evaporates, the mineral calcite is precipitated to form stalactites. Stalagmites also are found in caves but build up from the floor by the evaporation of water leaving behind the mineral calcite.

Sedimentary rocks commonly are found in layers as in a layered cake. Thus, the oldest rock layers are at the bottom and the youngest are at the top. Many sedimentary rocks contain shells of animals that lived when the rock was formed; they are called *fossils*.

Round, ball-like objects may be found in some sedimentary rocks and are called *concretions* or *nodules*. Sometimes concretions contain rare minerals. A common concretion is called a *geode* and it is generally composed of quartz and calcite.

Classification of sedimentary rocks is shown in table 3.

SELECTED SEDIMENTARY ROCKS IN SOUTH DAKOTA

Sedimentary bedrock abounds in South Dakota. Outcrops of these rocks occur here and there in areas east of the Missouri River chiefly along the channels of the major streams. Glacial deposits are sedimentary, unconsolidated rocks and are found throughout the area east of the Missouri River. Minor amounts of glacial materials are found on hilltops that border the Missouri River immediately to the west.

The area west of the Missouri River reveals abundant sedimentary rock. Gray to black shales are widespread. Rocks in the Badlands have been and are still being eroded into scenic sculptured forms. Huge

TABLE 3 – Classification of Sedimentary Rocks[1]

Mineral grain size	Mineralogic Composition				
	Calcite	Dolomite	Quartz	Gypsum-anhydrite	Clay minerals
1/16 inch (1.4 mm) or greater			Quartz conglomerate or breccia		
1/64 inch to 1/16 inch (0.4 mm to 1.4 mm)	Limestone	Dolomite	Sandstone		
Cannot be seen with unaided eye			Chert or flint	Evaporites	Clay or shale

[1] Sedimentary rocks also include the following mineral fuels:
peat (decomposed plant remains with some stems, leaves, and roots visible).
coal (decomposed plant remains with stems, leaves, and roots not visible).

straight walls and cliffs of limestone rise out of Spearfish Canyon in the Black Hills where streams have cut down through the rock. In some areas water has dissolved limestone to form tremendous caves such as Jewel Cave and Wind Cave. Red shale surrounds the Black Hills to form what is commonly referred to as the "Racetrack."

Sedimentary rocks, like igneous rocks, are found as minor components in glacial deposits.

Sedimentary rock is used in the State for road metal, ingredients for concrete, and in the manufacture of light-weight aggregate and cement. In the past such rock was used for building stone.

Limestone

Limestone crops out at many places in the State such as near Richland along State Highway 50, along the Missouri River bluffs west of Yankton, and in the bluffs north of Yankton along tributary streams to the Missouri River. In the western part of the State limestone is found along State Highway 79 just north of Rapid City and at various locations along State Highway 79 south of Rapid City to the Nebraska-South Dakota border. Also limestone is found to outcrop south of Fairburn and in the area west through Buffalo Gap in the southern Black Hills.

By far the best exposure of limestone is along the Spearfish Creek in Spearfish Canyon where the high walls of the Pahasapa Limestone (Madison) stand out in majestic splendor.

Sandstone

Sandstone in outcrops is not a common rock type in eastern South Dakota. However, in the bluffs just across the Big Sioux River in Iowa and along U.S. Highway 12 from Sioux City to Hawarden, Iowa, much sandstone is found and can be collected.

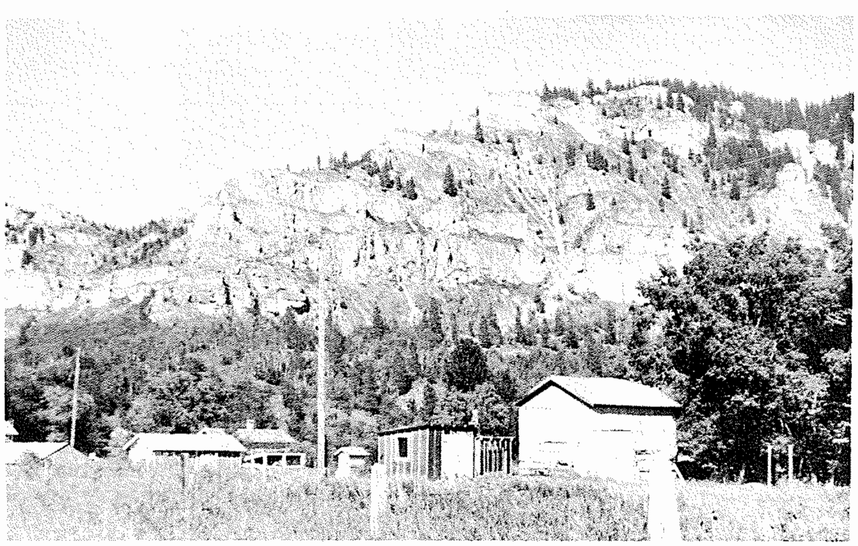
Sandstone is a very common rock type in western South Dakota. Many of the ridges and steep slopes in the Rapid City area are formed in sandstone. A unique exposure of varied colored sandstone is found in the mouth of Calico Canyon about 1 mile south of Buffalo Gap. Sandstone is exposed along U.S. Highway 18 just east of Hot Springs, in the roadbanks along U.S. Highway 14 in the Deadwood area, and along Firesteel Creek about 6 miles west of Mitchell, South Dakota.

Shale

Shale is the most abundant rock type found throughout the State. Light-to-dark shale crops out in the bluffs of the Missouri River from Fort Thompson to the North Dakota border and at various places in the bluffs of the James River.

In the region of the Black Hills shale that exhibits gray, green, red, and black colors can be found. Green shale can be collected in a roadcut of Interstate 90 north of Rapid City and in exposures in a roadcut along U.S. Highway 85 west of Lead, South Dakota. Red shale is seen at many places throughout the Black Hills and in the popular area known as the "Racetrack" or the "Red Valley." Gray and black shales can be seen in the bluffs and hills along State Highway 79 south of Rapid City to the Nebraska border.

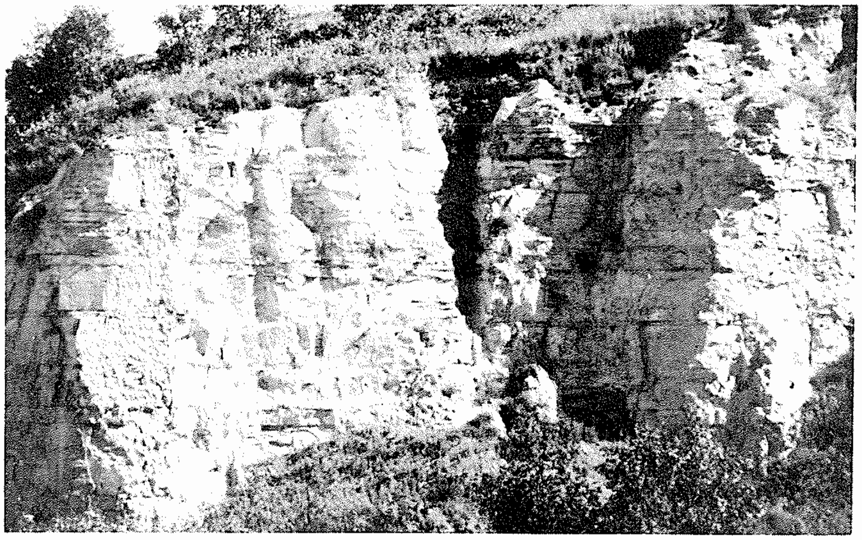
Some of the intense black shale may produce some petroleum residues, and if the flame of a match is placed in contact with the shale, the shale may burn.



Pahasapa Limestone, Spearfish Canyon near Savoy, Black Hills.
←

Dakota Sandstone, highway 12, north of Sioux City, Iowa.

Carlile Shale with concretion, Union County State Park.



Niobrara Chalk, old cement plant west of Yankton.

Chalk

Chalk is a limestone that is soft and rubs off easily on the fingers. Chalk in outcrops has a white, yellow, or dirty gray color. The purest chalk in the State crops out in the bluffs of the Missouri River from Fort Thompson to Yankton, South Dakota.

In the past chalk has been used as a building stone and a number of homes still exhibit exterior walls made of chalk. Chalk also has been used in the manufacture of lime and cement.

Conglomerate

Conglomerate is not a common sedimentary rock in South Dakota. Thin layers of conglomerate can be seen along the Nemo road from Rapid City to Deadwood, South Dakota. An excellent exposure of conglomerate is found in the south bank of Fall River that flows through Hot Springs, South Dakota. Another good exposure of conglomerate can be seen in outcrops as one travels west from Buffalo Gap through the southern Black Hills.

In eastern South Dakota conglomerate is associated with the Sioux Quartzite. Outcrops of conglomerate occur along the banks of Split Rock Creek from Sherman, South Dakota, southward to Garretson, and in the area of Dell Rapids, South Dakota.

Volcanic Ash

Volcanic ash is rather widespread over the State. Some of the ash deposits have turned to bentonite, while others maintain their gritty nature. A good place to look for volcanic ash is in the general region of the White River Badlands. The ash beds range in thickness from a fraction of an inch up to 15 feet.

Volcanic ash is silvery-gray in color and glistens in the sun as light rays reflect from the glassy (silica) surfaces of the ash particles. Because the ash particles are very small, they have been used for scouring powder.

Lignite Coal

Lignite coal is treated as a sedimentary rock. Thin coal layers occur in sandstones and shales of Cretaceous Age. Coal layers up to 5 feet thick have been mined near Isabel and Firesteel, South Dakota. At various places in Perkins and Harding Counties, coal is sandwiched in between shale and sandstone layers. A good area in which to look for coal is the Ludlow region.

Around the turn of the century coal was mined on the south bank of the Cheyenne River about 3 miles south of Edgemont, South Dakota. The coal is associated with a sandstone.

Coal is not too abundant in eastern South Dakota. It may be seen associated with sandstone layers along the course of the Big Sioux River.

METAMORPHIC ROCKS

Metamorphic rocks are formed from rocks that already exist and have been changed chiefly by heat and pressure. The source of heat and pressure may be from the weight of overlying rocks, rock movement caused by earthquakes, or by hot magma coming into contact with cold rock.

Table 4 is a list of common rocks and their metamorphic equivalents.

TABLE 4 – Common Rocks and Their Metamorphic Equivalents

Original Rock	+	(Heat and Pressure)	=	Metamorphic Rocks
Limestone	+	(Heat and Pressure)	=	Marble
Shale	+	(Heat and Pressure)	=	Slate
Sandstone	+	(Heat and Pressure)	=	Quartzite
Granite	+	(Heat and Pressure)	=	Gneiss
Basalt	+	(Heat and Pressure)	=	Schist

Marbles generally are white, green, black, brown, or yellow; the color chiefly due to the kinds and color of minerals in the original rock. Marbles are used extensively as a decorative and building stone.

Slate is most often blue, gray, black, or red in color. Because slate can be split into large sheets, it is used for blackboards, floors, and walkways.

Quartzite is a very hard durable rock. Its color may be clear, black, gray, or pink. Quartzite is used as a building stone.

Gneiss frequently is called *the banded rock* because dark and light coarse-grain minerals form separate layers. Feldspar, quartz, and muscovite are the light minerals; whereas, biotite, magnetite, and hornblende are the dark minerals.

Schist contains about the same minerals as in gneiss but they are much smaller in grain size. The minerals muscovite and biotite are abundant and with the other minerals occur in thin layers. The mica minerals make the rock sparkle in the sunlight.

Classification of metamorphic rocks is shown in table 5.

SELECTED METAMORPHIC ROCKS IN SOUTH DAKOTA

Metamorphic rocks are found in place in a few areas in eastern South Dakota and extensively in the central region of the Black Hills. The Sioux Quartzite[1] is exposed at Sioux Falls, Dell Rapids, Alexandria, and Garretson. Streams have cut down through the quartzite to form land features such as

[1] The Sioux Quartzite is thought by some as not representing a true metamorphic rock because separate quartz grains and traces of original sedimentary bedding planes can be seen. However, here the Sioux Quartzite is listed as a metamorphic rock.

TABLE 5 -- Classification of Metamorphic Rocks

Rock	Texture	Rock commonly derived from	Chief mineral
Quartzite	Unfoliated, massive	Sandstone	Quartz
Marble	Unfoliated, massive	Limestone	Calcite
Slate	Slaty (very thin layers)	Shale	Mica, quartz
Schist	Schistose (thin layers)	Basalt, andesite, shale, rhyolite gabbro	Plagioclase, muscovite, biotite, quartz amphibole
Gneiss	Gneissose (layered)	Granite, shale, diorite, rhyolite, etc.	Feldspars, quartz mica, amphibole, garnet

Sioux Quartzite, east of Sioux Falls.

the Dells at Dell Rapids, Devil's Gulch at Garretson, the Falls at Sioux Falls, and the Gorge in the proposed Palisades State Park near Garretson.

In the central part of the Black Hills metamorphic rocks, chiefly slates, schists, and quartzites, are common. Because of their thin platy layers, these rocks exhibit in many areas high angles of inclination. The surface of these layers of rock frequently glistens in the sun because light is reflected from the mica minerals. In the Black Hills metamorphic rocks do not form high peaks as do the igneous rocks. Many of the large valleys and gorges in the central part of the Black Hills have been created from the erosion of the less resistant metamorphic rocks.

Metamorphic rocks are found as unconsolidated components of glacial drift.

Metamorphic rocks in South Dakota are used as road metal, as aggregate for concrete, and as flagstone.

Quartzite

The pink rock that is found in places at Sioux Falls, Garretson, Dell Rapids, Spencer, and Alexandria in eastern South Dakota is quartzite. It is readily distinguishable by its color and stands out in contrast to other rocks and soil at the surface. As a component of glacial deposits the pink quartzite is readily identified.

Quartzite also is found in the Black Hills. The rock is blue to blue-black in color and occurs as layers in schist. A good place to look is in the area of Hill City to Pactola Lake along U.S. Highway 385.

Schist

Schist is found in outcrops in the general area from Pringle to Lead, South Dakota. The rock is light gray, brown, and green in color and shows well developed cleavage. The dark-green color is caused by the presence of the mineral chlorite. Some of the schists contain much mica which causes the rock to glitter as light is reflected from the platy mineral face of the micas. Minerals in schist usually are large enough to be identified by the unaided eye.

Slate

In the general area from Pringle to Lead, South Dakota, slate may be found in outcrops along the road sides. The rock is light gray, brown, green, and black in color and it exhibits good cleavage. Slate differs from schist in that the rock is composed of very fine-grained minerals. The minerals particularly are too small to be recognized by the unaided eye. Like the schists, the reflected light from the platy mica crystals is a common feature.

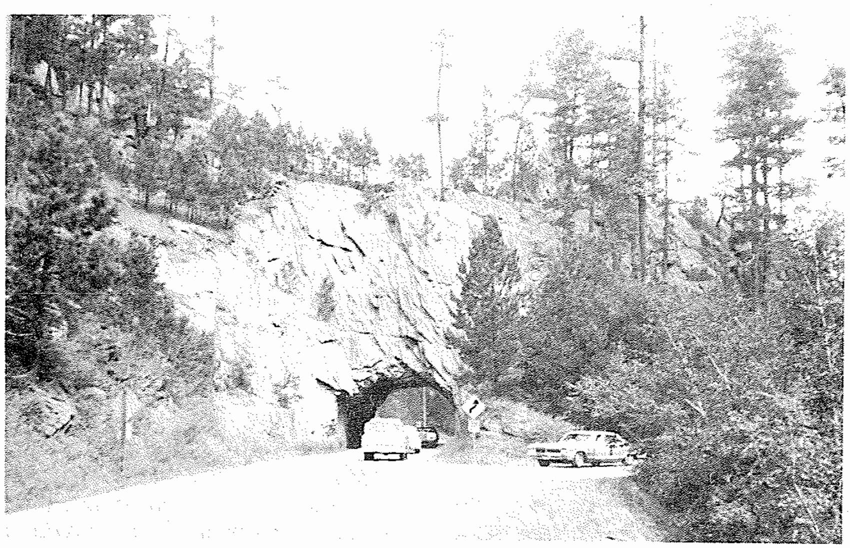
Gneiss

Along Little Elk Creek about 3 miles north of Nemo a rock exists that is referred to as a *gneissoid* or *gneisslike*. Other than at this locality, gneiss is not found in place in South Dakota. It may exist as a rock type in unconsolidated glacial material.

ACKNOWLEDGMENTS

Over the years several publications printed by State Geological Surveys have conveyed information about rocks and minerals. These publications were

Sioux Quartzite, Palisades State Park.



Tunnel through Schist, highway 16A near Keystone.

designed especially for rock and mineral collectors who may roam the respective states in search of mineral and rock rarities. In this publication material was drawn freely from published reports of other State Surveys. Particular acknowledgment is given to the following:

Illinois Geological Survey, Educational Series 5, "Guide to Rocks and Minerals of Illinois"

Indiana Geological Survey, Circular No. 4, "Guide to Some Minerals and Rocks in Indiana"; Circular No. 5, "Let's Look at Some Rocks"

Minnesota Geological Survey, Educational Series 2, "Guide to Mineral Collecting in Minnesota"

Pennsylvania Bureau of Topography and Geological Surveys, General Geology Report C-33, "Mineral Collecting in Pennsylvania"

Michigan Geological Survey, Division — Department of Conservation, Publication 42, "Rocks and Minerals of Michigan"

Geological Survey of Alabama, Circular 38, "Rocks and Minerals of Alabama"

Nebraska Conservation and Survey Division, University of Nebraska, Educational Circular 2, "Minerals and Gem Stones of Nebraska"

Bureau of Economic Geology, University of Texas, Guide Book No. 6, "Texas Rocks and Minerals"

For detailed discussion of minerals and localities where they have been found, refer to: Bulletin 18, "Mineralogy of the Black Hills," South Dakota School of Mines and Technology, Rapid City, South Dakota

Happy Collecting !!

APPENDIX

Keys for Indentification of Common South Dakota Rocks and Minerals

Two keys, one for minerals and one for rocks, briefly present clues that may aid the collector in identifying rocks and minerals found in South Dakota. In outline form, the keys are a guide to some of the easily observable properties that various rocks and minerals display.

The minerals are arranged in two groups: 1) those with a metallic luster, and 2) those with a nonmetallic luster. Each group is arranged according to increasing hardness. Other characteristics such as color, streak, cleavage, fracture, and composition are listed.

MINERAL IDENTIFICATION KEY

C - color S - streak	H - hardness Cl - cleavage F - fracture	Remarks	Name and composition

I. METALLIC LUSTER, STREAK COLORED

A. Hardness not more than 2.5

C - lead gray S - black	H - 2.5 Cl - cubic; perfect in 3 directions F - subconchoidal or even	Very heavy; occurs as crystals grains, or masses; easily identified by color and cleavage	**Galena** PbS
C - copper red S - metallic, shiny	H - 2.5 Cl - none F - jagged	Very heavy, apt to have green coating; distorted or wirelike forms; malleable	**Native copper** Cu
C - yellow S - golden yellow	H - 2.5 F - hackly	Shiny yellow color; extremely heavy; flattens easily when hit with hammer	**Gold** Au

B. Hardness greater than 2.5 but not greater than 6.5

C - yellow-brown to black S - yellow-brown	H - 5.5 (may be as low as 1) Cl - none F - uneven	In earthy masses; coloring material in many sandstones conglomerates, and soils; often mixed with and difficult to distinguish from geothite and other iron minerals	**Limonite** FeO(OH) H_2O
C - Silver white S - gray-black	H - 5.5 - 6 Cl - good	Prismatic crystals, brittle commonly in massive units	**Arsenopyrite** FeAsS
C - brassy yellow S - greenish black	H - 6 Cl - poor F - conchoidal to uneven	As compact masses, grains, cubes, and in 8- and 12-sided crystals; commonly with lead-zinc ores	**Pyrite** FeS_2

C - pale brassy yellow to silver white S - greenish gray	H - 6 Cl - poor F - uneven	As fibrous, radiating, tabular and cockscomb crystals or compact masses; usually lighter colored than pyrite, but difficult to distinguish from pyrite; associated with coal, and with lead-zinc ores	**Marcasite** FeS_2
C - reddish-brown gray, black S - reddish-brown	H - 5.5 - 6 may be softer	Commonly occurs as granular or compact masses; shiny, scaly variety is specular hematite. Red earthy variety is red ocher	**Hematite** Fe_2O_3
C - black S - black	H - 6	Fragments cling to magnet, may act as natural magnet known as lodestone	**Magnetite** Fe_3O_4

II. NONMETALLIC LUSTER, STREAK WHITE

A. Hardness not greater than 2 (can be scratched by fingernail)

C - usually white, but may be almost any color	H - 2 Cl - perfect in one direction, less perfect in two others	Commonly found in South Dakota as twinned or needle-shaped crystals in weathered shales containing pyrite and calcium carbonate	**Gypsum** $CaSO_4.2H_2O$
C - white or a shade of green	H - 2	As needle-shaped crystals or powdery coating on pyrite or marcasite; has an astringent taste	**Melanterite** $FeSO_4.7H_2O$
C - yellow greenish-yellow	H - soft (unknown) Cl - good cleavage one direction	Usually occurs as a powder or loosely coherent aggregate or compact masses. Found as coatings.	**Carnotite** $K_2(UO_2)(VO_4)_2\ .nH_2O$

B. Hardness greater than 2 but not greater than 3 (can be scratched by a penny)

C - colorless silver white, gray, brown	H - 2 to 2.5 Cl - perfect in one direction	In scales or "books"; splits into thin sheets; common in sandstones, shales, and in igneous and metamorphic rocks	**Muscovite** (white mica) $(OH)_2KAl_2$ $AlSi_3O_8$
C - brown or black	H - 2.5 to 3 Cl - perfect in one direction	As scales or "books"; splits into thin sheets; common in igneous and metamorphic rocks but not in sedimentary rocks such as sandstone or shale	**Biotite** (black mica) $(OH)_2K(Mg,Fe)_3$ $AlSi_3O_8$
C - purple-lilac yellow-gray white	H - 2.5 - 4 Cl - good basal cleavage	Easily fusible to white globole show crimson in flame test. Commonly found in scaly masses	**Lepidolite** $KLi_2Al(Si_4O_{10})(OH.F)_2$

C - colorless white, gray and various tints	H - 3 Cl - perfect in three directions not at right (rhombohedral)	Common mineral; effervesces vigorously in cold acid; occurs in many crystal forms and as fibrous, banded, and compact masses; chief mineral in limestones	**Calcite** $CaCO_3$
C - white, gray, red or almost any color	H - 3 Cl - perfect in one direction less perfect in two other directions	Very heavy; commonly in tabular crystals united in diverging groups, as laminated or granular masses; associated fluorite	**Barite** $BaSO_4$

C. Hardness greater than 3 but not greater than 5 (cannot be scratched by a penny; can be scratched by knife)

C - white, gray, light yellow	H - 3.5 Cl - in one direction F - uneven	Relatively heavy; effervesces in acid; associated with fluorite and barite	**Witherite** $BaCo_3$
C - white, pink, gray, or light brown	H - 3.5 Cl - perfect in three directions, not at right angles (rhombohedral)	In grain, rhombohedral crystals and cleavable or granular masses; effervesces slowly in cold acid when powdered, more vigorously in warm acid; principal mineral in rock called dolomite	**Dolomite** $CaMg(CO_3)_2$
C - colorless white, gray grayish black	H - 3.5	In fibrous or compact masses, or may be in orthorhombic crystals as a coating on galena; very heavy; effervesces in acid; formed by alteration of galena	**Cerussite** $PbCO_3$
C - brown to gray S - usually white but may tend toward brown when weathered	H - 3.5 Cl - in three directions no at right angles (rhombohedral) slightly curved surfaces	In fibrous or botryoidal masses or rhombohedral crystals; effervesces in hot acid	**Siderite** $FeCo_3$
C - yellow, yellow brown to black S - light yellow to brown	H - 3.5 Cl - parallel to dodecahedral faces; in six directions	In crystals, in fibrous or layered masses; associated with galena, with fluorite also	**Sphalerite** ZnS
C - gray, brown black S - reddish-brown to black	H - 4 Cl - good	Usually striated short crystals may be massive	**Wolframite** $(FeMn)WO_4$

C - colorless white, yellow purple, green, blue	H - 4 Cl - perfect, parallel to octahedral faces; in four directions	In cubes and cleavable masses; many colors; mined in Illinois	**Fluorite (Fluorspar)** CaF_2
C - white-yellowish white	H - 4.5 - 5 Cl - good	Uneven fracture Fluoresces white	**Scheelite** $CaWO_4$
C - white tinted yellow blue, or green	H - 5	As crystalline incrustations or in earthy or compact masses; associated with fluorite-sphalerite ores and with galena and spahlerite	**Smithsonite** $ZnCO_3$
C - green-blue	H - 5	Conchoidal fracture brittle tabular crystals but may be massive	**Apatite** $Ca_5(PO_4)_3F$

D. Hardness greater than 5 but not greater than 7

C - white, green, brown, black	H - 5 to 6 Cl - in two directions, intersecting at about 60° and 120°	In long slender 6-sided crystals, cleavage angle important in differentiating from pyroxenes; common in metamorphic and some igneous rocks	**Amphibole Group** $(Mg,Fe,Ca)_7$ $(Si_8O_{22})(OH)_2$ (may also contain Na or Al)
C - gray, dark green, black, dark brown	H 5 to 6 Cl - in two directions intersection at about 90°	Crystals short, stout, and 8-sided; cleavage angle important in differentiating from amphiboles; common in igneous and some metamorphic rocks	**Pyroxene Group** $(Mg,Ca,Fe)_2$ $Si_2O_6)$
C - white gray, pink, light blue	H - 6 Cl - in two directions nearly at right angles	As crystals, cleavable masses and grains; common in igneous and metamorphic rocks, also in stream gravel and sand; many varieties	**Feldspar Group** K,Na,Ca,Ba $(Al,Si)_4O_8$
C - black brownish-black S - dark red to black	H - 6 Cl - good prismatic	Good. Frequently tarnished iridescent. Opaque to transparent in thin splinters	**Columbite** $(FeMn)(NbTa)_2O_6$ **Tantalite** $(FeMn)(TaNb)_2O_6$ always occur together
C - white when pure may be colored by impurities	H - 7 F - conchoidal	Finely crystalline variety of quartz; botryoidal or concretionary masses; lining in geodes	**Chalcedony** SiO_2

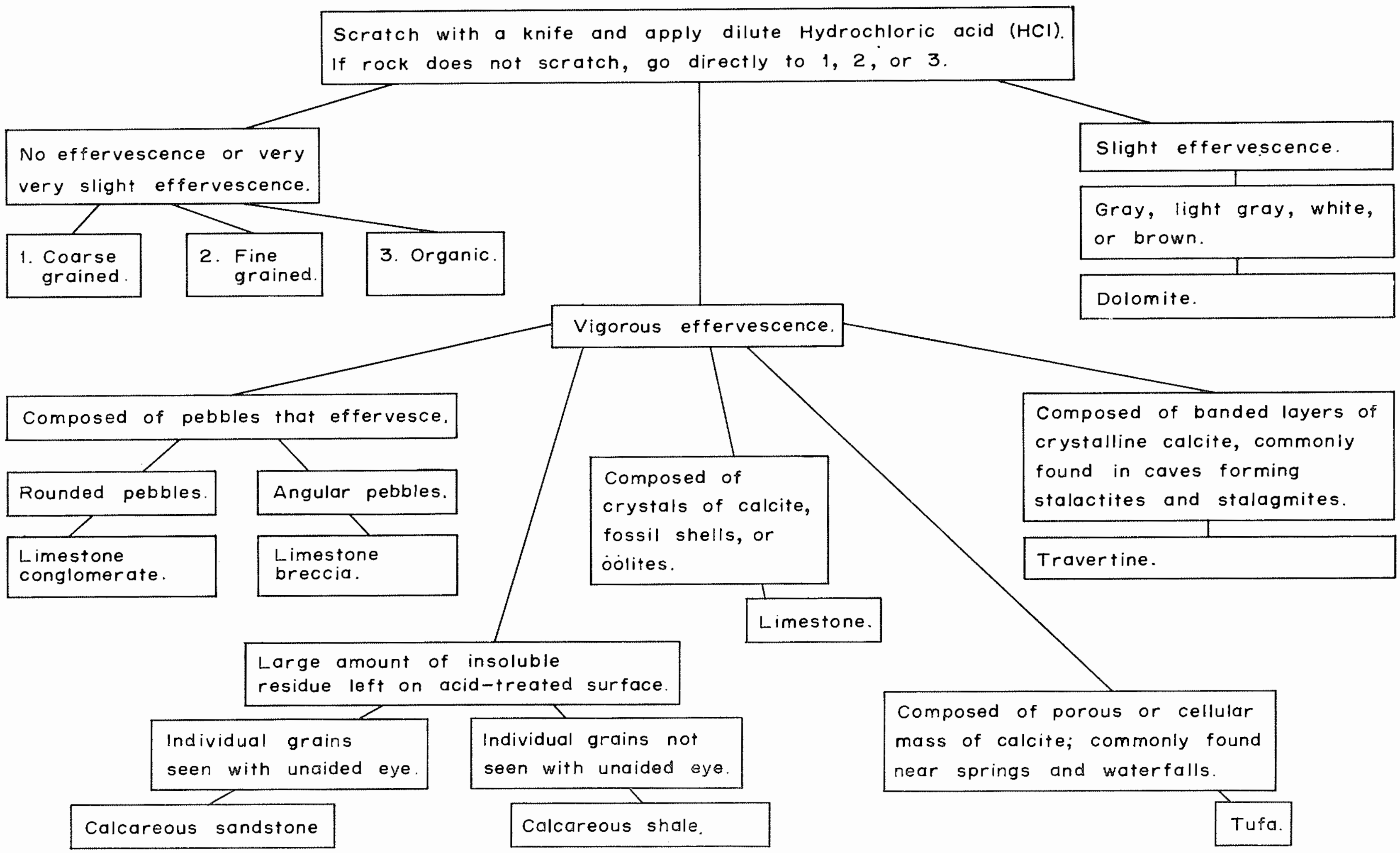
C - colorless white, or almost any color	H - 7 F - conchoidal	Most abundant mineral; occurs in 6-sided crystals capped by pyramids, in grains or masses; principal mineral in sandstone, also abundant in igneous and metamorphic rocks; is a variety of silica	**Quartz** SiO_2 Variety names - flint, chert, smoky, rose, milky, amethyst
C - red	H - 7 F - conchoidal	A variety of quartz usually colored red by hematite inclusions; common in glacial and river sand and gravel found along Lake Michigan shores and in the Mississippi River	**Jasper** SiO_2
C - many; arranged in bands	H - 7 F - conchoidal	Cloudy banded variety of silica; widely used as semi-precious stones. Onyx and silicified wood are forms of agate; found in glacial gravels and upper Mesozoic sediments	**Agate** SiO_2
C - white, gray, pink, yellow, green	H - 7 Cl - perfect prismatic	Characterized by prismatic cleavage. Li gives crimson flame test. Not soluble in acid	**Spodumene** $LiAlSi_2O_6$

E. Hardness greater than 7 (cannot be scratched by quartz)

C - red, brown, yellow, green, black, white	H - 7.5 Cl - poor F - even	Irregular grains or masses Sometimes as 12-,24- and 36-sided crystals; abundant in glacial sands and Lake Michigan beach sands; common in metamorphic rocks	**Garnet Group** $(Ca,Mn,Fe,Mg)_2$ $(Al,Cr)_2(SiO4)_3$
C - black, green, pink	H - 7 to 7.5 Cl - poor F - uneven	Rounded triangular cross section. Coal like fracture. Vertical striated on prism face.	**Tourmaline** $B_3Al_3(AlSi_2O_9)_3$ O, OH, F
C - green, light yellow, bluish-green	H - 7.5 to 8 Cl - poor F - uneven	Hexagonal crystals. Note vertical striated and grooved along prism	**Beryl** $Be_3Al_2Si_6O_{18}$

The rocks are arranged according to their reaction to dilute hydrochloric acid applied to a scratched surface. (The acid reacts more readily to powdered material produced by scratching the rock.) After the reaction to acid has been determined, the texture and components of the rock should be noted. Because rocks grade into one another, clear distinctions are not always possible.

ROCK IDENTIFICATION CHART



I. COARSE-GRAINED ROCKS

A Rock consists of interlocking grains or crystals: easily seen; too hard to scratch with a knife

1. Crystals aligned in one direction

   a) Crystals in parallel bands with layers of quartz and feldspar separated by mica and other minerals — **Gneiss**

   b) Crystals in thin parallel bands; tends to split into thin sheets parallel to banding; some varieties may be scratched with a knife — **Schist**

2. Crystals not aligned in any particular direction

   a) Light gray, pink, red, or tan with only a few dark minerals; feldspar and quartz principal minerals — **Granite**

   b) Dark to medium gray; composed of feldspar and dark minerals with little quartz — **Gabbro**

   c) Dark green to black; essentially dark minerals, may have some feldspar; quartz generally lacking — **Peridotite**

   d) Light color; similar to granite in texture but lacks quartz; composed of feldspar and some dark minerals — **Syenite**

   e) Large, easily seen crystals set in a fine- to extremely fine-grained background; any color — **Porphyry**

   f) Essentially quartz; grains may be identifiable; specimens break through rather than around grains — **Quartzite**

B. Rock composed of individual rock particles or fragments, non-interlocking crystals, cemented or not cemented together; may or may not be scratched with a knife.

1. Particles or fragments not uniform in size; a mixture of pebbles, sand, and smaller materials

   a) Solid rock consisting of particles or fragments generally rounded and cemented together — **Conglomerate**

   b) Solid rock consisting of particles or fragments, generally angular and cemented together — **Breccia**

   c) Fragments ranging in size from clay to large boulders; may be compacted, but not cemented; much clay generally present; may effervesce — **Glacial till**

   d) Loose particles of many sizes, not cemented together; some particles may effervesce — **Gravel**

2. Rock particles or fragments, about the size of grains of sugar (2 to .05 mm)

   a) Loose particles consisting largely of quartz — **Sand**

   b) Solid rock consisting largely of quartz; can be separated easily into individual particles; granular; breaks around rather than through grains — **Sandstone**

II. FINE-GRAINED ROCKS

A. Cannot be scratched easily with a knife, crystals or particles not easily seen with the unaided eye; very hard, difficult to break; may contain a few crystals or particles large enough to see; granular

1) Dense; brittle; splintery or conchoidal fracture; sharp edges and corners when broken; often associated with limestone; usually white or gray; very dense, dull varieties called flint	**Chert**
2) Light gray, pink, red, or tan varieties common; boulders or fragments in the glacial drift	**Felsite**
3) Dark gray, greenish, black, or maroon varieties common; may have small mineral-filled cavities; occurs as boulders or fragments in the glacial drift	**Basalt**
4) Essentially quartz; grains may be identifiable, specimens break through rather than around grains	**Quartzite**

b. May or may not be scratched with a knife; fairly uniformly fine grained

1) Soft, feels slippery or soapy when wet; may disintegrate in water; gives off an earthy odor when breathed upon	**Clay**
2) Loose; gritty; particles smaller than table salt	**Silt**
3) Solid rock; often in thin beds or sheets; separates into silt; mica flakes may be present; may contain fossils; may effervesce slightly	**Siltstone**
4) Solid rock; breaks into thin platy sheets; may feel slippery when wet; black to gray; may contain fossils; shows thin laminations; may effervesce	**Shale**
5) Solid rock; does not break into thin platy fragments; may effervesce slightly	**Mudstone**
6) Solid rock; usually gray or black; splits into platy sheets or slabs; harder than shale	**Slate**
7) Powdery; white or light brown; commonly associated with chert and quartz from which it forms	**Tripoli**

III. ORGANIC ROCKS (DARK COLORED)

A. Soft, spongy when wet; very lightweight when dry; forms in swampy places

1) Fine mass with coarse plant fragments; dark gray to black	**Peat**
2) Plant fragments small and not easily recognized; fine-grained; black to dark gray; earthy	**Muck**

B. Hard but can be scratched with a knife

1) Black; contains bands of shiny and dull material; burns well	**Coal**
2) Dark gray to black; does not contain shiny bands; splits into thin sheets; burns poorly or not at all	**Bituminous shale**

EQUIPMENT FOR COLLECTING

1. Hammer (bricklayer's) with one chisel or pick head.

2. Cold chisel about 6 inches long with an edge about ½-inch wide.

3. Dilute hydrochloric (muriatic) acid (10 percent solution) in a dropper bottle for testing the presence of carbonate minerals. Mark the bottle **P O I S O N.** If acid is spilled on skin or clothing, wipe immediately and, if possible, rinse with water.

4. Magnifying glass or hand lens — 10 power is probably most useful.

5. Hardness testers — penny, square of window glass, pocket knife, or nail.

6. Streak plate — piece of unglazed white porcelain (such as the back of a tile) for testing the color of the streak of minerals.

7. Notebook and pencil for keeping records of the locality and bed from which specimens were collected.

8. Collecting bag — a musette bag, a knapsack, or similar bag of strong material.

9. Heavy gloves and goggles to protect hands and eyes.

10. Labels and wrappings. Field identification of specimens may be written on adhesive tape and attached to the specimen or on a slip of paper enclosed in the wrapping. Newspaper, brown paper, or paper bags can be used for wrapping specimens. Label the outside of the wrapped specimen too. Take only the best specimens home with you. Trim specimens to hand size (about 2 by 3 inches).

    All specimens should be labeled with the following information: Name of mineral or rock type, where found, collector's name, and date. As your collection grows, you may want to set up a system of cataloging. List specimens and assign a number to each one. Place a small amount of white enamel on a corner of each specimen; when the enamel dries, number the sample with India ink; coat number with lacquer. Corresponding numbers should be entered on your list of specimens.