ROCKS AND MINERALS: THE HARD FACTS

1 videocassette . . . . 17 minutes

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INTRODUCTION

For some people, the study of rocks and minerals is a profession. Skilled and experienced geologists study types and formations of rock in search of rare or valuable mineral resources like uranium, precious metals, oil and coal, and precious gemstones. Engineering geologists study the structure of rocks underlying the foundations of proposed buildings or along the routes of proposed highways. Others monitor earthquakes and volcanic activity in an effort to understand better these processes and make accurate predictions of future activity.

To the inexperienced, the mere classification of a rock may be at once confusing, frustrating, and finally inconclusive. The variety and appearance of the various rocks and minerals that occur at Earth's surface are indeed enormous. But with a little background, understanding, and perhaps the help of a local field guide or geological map, the amateur can quickly learn some of the tricks of quick field identification. These include recognition of 4 or 5 of the most common minerals, determination of texture, and noting the presence or absence of any pattern in the structure of the rock. The vast number of local mineralogical societies indicates that there is a broad range of amateur interest in the study of rocks and minerals. These groups usually welcome new members and interested visitors to their meetings and field trips.

The thoughtful science teacher can use the study of rocks and minerals in a variety of ways and relate it to a wide range of topics. If students are first encouraged to collect and take to school several 'interesting looking' rocks, the teacher is guaranteed plenty of materials and strong student involvement as the samples are discussed and examined.

Observation skills can be directed and honed as students crack open rocks and try to determine crystal sizes and types. Inferential skills are exercised in attempts to explain the alternating bands of light and dark minerals in some metamorphic rocks, or the presence of the imprint of an ancient fern between the layers of a sample of shale. If the students have collected the samples themselves, they have also learned something about field work, an important part of all sciences.

In the study of atomic structure and basic chemistry, minerals and rocks can be used to illustrate such concepts as element, compound, crystal (and 'lattice'), bonding (including types and relative strengths), and mixtures. Simple models of atomic structure can be compared with actual samples so students can see how the chemistry of a substance affects its forms.

PROGRAM DESCRIPTION

In this program, we follow an Earth scientist to several rock outcrops and exposures in order to examine firsthand some of the characteristics of the rocks and minerals of the Earth's crust.

The first stop is at the bottom of an abandoned feldspar quarry, where several minerals are easily observed in relatively pure form. With actual samples, molecular models, and animation, the geologist describes the formation of crystalline solids. Several physical properties that can be used to identify minerals are demonstrated, and tests to distinguish and identify minerals are performed.

Next, we visit an outcrop of nearly horizontal beds of a sedimentary siltstone. Here, the geologist points out some of the distinguishing features of sedimentary rocks, including bedding and fossils. Through animation, the processes involved in the formation of sedimentary rocks are demonstrated.

Finally, we travel to an outcrop of metamorphic rock, where the characteristic banding, or metamorphic 'layering' is explained with the aid of actual samples and a graphic representation of the recrystallization of the minerals of a different type of rock.

The program closes with a summary discussion of the processes involved in the creation of the various rocks of Earth's crust. Here, the concept of the rock cycle is introduced.

SUGGESTED ACTIVITIES

Begin any study of rocks that you undertake with an introduction that directs students' attention to their practical, everyday relationship with rocks. Note, for instance, the use of rocks as building stones in their schools or homes. Concrete (in foundations and roadways, for example) contains sand, gravel, and cement made from quarried limestones or dolostones. Remind students of any local outcrops of rock, and ask them to look carefully for details in the outcrop. Note how the presence of rock controls both the natural and cultural development of the landscape. The paths of rivers, streams, highways and railroads are determined, at least in part, by the nature of the rocks they lie upon. The economic importance of the rocks themselves can be discussed as well, particularly if the rocks in your area yield economic minerals or fuels.

1. Review the Rock Cycle with your class (see Bibliography for sources). Have students work in teams to develop large scale posters of the rock cycle. Actual samples of the various types of rocks can be glued to the poster, and photographs of volcanoes, streams, etc., can be used to illustrate the processes involved. Display the finished products in the hallway or front office.

2. Obtain hand samples (baseball size) and smaller fragments of several of the more common rock-forming minerals (quartz, various feldspars, biotite and muscovite micas, hornblende) and perhaps some of the more 'showy' minerals (pyrite, bornite, iceland spar calcite). Depending on your location, these may be found locally or can be ordered from Ward's (see Bibliography). After a discussion of the physical properties of minerals, have students analyze and neatly record their observations of the color hardness*, luster, streak*, cleavage or fracture, and (if the skills exist) the density or Specific Gravity of the samples. Have them perform the destructive tests on the small samples, preserving the larger samples for use by future classes.

   Finally, have them compare their findings with the properties listed in one of the guides or keys listed in the bibliography. This activity requires careful observation, manipulation of materials, and the use of reference materials, but avoids the frustration of actual identification of unknown samples. Provide several 'unknown* mineral samples for interested students to identify (as described earlier) with the use of field guides or keys.

3. Prepare a labeled set of typical igneous (granite, gabbro, rhyolite, basalt), sedimentary (sandstone, conglomerate, shale), and metamorphic (gneiss, schist, slate) rocks, and have students describe them. Use the student descriptions as a starting point for a discussion of the distinguishing features for each class of rock. Discuss with the class why some features (e.g., banding of light and dark minerals) are more useful than others (e.g., the size or shape of the sample).
4. Have students collect and bring in to class, samples of local rocks. Students should be instructed to record the date and collection site for each sample. This is easily accomplished with a strip of masking tape around the sample. Back in class, a dot of white paint applied to each sample can be marked with a number in black felt-tipped pen. As the students identify their rocks, a numbered key containing collection information and the rock type or name can be made. Egg-sized samples can be neatly stored in egg cartons, and the key taped to the inside of the lid. Provide several 'unknown' mineral samples for interested students to identify (as described earlier) with the use of field guides or keys.
5. Take your class on a field trip to a local road cut or any other relatively fresh outcrop. Point out gross features and small details. (Stay off the Interstate and check with local police concerning local road cuts. Obtain permission from owners of private property, and ask specifically if you may collect.) Have students record their observations and draw sketches or diagrams of specific features. See 'Sources' for help in locating and identifying outcrops in your area.

SOURCES FOR TEACHERS

You and many of your collegues may have little or no experience with rock formation and identification, but it is not difficult to find information concerning the geology of your area. Following are several possible sources of information from local areas:

Your State Geologic Survey, Museum, and Education Dept.

A phone call (or a letter on your school letterhead) to any or all of these agencies will provide you with pamphlets, booklets, and maps free of charge or at nominal cost. Check your phone book for listings.

A local college or university Earth Science or Geology Dept.

Someone in the department will most likely have a good knowledge of the local geology, and can provide you, at least, with a bibliography. If you can, arrange a field trip to visit their lab with your students. A university student may wish to visit your class or lead your class on a field trip. The enthusiasm of most geologists is infectious.

Local Mineralogical and Gemological Societies

Check the phone book and your local library for their listings. These groups generally welcome new members and guests, and they are up on all the good collecting sites in your area. You may be able to arrange for a collector to visit your class. The wild array of crystal types, forms, and colors displayed by their samples will interest most students.

Your local Library

Local libraries often have many of the State publications (see above) in their collections. They may have, in addition, local field guides as well as those mentioned on the next page.

BIBLIOGRAPHY

The following field guides and texts will be useful to the teacher wishing to learn more about rocks and minerals, and to students identifying their samples.

Chesterman, C.W., **The Audubon Society Field Guide to North American Rocks and Minerals.** Knopf, 1978
[Excellent photographs and written descriptions (including physical properties). Includes discussion of rock and mineral formation and classification.]

Cvancara, Alan M., **A Field Manual for the Amateur Geologist.** Prentice-Hall, 1985.

Dictionary of Geological Terms. American Geological Institute, 1982.
[Useful if you read any advanced texts. Also helps with some of the field guides' descriptions.]

Mamowitz, S.M, and Spaulding, M.E., **Earth Science.** D.C. Heath and Co., 1985.
[An excellent high school text. Chapters 3 through 5 provide a concise introduction to rocks and minerals, and the appendix contains a simple identification key.]

Simon and Schuster's Guide to Rocks and Minerals. Simon and Schuster, 1978.
[Excellent photographs and written descriptions (including physical properties). Includes discussion of rock and mineral formation and classification.]

Strahler, A.M., **The Earth Sciences.** Harper and Row, 1971.
[An advanced text for deeper understanding of geologic processes.]

SCRIPT

Narrator

Deep underground, miners chip away at solid rock. Chunks of ore are carried out of the mine on belts and refined into the pure mineral, coal.

People dig for rocks and minerals all over the world, from gem stones in Australia to coal in North America.

To find out what rocks and minerals are and how they form, we're going to travel with an earth scientist, Steve Kluge. We'll see some of the building blocks of the earth's crust and find out how they're transformed into the many rocks of the world around us.

TITLE Rocks and Minerals: The Hard Facts

Steve Kluge:

This is an abandoned quarry. Seventy-five years ago, people were mining here for materials used in the manufacture of ceramics.

When they finished, they left us with this slice in the earth: a good place to study geologic processes. Of course, this slice isn't very deep. It really represents only a scratch into the earth's crust.

The crust is the earth's brittle, rocky,outer layer. It's only a thin skin riding on the hot plastic inner layers. But it's from this thin skin that we get all our rocks, minerals and resources.

This old quarry is a good place to start learning about the earth's crust because several basic earth materials occur here in relatively pure form.

These materials are called minerals. And they're easy to pick out. This is quartz....this is feldspar... and this up here, is a mineral called mica.

Minerals form as individual atoms bond together into an orderly, repeating, three-dimensional structure. These structures are what we call crystals.

Once a crystal forms it will keep growing adding more new atoms to its orderly pattern as long as conditions allow.

As we can see from these models, each mineral has its own specific crystalline structure. This is a model of the mineral, calcite and this, a fluorite. This unique arrangement gives each mineral its own specific physical properties. Some of them are easy to see. For instance, if we talk about *color,* we can see that the quartz is white, while the feldspar is pink. The quartz is also very *hard.* Whereas the mica is soft and flaky.

We can define a mineral as a crystal and solid that occurs naturally in the crust of the earth.

Geologists have identified hundreds of different minerals but only about four occur commonly in the rocks around us.

We can identify minerals by testing them for their physical properties. We'll take a look at the way geologists test for some of these physical properties. The first thing you might notice is that minerals are many different colors, not just pink and white.

This pyrite is so yellow and shiny, it's often called "fool's gold." This amethyst is a deep purple and the bornite is multi-colored.

We can check the color of a mineral in another way, too. These two samples seem to be the same color -a shiny grey. But if we rub each on this white tile, so that a little bit of dust comes off, we get a much different picture.

The color of this powdered mineral is called the mineral's streak.

If we look closely, we see that the minerals are different in a couple of other ways, too. This one here is silver and shiny, almost like metal..while this one is dull and earthy.

The way a mineral reflects light is called its *luster.* And you can see that different minerals have different lusters.

Just by looking, we've already divided the minerals into several different categories. Different colors. Different streaks. And different lusters.

Now, let's compare the minerals to see how hard they are. We usually think of all minerals as being very hard, but some are not as hard as others.

For instance, this mica is so soft that I can scratch it with my fingernail. This mineral is harder - my nail won't make a mark on it, but I can scratch it with a steel file.

This quartz is even harder. It scratches my thumb nail. It'll scratch this mineral. In fact, it's so hard that it will scratch this steel file.

The next test you would do, to identify a mineral, is to break it. I'll show you why:

When we break this mica, we get thin, flat sheets. If I break it again... there's more flat sheets....every time.

Now let's break this one: It didn't break into thin sheets but each piece is the same shape as the original. If I break it again, the pieces are smaller but they're still the same shape as the original.

The way that a mineral breaks is called *cleavage.* And any minerals can be identified by their cleavage. This is because the way a mineral breaks is determined by the arrangement of the atoms in its crystal.

The shape of this model of calcite is reflected in this crystal. Cleaving minerals is one step in preparing gems for jewelry.

Color, streak, luster, hardness and cleavage. These are all simple tests that help us to identify minerals.

But minerals usually do not occur in their pure form. More often we find them together with other minerals in a solid mixture called "a rock." Rocks can be formed in several different ways.

We'll visit some places to see evidence of what some of those processes are.

Narrator:

Originally, the earth was a ball of fiery liquid called *magma.* The first rock formed of this magma cooled and became solid.

This is called igneous rock..because igneous is the Latin word for fire. There are still places deep within the earth where temperatures are hot enough to melt rock into magma. Sometimes the magma is forced up into cooler regions.

Steve Kruge:

When they made this road, workers cut a slice through rock that was formed in just this way. Igneous rock. Let's take a look at it.

The rocks in this wall formed deep within the earth hundreds of millions of years ago. It formed when the magma began to cool.

Tiny crystals of several different minerals formed and grew until they ran out of room. This is the result... an igneous rock called granite. Like all igneous rocks, it's a random mixture of interlocking crystals.

We can see crystals of some of the same minerals that we saw in the quarry. Feldspar, quartz and mica.

Almost all igneous rocks are formed this way but not all igneous rocks look alike. The differences we see tell us more about how the rock was formed. For instance, some rocks may be formed with different minerals. This gabbro was formed from minerals that are rich in iron and magnesium.. .formed from magma that is very different from the magma that formed the granite.

Another thing we can easily see is the size of the crystals. What geologists call the *texture.*

There's a good size crystal with mica right in here. And you can see some very large feldspar crystals throughout the rock.

The quartz shows up over in here., another large crystal. These crystals are large enough to see with the naked eye.

This igneous rock is called rhyolite. It's made of the same minerals that the granite is made of, but the crystals are almost too small to see. This tells us more about how the rock was formed.

Sometimes the magma pushes clear through to the surface. As the magma reaches the surface, gases and water escape from it and it changes its nature somewhat. So we also change its name. It's now called lava.

The lava may build up a mountain we call a volcano. The lava cools to form rock so quickly that the crystals don't have time to grow on it. That's how this rhyolite was formed.

It cooled very quickly and the crystals had no time to grow. The granite cooled very slowly so it has large, easy-to-see crystals.

The two look very different but the only real difference is the time they took to cool.

All of the original rocks of the earth's crust were igneous rocks. Just as these are.

But those original rocks were formed billions of years ago, and since then have undergone many transformations into many different kinds of rocks. We'll take a look at some of those transformations.

Narrator:

After rocks are formed, water, wind and ice very gradually scour and grind them into small particles, like sand and silt.

These particles may be carried by moving water through streams and rivers... and finally into the sea. There the particles, called sediment, settle to the bottom and build up layers.

As the layers become thicker, they are compressed and cemented into rock. This is called sedimentary rock.

If the layer is made up mostly of plant material, it may turn into coal.

If it's made up mostly of chemicals or salts, it may be compressed into lime stone.

If it's a layer of weathered rock particles, it will likely look like this:

Steve Kruge:

The most striking thing about this rock is its layers, the horizontal beds of sediment deposited millions of years ago. Because of the way it was formed, we call this rock, "sedimentary rock."

You'll notice that the layers are very uniform. They stay about the same thickness for some distance. And here, each layer is made of almost the same material as the next.

Most sedimentary rocks are made of particles that have been cemented together. In this case, the particles are so small that they're hard to see with the unaided eye.

In other rocks, the particles may be the size of pebbles, or even small boulders. Sometimes, you can find the remains of ancient animals that were trapped in the sediment as it was compressed into rock. This is called a fossil.

The sediments that form these rocks were deposited, buried and compressed, deep within the ocean. Over millions of years, geological forces raised them to their present position - - part of a mountain range, high above sea level.

Narrator:

It takes great forces to raise rock out of the sea, bend the layers, tilt them and make them into mountain tops. These same geologic forces also work deep in the crust. There, great heat and pressure break and realign the atoms of the mineral crystals.This creates a new structure - - a new mineral.

Steve Kruge:

The result is a rock like this. It may once have been an igneous or a sedimentary rock.

And then, deep within the earth and at great temperatures, pressures were exerted on the rock..like this. The bands that we see here are the new minerals that formed under that great heat and pressure.

We can see that this rock has alternating bands of light minerals and dark-colored minerals.

We can see that the bands in this rock are not nearly as uniform in color or thickness as the layers we saw in the sedimentary rock. This rock is called gneiss.

It's part of a larger class of rocks called the metamorphic rocks. Metamorphic means changed form..and we can see why.

Hundreds of millions of years ago, it may have been like the granite we visited earlier. Or like the layered sandstone. But it was changed under great heat and pressure into a very different kind of rock.

The earth's crust is a complex and constantly changing environment. Its basic building blocks are the minerals.

We usually find minerals in solid mixtures called rock. But even rock is not permanent. There are three things that can happen to any rock. It can be melted, and then cooled to form a new igneous rock. It can be weathered, deposited and compressed to form a sedimentary rock .. or it can be changed by heat and pressure into a metamorphic rock.

Through these processes, sometimes called the rock cycle.. the minerals of the earth's crust are constantly changed and transformed into all the rocks that we see around us.

Narrator:

Traveling with Steve Kruge has been more than just an exploration of some rock outcrops. In a sense, it has been a journey into the heart of the earth, where individual atoms join together to form minerals.

When minerals interlock in rocks, and where rocks themselves, are changed and transformed over the millions of years of geologic history.

END