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THIS TEACHER'S GUIDE FOR A UNIT ON PETROLOGY IS SUITABLE FOR ADAPTATION AT EITHER THE UPPER ELEMENTARY OR THE JUNIOR HIGH SCHOOL LEVELS. THE UNIT BEGINS WITH A STORY THAT INTRODUCES VOLCANIC ACTION AND IGNEOUS ROCK FORMATION. SELECTED CONCEPTS ARE LISTED FOLLOWED BY SUGGESTED ACTIVITIES. A BIBLIOGRAPHY, FILM LIST, VOCABULARY LIST, AND QUESTION AND ANSWER SECTION ARE INCLUDED. (DH)

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Baton Rouge, LA.

UNIT: PETROLOGY

LOUISIANA ARTS AND SCIENCE CENTER

1967

PETROLOGY

A STUDY OF ROCKS

INTRODUCTION

A good introduction to Petrology is the story of the farmer in Mexico and the Paricutin Volcano. A Mexican farmer named Dionisio Pulido was plowing his cornfield on February 20, 1943, and he realized the ground under his bare feet felt unnaturally warm. This struck him as strange, just as strange as the rumblings that had been coming from under the earth for the last two weeks. But since early spring planting must be done, Pulido continued to prepare his soil for seeding. Suddenly, to his astonishment, a patch of ground collapsed near his feet, the rumbling became a roar, and a column of white smoke rose from a crack that appeared in the ground. Soon a tremendous explosion tore through the patch of ground that had just sunk. Dust, rocks, and great black clouds were thrown many hundreds of feet into the air. Terrified, the Mexican farmer rushed to the nearby village of Paricutin to tell his neighbors of the dreadful things happening in his cornfield. But by the time Pulido arrived, they had already heard the noise of the explosion and had seen the black clouds. In panic, they were piling their belongings into carts and onto their burrows, and preparing to flee for their lives.

Ask the class if they know what is happening. Ask if someone will explain why a volcano erupts. After several students give their version the physiographic relief globe could be shown and an explanation of the various layers inside the earth given. Some reasons for heat formation in the earth are:

1. Radioactive minerals. Over very long stretches of time these minerals "decay," or break up, into other substances. As they do so, heat is given off, just as it is by atomic reactors.

2. To the above heat is added more heat from chemical reactions in the earth's crust.

3. Still further heat is created, here and there, by friction, as big sections of the crust shift and rub against one another.

4. Some heat comes from the very core of the planet, which may be molten.

Explain to the class how all of this heat and pressure from the weight of the bedrocks, is constantly at work on the material that makes up the crust. Near the surface, show on the globe how this material is in the form of bedrocks, which consist of distinct minerals. Deeper down, heat and pressure probably keep the material in a "doughy" form, which geologists call magma. This magma finds weak spots in the earth's crust and comes forth to the surface as a lava flow or a volcano. The models of volcanic action should be shown and explained.

Put the word igneous on the board and define it. Igneous means made from fire. Explain to the class the following:

Much of the rock that we see is made in this manner. The magma reaching the surface is called lava. Some lava that is blown forth from the volcano and falls to earth takes on different forms.

Bomb. A round piece of newly-hardened lava that takes its shape while flying through the air.

Block. A piece of lava that has sharp corners.

Cinders. Course pieces of rock that are formed while flying through the air.

Pumice. Very bubbly rock that is puffed up by gas. It actually floats.

Show the class the other rocks that have been brought. Explain the following about each:

Granite is greatly used for buildings and monuments. You can see the crystals in this rock.

Basalt forms some famous columns. It is found farther away from volcanic opening than granite.

After the display rocks have been passed around for inspection, use the model volcano to demonstrate how a volcano works. Put on the board these concepts:

1. Beneath the earth there is tremendous heat and pressure.
2. This heat and pressure causes magma to force its way to the surface of the earth.
3. It is this cooled magma which forms a large portion of the rocks.
4. There are other ways in which rock is formed.

Discuss each of these concepts with the class briefly.

The following is a list of student activities. These can be done by groups or by individual students to be presented to the class during the appropriate class discussion or at the end of the unit as a culmination project.

1. Rock Hound: Collect different kinds of rocks. Separate them into igneous, sedimentary, and metamorphic rocks. Label the rocks and arrange them as a display with a brief statement explaining each group.

2. Learn to read contour maps. Write to the United States Geological Survey Department of the Interior, Washington, D. C., to find out whether a contour map has been made for the area where you live. If so, get one and study it. Explain the use of such a map.

3. Find a place where you can observe the materials beneath the topsoil, such as an excavation for a road or building, or the side of a gully or stream bank. How can you identify the top soil? How deep is it? What kinds of materials are beneath the top soil? Learn to observe carefully.

4. Prepare a report on the work of Baron Cuvier and William Smith with fossils. How has their work helped to determine the age of different rock layers?

5. In reference books read about the following topics: earthquakes; seismographs; floods; waterfalls; oxbow lakes; ice age; icebergs; springs; oceanography; water softening.

6. Perform an experiment to show what materials the soil contains.

7. Make a collection of about twenty-five easily carried stones. Put these in groups having but one kind of stone in each. How many groups have you? Try to find out from a geology textbook the kinds of stones found in each group and write a report on your findings.

8. List all the things used in the construction of your house that came directly from rocks. List those that came from earth products. List all the utensils used in the home that originated directly or indirectly from the earth.

9. Look up information on one of the following and prepare a report:

   a. How earthquakes are detected.
   b. How underground deposits of petroleum are located.
   c. How limestone caves are formed.
   d. How petroleum is refined.
   e. How magnesium is obtained from sea water.
   f. How alluvial deposits are formed.
   g. How tsunamis (tidal waves) are produced.

10. Give a report on the formation of coal.

11. On a world map show the location of some famous volcanoes: Vesuvius, Stromboli, Mauna Loa, Pelee, Etna, Paricutin.

12. Demonstrate how crystals are formed.

13. Demonstrate how fossils are formed.

14. Demonstrate how the formation of one type of rock can be imitated.

15. Demonstrate a test for limestone.

16. Bring in examples of various minerals. Class project.

17. Demonstrate to the class how materials combine.

18. Demonstrate what makes an earthquake.

19. Demonstrate how adobe bricks are made.

20. Find out and report to the class how the Indians made arrowheads of rock. What other tools did the Indians make from rock?

21. Define the words china, porcelain, glaze, ceramic, and quarry and tell the class.

22. Be responsible for a bulletin board containing pictures of interesting rocks.

23. Make a table top display showing the difference between the formation of intrusive and extrusive rocks.

24. Arrange a display showing clastic sediments, chemical sediments, and organic sediments.

25. Give a report on the source of precious stones.

26. Keep a bulletin board corner for news clippings of any earthquake activity in the world.

27. Perform an experiment to show the class that heat is produced by pressure.

The following demonstrations and experiments were taken from many sources. They are recorded here for your convenience. You may want to put them on cards for easy use and filing.

I. Problem: What are some of the common minerals?

A. Grade Level: Upper Elementary and Junior High School

B. Materials:

1. Common mineral specimens, calcite, semiprecious stones from costume jewelry, precious stones, quartz, and metallic minerals.

2. Reference books, encyclopedia.

C. Procedure:

1. Have some former student or a teacher of geology display a collection of minerals.

2. Students should gather various minerals that interest them and should form a study committee. Student research could well be carried on as an independent project.

3. Each committee should study the specimens and research in order to answer some typical questions: What minerals are included in this group? What are their properties? Where are they found?

4. Research findings should be consolidated and presented to the class.

D. Results: The children should learn the names, the basic properties, and important uses of some common minerals.

II. Problem: How do materials combine?

A. Grade Level: Upper Elementary and Junior High School.

B. Materials:

1. Sulphur powder
2. Iron filings
3. Two test tubes
4. Magnet
5. Hot plate or burner
6. Saucer

C. Procedure:

1. Mix sulphur and iron filings in a test tube.
2. Shake the two elements together.
3. Pour them out onto a saucer.
4. Using a magnet, separate the iron filings from the sulphur.
5. Put twice as much sulphur as iron filings into a second test tube.
6. Heat this one over a hot plate.
7. Cool.
8. Break the test tube and remove the material from it.
9. Using the magnet, try to separate the iron filings from the sulphur.

D. Results: When the iron and sulphur are mixed in the first test tube, the magnet picks out all the iron filings. When the iron and sulphur are mixed in the second test tube and heated, a change in color occurs. The magnet is unable to separate the iron filings from the sulphur.

E. Supplemental information:

A mixture is the mixing together of two or more elements retaining its individual properties. A compound is the union of two or more elements with a chemical change and each element is no longer in its original form.

III. Problem: How are crystals formed?

A. Grade Level: Upper Elementary and Junior High School

B. Materials:

1. Stove or hot plate
2. Quart mason jar; one quart of water
3. Three ounces powdered alum; this may be purchased from any drug store
4. Tint or vegetable dye
5. Circle of blotting paper, filter paper, or cheese cloth.

C. Procedure:

1. Fill mason jar with water, pour into pot and heat to rolling boil. Add three ounces of powdered alum to boiling water.

2. Boil for few moments, turn off heat.

3. Stir, add pinch of color.

4. Remove from stove, pour into jar through filter.

5. Allow to stand twenty-four hours. Tap jar occasionally while mixture is cooling to help formation of crystals.

D. Results: Crystals form in the bottom of the jar. If you suspend a small basket made of pipe cleaners or a ball of cotton in the solution, the crystals will adhere to it and make a decorative object.

E. Supplemental information:

Crystals have different shapes and are formed in many different materials. To study different formations of crystals put both alum and sugar crystals on a slide under a microscope of low magnification. The alum crystals are diamond shaped; the sugar ones, cube shaped.

IV. Problem: What is a test for limestone?

A. Grade Level: Upper Elementary or Junior High School

B. Materials:

1. Hydrochloric acid
2. Glass rod
3. Limestone
4. Several other rocks

C. Procedure:

1. Using a glass rod, put a drop of the hydrochloric acid on each rock.

2. Notice in each case whether the rock fizzes.

D. Results: The limestone will bubble.

V. Problem: How may imitation fossils be made?

A. Materials:

1. A pint bowl
2. An old spoon
3. A pasteboard-box cover about three inches square and one-half inch deep
4. Portland cement. Plaster of Paris may be used as a substitute.
5. Water
6. A small fern leaf or other object with which to make an impression.

B. Procedures:

1. Mix the Plaster of Paris or cement.

2. Lay the fern leaf on the surface of the cement paste in the box cover and gently press it into the cement so that the upper surface of the leaf is even with the cement surface.

3. Set it away for twenty-four hours with the leaf embedded in the cement surface.

4. Examine the cement and the fern leaf. What has happened to the pasty cement?

5. Lift the leaf out of the cement block. It may be necessary to use the point of a knife or a pin to remove it neatly.

6. What do you find where the fern was embedded?

7. Make a line drawing of the cement or plaster block with the fern impression in the surface.

C. Results: The experiment that you have performed with pure cement or Plaster of Paris illustrates what happens to objects over long periods of time, perhaps thousands of years, in the earth where cement is impure and mixed with other substances.

VI. Problem: Does pressure and crushing cause heat?

A. Grade Level: Intermediate

B. Materials:

1. Ice pick
2. Small spongy-rubber ball
3. Thermometer
4. Thread
5. Book

C. Procedure:

1. With an ice pick punch a hole into the center of a small, spongy-rubber ball.

2. Into this hole a tiny thermometer bulb and tube is introduced.

3. Then the ball is rolled on the table top, under heavy pressure from a board or book.

4. A thread is first tied around the thermometer tube to mark the level of the mercury before the rolling begins. Care must be taken not to break the thermometer.

5. After five minutes of pressure and kneading of the sponge ball, the thermometer shows an increase of ten degrees or so.

D. Results: This experiment demonstrates that pressure does cause heat.

BIBLIOGRAPHY

Books

Cassanova, Richard. An Illustrated Guide to Fossil Collecting. Naturegraph, 1957.

Comfort, Iris T. Earth Treasures: Rocks and Minerals. Edgewood Cliffs: Prentice Hall.

Evans, Eva Knox. The Adventure Book of Rocks. Capitol, 1955.

Forsee, Aylessa. Beneath Land and Sea. Philadelphia: Macrae Smith Company, 1962. Illustrated.

Fenton, Carroll Lane. Earth's Adventures. New York: The John Day Company, 1942. Pp. 207.

Gallant Roy. Exploring Under the Earth. New York: Garden City Books, 1960. Illustrated by Polgreen.

Metcalfe, June. Mining Round the World. New York: Oxford University Press, 1956.

Parker, Bertha Morris. Stories Read From the Rocks. New York: Row, Peterson and Company, 1941.

Pough, F. H. Field Guide to Rocks and Minerals. Boston: Houghton Mifflin, 1953.

Richards, Horace. The Story of Earth Science. Philadelphia: Lippencott, 1959. Illustrated. Pp. 169.

Shuttlesworth, Dorothy. The Story of Rocks. New York: Doubleday, 1956.
This book is colorful, interesting, and good for identifying rocks.

Syrocki, Boleslaus. What Is A Rock? Chicago: Benefic Press, 1959.

Weaver, Dolla. For Pebble Pups: A Collecting Guide for Junior Geologists. Chicago: Natural History Museum, 1955. Illustrated. Pp. 95.

White, Anne Terry. All About Our Changing Rocks. New York: Random House, 1955. Illustrated. Pp. 142.

Williams, Henry. Stories in Rocks. New York: Henry Holt, 1948. Illustrated. Pp. 151.

Zim, Herbert Spencer. What's Inside the Earth? New York: Morrow, 1953. Illustrated. Pp. 30.

______. Rocks and Minerals. New York: Simon and Schuster, 1957.

Films

Available at the East Baton Rouge Materials Center. Many also available at Southern University.

96 Earth's Rocky Crust
182 Mountain Building
192 Understanding Our Earth: How Its Surface Changes
31 Volcanoes in Action
12 Our Earth

Filmstrips

All are available at the East Baton Rouge Materials Center and most are available at the regional depository at Southern University.

2998 Story of Mountains
3001 Story of Volcanoes
2090 What the Earth is Made of
1205 The Earth is Born
422 Carlsbad Caverns
1761, 1926 How Rocks Are Formed
1760 What is Soil?

The following might be useful in identifying rocks and classifying them. It was taken from World Book Encyclopedia, Volume 16, page 351. There are colored pictures to accompany the text.

Rock	Color	Structure
Basalt	Dark, greenish-gray to black	Dense, microscopic crystals, often form columns.
Gabbro	Greenish-gray to black	Coarse crystals
Granite	White to gray, pink to red	Tightly arranged medium-to-coarse crystals
Obsidian	Black, sometimes with brown streaks	Glassy, no crystals, breaks with a shell-like fracture
Peridotite	Greenish-gray	Large, pipelike formations
Pumice	Grayish-white	Light, glassy, frothy fine pores, floats on water
Rhyolite	Gray to pink	Dense, sometimes contains small crystals
Scoria	Reddish-brown to black	Large pores, looks like furnace slag
Syenite	Gray to pink and red	Coarse crystals, resembles granite but has no quartz
Metamorphic Rocks		
Gneiss	Gray and pink to black and red	Medium to coarse crystals arranged in bands
Marble	Many colors, often mixed	Medium to coarse crystals, may be banded
Quartzite	White, gray, pink, buff	Massive, hard, often glassy
Schist	White, gray, red, green, black	Flaky particles, finely banded, feels slippery, often sparkles with mica
Slate	Black, red, green	Fine grains, dense, splits into thin, smooth slabs
Sedimentary Rocks		
Breccia	Gray to black, tan to red	Angular pieces of rock, held together by natural cement

Rock	Color	Structure
Clay	White, red, black, brown	Fine particles, dusty when dry, muddy and sticky when wet
Coal	Shiny to dull black	Brittle, in seams or layers
Conglomerate	Many colors	Rounded pebbles or stones held together by natural cement
Flint	Dark gray to buff	Hard, breaks with a sharp edge
Limestone	White, gray, and buff to black and red	Forms thick beds and cliffs; may contain fossils
Sandstone	White, gray, yellow, red	Fine or coarse grains cemented together in beds
Shale	Yellow, red, gray, green, black	Dense, fine particles, soft, splits easily, smells like clay

Below is a chart the students might find helpful in beginning a rock collection.

Scale of Hardness of Minerals

Arranged from soft to hard

Hardness	Example	Test for Hardness
1	Talc (from which talcum powder is made)	Can be scratched easily with fingernail
2	Gypsum (from which chalk and plaster of Paris are made)	Can be scratched with fingernail but less easily
3	Calcite	Can be scratched with a pin
4	Fluorite	Can be scratched easily with a knife but it can not scratch glass
5	Apatite	Can be scratched with a knife
6	Feldspar	Cannot be scratched with a knife; it can scratch glass
7	Quartz	Scratches glass easily
8	Topaz	Scratches quartz easily
9	Corundum (ruby, sapphire, and so forth)	Scratches topaz easily
10	Diamond	Scratches other materials, can be

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8	Topaz	Scratches quartz easily
9	Corundum (ruby, sapphire, and so forth)	Scratches topaz easily
10	Diamond	Scratches other materials, can be scratched only with another diamond

Vocabulary

1. Aggregate
2. Bedrock
3. Extrusive
4. Fault
5. Fissure
6. Fossil
7. Geology
8. Humus
9. Igneous rock
10. Lava
11. Lithification
12. Loam
13. Magma
14. Mantle rock
15. Metamorphic rock
16. Mineral
17. Molten
18. Ore
19. Rock
20. Sedimentary rock
21. Strata
22. Stone
23. Volcano

Worksheet

Much of this information was taken from World Book Encyclopedia Volume 16.

1. What do we mean by the term "rock"?

   Rock is the hard, solid part of the earth's crust.

2. Define soil.

   Soil itself is made up of tiny bits of rock usually mixed with organic materials from plants and animals.

3. Where can one find rock?

   Rock is found under a layer of soil in which plants or trees may grow, beneath the oceans, and under the polar icecaps.

4. Where could the layers of rock be seen?

   You can often see layers of rock in the exposed hillsides along highways. Rivers frequently cut deep channels through the rock. Great cliffs of rock line many sea shores. In desert regions, rock cliffs and pinnacles may rise high above sandy plains.

5. What do we mean when we say that most rocks are aggregates?

   Most rocks are aggregates, or combinations, of one or more minerals. Basalt, for example, contains crystals of the minerals plagioclase and pyroxene. Some rocks appear to be dense and massive and have no mineral grains. But if you examine a very thin slice of such rock under a microscope, you can see grains of minerals.

6. What are some of the differences between a rock and a mineral?

   a. Rocks are generally made of minerals and are not usually similar throughout; hetrogeneous. A mineral is similar throughout; homogeneous

   b. Minerals are made up of one or more elements. A definite crystal shape is typical of the mineral. A mineral has a special color, hardness and shape. It is often easy to identify because it is simple in form and composition.
      Rocks are made up of a great variety of materials. Coal, for example, is a common rock made of the remains of plants which were buried millions of years ago. Other rocks are made entirely of shells or bones.

7. What are some of the ways that rocks and minerals are useful to us?

   a. Builders use granite, marble, and other rocks in construction work.

   b. Cement, made from limestone and other rocks, binds crushed stone into strong, long-lasting concrete for buildings, dams, and highways.

   c. Metals such as aluminum, iron, lead, and tin come from rocks that we call ores. Ores also supply such radioactive elements as radium and uranium.

   d. Some rocks contain valuable nonmetallic minerals such as borax and graphite. Asbestos rock has a fibrous mineral that is used to insulate our homes.

   e. All gems, except amber, coral, and pearl, come from rocks. Where do we get these?

   f. Geologists trace the history of the earth by studying rocks.

   g. Geologists find oil deposits by studying different rock layers.

   h. Other scientists study fossils to learn about life that existed millions of years ago.

   i. Thousands of young people and adults enjoy collecting rocks and minerals as a hobby.

8. Since both graphite and diamonds are made only of carbon atoms, why do we classify them differently?

   Rocks are made up of minerals, and the mineral content of rocks vary. This mineral content is one means of grouping or classifying rocks. Each mineral has an atomic structure and a chemical composition different from other minerals. The composition may be the same as in another mineral but the arrangement of atoms will differ, or vice versa. For example: graphite is made solely of carbon atoms. In this arrangement the carbon is soft and is a good lubricant. Diamond is composed of carbon atoms, but in different arrangement than graphite. The carbon atoms take the "diamond" arrangement only under extreme pressure while crystallizing. They become very hard and abrasive.

9. What are the three big classifications of rocks, based on their mode of formation?

   Rocks are classified as igneous, sedimentary, or metamorphic.

10. Explain how igneous rocks are formed.

Deep within the earth there exists molten, or melted, rock material called magma. Magma is under great pressure and is extremely hot, 1380°F. to 2000°F. This hot material sometimes rises to the earth's surface through fissures, or cracks, caused by earthquakes and other deep movements of the earth's crust. Sometimes the intense heat and pressure of the magma weakens the rocks above it until they give way to its force. Igneous rocks form when magma cools and solidifies.

11. What is the difference between extrusive and intrusive igneous rocks?

Extrusive rocks form when magma is extruded, or forced out, onto the surface of the earth. The magma may penetrate the surface as a volcano erupts great masses of hot lava, cinders, and ash, or pours forth great rivers of molten rock. Lava is the name for magma that reaches the surface. Exposure to the cooler surface temperatures causes the lava to harden in a few hours. The minerals it contains do not have time to form large crystals. It may harden so quickly that it forms <u>obsidian</u>, a smooth, shiny volcanic glass; pumice, a finely porous rock frothy with air bubbles; and scoria, a rough rock that looks like furnace slag. Lava that hardens more slowly forms rocks with tiny mineral crystals. These finely crystalline rocks include dark-colored basalts and light-colored felsites. Sometimes a volcano throws lava from the earth with great violence. The masses of lava form lumps of rock that range in size from tiny particles of volcanic dust to volcanic bombs that may be an inch to several feet in diameter. Pieces that become bound together by natural cement are called agglomerate rocks or volcanic breccias.

Intrusive rocks form from magma that does not rise all the way to the surface of the earth. It may push up the surface rock in the shape of a huge blister. Or, it may fill in the folds caused when mountains form. Sometimes it spreads out in sheets between layers of older rocks. Beneath the surface, the molten rock cools and hardens slowly. Rocks formed in this way have coarse mineral grains and crystals that can be seen with the unaided eye. The coarsely crystalline rocks include the granites, syenites, and gabbros.

12. How is sedimentary rock formed?

Sedimentary rock consists of materials that once were part of older rocks or of plants and animals. These rocks were deposited millions of years ago as strata, layers, of loose material. Most of the deposits occurred on ocean floors, but some appeared on land and in fresh water. As time passed, the loose materials changed into solid rocks. Geologists divide these rocks into three groups, according to the type of material from which they were formed. These groups are:

1. Clastic sediments;
2. Chemical sediments; and
3. Organic sediments.

13. What are clastic sediments?

Clastic sediments are rock fragments that range in size from coarse boulders and cobbles, through pebbles and gravels, to fine grains of sand and particles of silt and clay. Rocks break and crumble into fragments by a natural process called weathering. These fragments are carried about and deposited, chiefly by running water, but sometimes by wind and glaciers. Eventually, layers build up and then a lithification, stone-forming process, takes place. Sometimes pressure compacts (squeezes) the water from the deposits. This locks the particles together and forms rocks called siltstone from silt, and shale from clay. Natural chemical substances cement (bind) grains of sand together to form sandstone. Sometimes water-worn boulders, cobbles, and pebbles become cemented together to form conglomerate rocks. Broken and angular pieces become cemented to form breccias.

14. What are chemical sediments?

Chemical sediments are deposits of minerals that were once dissolved in water. The evaporation of the water causes minerals to crystallize, leaving deposits of rock salt (sodium chloride), phosphate rocks (calcium phosphate), and gypsum (calcium sulfate). Many limestone beds form from calcite (calcium carbonate) crystals, and some deposits of iron ore form from the crystallization of dissolved iron oxide. Dissolved silica makes beds of flint rocks.

15. What are organic sediments?

Organic sediments are the shells, skeletons, and other parts of plants and animals. Shellfish take calcite from water and use it to build their shells. Coral polyps use the same mineral to build coral reefs. Coral reefs and piles of shells harden to form fossiliferous limestone. The shells of one-celled animals called foraminifera make chalky limestone such as that found in the famous white cliffs of Dover, England. Coal is formed from ferns and other marsh plants that became buried in swamps and decayed. These deposits of organic matter changed into beds of peat and coal.

16. How is metamorphic rock formed?

Metamorphic rock is rock that has changed its appearance, and sometimes its mineral composition. These changes may be caused by hot magma, pressure and heat from mountain-building movements in the earth, or the chemical action of liquids and gases. All kinds of rock, including igneous and sedimentary, have gone through such metamorphism to produce metamorphic rocks.

17. Give some examples of metamorphic rock formation.

Granite is an igneous rock that contains quartz, feldspar, and mica. Metamorphism causes feldspar and quartz crystals to form layers between which mica crystals often lie in wavy bands. The new rock is called gneiss. Metamorphism recrystallizes the calcite in limestone to form marble. The quartz grains in sandstone become more tightly packed to form quartzite. Soft shales and clays harden to form slate, a rock that easily splits into smooth slabs. Felsites and impure sandstones, limestones, and shales change into schists that glisten with mica and other minerals such as hornblende, chlorite, and garnet.

18. Give some information on the following sedimentary rocks: sandstone, limestone, shale, and conglomerate.

Sandstone. Grand Canyon or Bryce Canyon is made of sandstone, consisting of sand cemented together ages ago. If a rock is sandstone, one can feel the sharp edges of the sand grains. Because of the size, shape, and sharpness of the sand grains, sandstone feels rougher and is more porous than limestone. Sandstone is also used in making glass. One kind of sandstone is made into grindstones. Red, brown, and orange sandstone contain iron. Wherever you see these colors in rock, it is probable that iron is present.

Limestone. This rock is fine-grained, gray, or creamy white. It is rather solid but can be scratched easily with the point of a knife. Another test for limestone is that you can drop a little hydrochloric acid on a broken piece. The acid will work on the limestone, and bubbles of carbon dioxide will come off. Remains of sea creatures millions of years old are sometimes found in limestone. In fact, it is lime from the remains of sea shells that makes up a large part of limestone rock. In Florida there is a rock called coquina which is made of shells partly cemented together. If the layers of shells had remained under water, they would no doubt have been pressed more tightly to form fine-grained limestone. As it is, you can still see the shells, partly broken down. Limestone is a good building stone. It is used for large office buildings, for monuments, and for bridges. The state of Indiana produces about two-thirds of the limestone used in this country.

Shale. This dark-gray rock breaks apart in layers quite easily. Shale is clay mud that has been cemented together under pressure. On the side of a cliff where rocks are exposed, you may find layers of shale, crumbling. Harder layers of sandstone or limestone may be seen between layers of shale. When shale crumbles, it falls to the bottom of the cliff, and the action of the weather keeps on breaking it up until it is once more mud or dust. You will often find the remains of sea creatures in layers of shale.

Conglomerate or pudding stone. This rock consists of sand, mud, and pebbles cemented together. The pebbles in this mixture reminded some people of plums in a pudding, so it was called "pudding stone."

19. Give some information on the following igneous rocks: obsidian, granite, and pumice.

Obsidian. The famous obsidian or natural glass is a rhyolite lava that has cooled very rapidly. No crystals formed at all and the calcium, sodium, and silica in the magma produced as true a glass as ever came from a glass furnace. Obsidian is usually black in color though it comes from a light-colored magma. The true color of obsidian may best be seen by holding a thin fragment up to the light. It varies from straw color to a light, olive brown. Indians of the West and of Mexico discovered the properties of obsidian long before Columbus landed. They made arrowheads, knives, axes, and other cutting tools from this unique rock.

Granite. This rock is very hard and has a mottled appearance caused by bits of a pink or gray mineral. It also has a shiny material that looks like bits of cellophane, and some flecks of a black mineral. The shiny material is mica. It is useful in manufacturing industries because it does not burn and because it is transparent. Sometimes large amounts of mica are found in the earth. It can be separated into thin sheets. The glassy-looking material in granite is quartz. Quartz crystals are glassy, six-sided crystals with a point at each end. Quartz is found in the earth in many different colors. Flint, which Indians used for arrowheads, is a kind of quarts. Many beautiful stones used in jewelry are quartz: amethysts, onyx, and opals, for example. Quartz is a very hard mineral. Granite is not only a hard rock, but it also takes a high polish. For these reasons, monuments and statutes are often made of granite.

Pumice. This rock is sometimes used for scouring. Pumice is a rock made from lava that cooled so quickly that bubbles of air had no time to escape. The air bubbles left holes in the rock. Because of these bubbles, pumice is lightest in weight of any rock and can float on water.

20. Give some information on the following metamorphic rocks: gneiss, marble, and slate.

Gneiss. This rock is very hard and seems to be in bands rather than in layers. It was once granite. Deep in the earth and under great pressure, the granite was remelted and cooled. Minerals in it melted together and formed these bands of color.

Marble. This rock is so beautiful that it is much in demand for statues and monuments. As a building stone it is very expensive. Marble was once limestone. Pure marble is white, but much of it is streaked with color because other minerals were melted with the original limestone deep in the earth.

Slate. This rock is the material of which some roofs and school blackboards are made. It was once soft, crumbly shale, but when it was remelted and cooled deep inside the earth, it became hard. Slate can be broken into sheets.

21. How can a beginner identify rocks?

It is hard at first but it soon becomes easy to recognize certain common types. Many beginners buy inexpensive reference collections of rocks or minerals from rock and mineral dealers. These collections identify common rocks and minerals. You can compare unknown rocks with known specimens.

All minerals have important characteristics, such as chemical composition, and streak color, that help identify them. Experts also study the formations in which certain rocks are found, and the physical characteristics of the rocks.

22. How can the chemical composition of a rock be determined?

Chemical composition may be determined by certain chemical tests for the mineral elements. For example, a simple chemical test for calcite in limestone is to pour soda pop over the rock. The pop, a weak acid, fizzes vigorously on limestone.

22. What is the "streak color" in determining the identification of rocks?

Streak color is the color of the powder obtained by rubbing a mineral across a hard, rough surface such as unglazed porcelain or a file. The powder color often differs from the color of the mineral mass. For example, pyrite (ferrous sulfide) looks yellow in rocks. But its streak color is black. Many minerals have a typical streak color.

23. How can one identify rocks by formations and physical characteristics?

You can often identify rocks by knowing where they are found and how they look. For example, you usually can recognize sedimentary rocks because they lie in stratified or layered, formations. Sedimentary rocks often contain fossils, and many have markings such as old mud cracks or ripple marks caused by waves. Except for volcanic glass, all igneous rocks are solid and crystalline. Some appear dense, with microscopic crystals, and others have larger, easily seen crystals. They occur in volcanic areas, and in intrusive formations that geologists call batholiths, laccoliths, sills, dikes, and stocks. Many metamorphic rocks have characteristic bands, and can be split easily into sheets or slabs.

24. If you wanted to collect rocks and begin the study of geology what equipment would you need?

You would need a hammer with a sharp point instead of a claw, a small chisel, a dull knife for testing the hardness of rocks, and a bag in which to carry your rocks. You will also find a hand magnifying glass useful. Most important of all, perhaps, you should have stout-soled shoes for climbing.

25. Where are some good hunting places for rock samples?

You can find interesting rocks and minerals in many places near your home. Good "hunting grounds" include mines, quarries, building excavations, ocean cliffs and beaches, and the rocky sides of road cuts and river banks.