Benny Blast's Guide to Understanding Rocks and Minerals

Teacher Guide

Steelworks Center of the West
Museum • Archives • Education
Pueblo Colorado

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Colorado State Education Standards met with these lessons:

Exploring How Rocks are Formed
Standard 1: Students apply the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations.
Standard 2: Physical Science: Students know and understand common properties, forms, and changes in matter and energy.
Standard 4: Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. *(Focus: Geology, Meteorology, Astronomy, Oceanography)*

Marshmallow Moosh
Science Standard 1: Students apply the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations.
Science Standard 2: Physical Science: Students know and understand common properties, forms, and changes in matter and energy. *(Focus: Physics and Chemistry)*
Science Standard 4: Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. *(Focus: Geology, Meteorology, Astronomy, Oceanography)*
Math Standard 1: Students develop number sense and use numbers and number relationships in problem-solving situations and communicate the reasoning used in solving these problems.
Math Standard 3: Students use data collection and analysis, statistics, and probability in problem solving situations and communicate the reasoning used in solving these problems.

Learning about the Properties of Minerals
Science Standard 1: Students apply the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations.
Science Standard 2: Physical Science: Students know and understand common properties, forms, and changes in matter and energy. *(Focus: Physics and Chemistry)*
Science Standard 4: Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. *(Focus: Geology, Meteorology, Astronomy, Oceanography)*
Reading and Writing Standard 3: Students write and speak using conventional grammar, usage, sentence structure, punctuation, capitalization, and spelling.
Reading and Writing Standard 4: Students apply thinking skills to their reading, writing, speaking, listening, and viewing.
Science Standard 4: Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.. *(Focus: Geology, Meteorology, Astronomy, Oceanography)*

cde Improving Academic Achievement

Colorado Department of Education Standards Met with these lessons (continued):

The Formation of Coal
Science Standard 1: Students apply the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations.
Science Standard 3: Life Science: Students know and understand the characteristics and structure of living things, the processes of life, and how living things interact with each other and their environment. *(Focus: Biology— Anatomy, Physiology, Botany, Zoology, Ecology)*

Chocolate Chip Cookie Mining:
Economics Standard 1: Students understand that because of the condition of scarcity, decisions must be made about the use of scarce resources.
Economics Standard 2: Students understand how different economic systems impact decisions about the use of resources and the production and distribution of goods and services.
Economics Standard 3: Students understand the results of trade, exchange, and interdependence among individuals, households, businesses, governments, and societies.
Science Standard 4: Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. *(Focus: Geology, Meteorology, Astronomy, Oceanography)*
Mathematics Standard 1: Students develop number sense and use numbers and number relationships in problem-solving situations and communicate the reasoning used in solving these problems.
Mathematics Standard 5: Students use a variety of tools and techniques to measure, apply the results in problem-solving situations, and communicate the reasoning used in solving these problems.
Mathematics Standard 6: Students link concepts and procedures as they develop and use computational techniques, including estimation, mental arithmetic, paper-and-pencil, calculators, and computers, in problem-solving situations and communicate the reasoning used in solving these problems.

Minerals and Their Products
Science Standard 5: Students understand that the nature of science involves a particular way of building knowledge and making meaning of the natural world.

Don't forget to check out available outreach kits and field trip experiences available at the Steelworks Museum. Call the museum for more information (719) 564-9086 or visit their website www.steelworks.us

How to use this guide:

Teacher background information:

The Earth's crust:

Rocks cover the entire surface of the Earth. These rocks are what scientists refer to as the earth's *crust.* Dirt and soil, which contains pieces of crushed rock and living material, is referred to as organic matter, and covers some areas of the Earth's crust. It is referred to as organic matter because it is normally associated with plants and trees, which are living things.

The difference between rocks and minerals:

Minerals have a definite chemical structure. They are composed of certain elements in specific proportions. Rocks, on the other hand, are made of minerals. The minerals may occur in rocks in large masses or in mixtures. Most minerals are formed in a liquid state and develop crystal structures as they solidify. That means they have solid, regular shapes. These shapes vary from simple to complex, from tiny to very large. Some minerals (gems) form beautiful crystals which we use as jewelry. The most famous gems are diamonds, emeralds and rubies. Crystals may vary in color, depending on their chemical content.

Composition of minerals:

Every mineral is composed of different substances, arrangements of these substances, or different amounts of them. The different substances the minerals are composed of are called elements. An element is a substance in its purest form. There are ninety-two elements in nature, although several artificial elements have been made by scientists in the laboratory.

Identification of minerals:

To identify minerals, scientists look for clues. One of the more obvious clues to the identification of minerals is color. Many minerals have distinctive colors, though this clue should not be relied upon heavily many minerals come in different colors. Another clue is texture. Some minerals are rough; others are smooth. Checking for luster or shininess is another way to identify minerals. Some are bright and shiny, like metals. Others may be glassy, others pearly, and some dull.

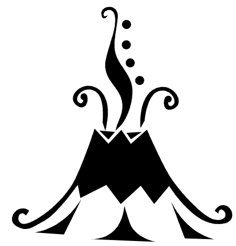
Geologists use a numerical scale called the Mohs Scale to help identify and rank minerals according to hardness. Rocks come in all forms and are not always hard. For example, clay is considered a rock. The hardest mineral on this scale is a diamond, which is given the number 10. The softest mineral is talc, given number 1. Geologists use the same tools that we use to find the hardness of a mineral. They have assigned numbers to the tools; fingernails are a 2 on the Mohs Scale, penny is a 3 and a paperclip is a 5. Higher numbers on the Mohs Scale can scratch lower numbers. Another clue used by geologists to determine the type of mineral is color. Many minerals have distinctive colors Checking for luster and sheen is another way geologists identify minerals. Another clue is texture. Some minerals may be very smooth and glassy while others are rough and bumpy. Geologists also use tools such as magnets to identify minerals. Some minerals, such as hematite, are very magnetic, and can be easily identified. Some minerals, such as fluorite, or fluoresce glow in ultraviolet light.

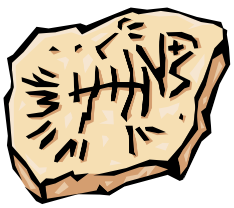
Sometimes the streak test is very helpful. It is conducted by rubbing the mineral across the back of a piece of tile, or unglazed ceramic, so that a streak of powder from the mineral is left. Strangely, the color of this powder streak is sometimes very different from that of the mineral itself. For instance, chalcopyrite has a brassy yellow color but leaves a black streak. Curiously enough, although the color of a mineral may vary considerably, its streak very seldom does. For instance, hematite may occur as red or black, but its streak is always red.

THE CLASSIFICATION OF ROCKS

All rocks are from three main categories: metamorphic, igneous and sedimentary. Scientists classify rocks into categories based on the way the rock was formed.

<ins>**Igneous**</ins> The word igneous means having to do with fire. These rocks came from deep within the earth's crust and are composed of a mixture of hot, melted rock substances, called magma, that flow under pressure. On the surface, they cool quickly and their minerals form small crystals. In the event that the magma does not succeed in reaching the surface, it thrusts itself between or into other preexisting rocks, and cools slowly. Because it is squeezed between or into other rocks along cracks and fissures, it is called intrusive. Igneous rocks are classified according to the minerals in them and by the size of their crystals.





<ins>**Sedimentary**</ins>

When classifying sedimentary rocks, have your students think of the kind of sediment that composes them. Usually these sediments are pebbles, sand, mud (clay), shells and plant life (peat). The deposits can be made in the sea along the edge of a continent or on the land itself. Sometimes sedimentary rocks are formed when the ocean water evaporates and minerals are changed to form vast beds of rock. Wherever deposits of sediment accumulate, whether in the ocean or on the continent, they may be cemented together to form solid rock. Rivers are constantly carrying sediments to the seas or depositing them on flood plains, in lakes, or along the base of mountains. Winds blow fine sediments. Ice erodes and transports both coarse and small fragments. These agents of erosion - wind, water and ice - spread their deposits in wide formations to make sedimentary rock. The best ways to identify a sedimentary rock are by the types of sediment they contain and their gradations. There may be a limestone with shale or shale with limestone depending upon whether mud or lime is the predominant sediment.

<ins>**Metamorphic**</ins>

Metamorphic rocks are originally igneous or sedimentary. Most metamorphic rock forms deep inside the earth, where the intense heat and pressure literally "morphs" them into another kind of rock. In many cases, the changes that they have undergone are so radical that it may be impossible to tell their original form. Therefore, the features of the metamorphic rock must be studied carefully. The best way to identify a metamorphic rock is to determine if the rock is composed of altered sediment and if there is evidence that the original crystals were altered due to pressure and heat. The pressure necessary for the change comes from layers and layers of rock piled on top of one another until they “morph” into another kind of rock.

Minerals can be used in our every day lives:
Almost everything you see or touch has been made directly or indirectly from minerals - glass windows, nails, electrical wiring, and coins. Minerals are also used in making matches, soap, bleaches, microscope lenses, telescopes and eyeglasses. Many of our medicines contain sulfur, zinc, mercury and other mineral ingredients. Today we depend upon uranium for atomic energy. Missiles flying in space need many special metals obtained from minerals. Of greatest importance are the fragments of minerals that make the soil. All of our food depends on them. Minerals are used for industry as well. Graphite, for example, is the "lead" in our pencils. Sulfur is another important industrial mineral. It is extremely valuable in the chemical industry where it is used to make sulphuric acid, a necessary agent in many chemical reactions. Halite is used as a source of both sodium and chlorine. Many minerals are important in making paper. One of these is barite. Jewelry is made of many different minerals, including diamonds, sapphires, rubies and emeralds. The International Gem Society defines a gem as "*minerals that have been chosen for their beauty and durability, then cut and polished for use as human adornment* ."

WEATHERING
Weathering happens when temperature and chemicals break down a rock. Temperature changes cause rocks to expand and contract, causing it to break up. The peeling of rock layers is caused by changes in temperature. Wind, carrying sand and other particles attacks the rock, causing erosion. Water that gets into cracks in the rock may freeze and expand, causing the rock to shatter. Glaciers pick up fragments of rock as they move, trapping the rock in the bottom of the ice. The moving glacier causes even more erosion to the underlying rocks. A weak acid, rainwater dissolves minerals on the surface on the rock. The minerals are then carried down and deposited in the rocks and soil below. New rocks are constantly being made from old rocks. Soil is made of fragments of rocks with their minerals, along with many other substances. The different types of soil are the direct result of the weathering of the rock that makes the soil. Except for the products of the sea, all animals and people are directly or indirectly dependent for food upon the plants that are grown in the soil.

FOSSILS
A fossil is the remains or evidence of a prehistoric plant or animal preserved in a geological structure. Most of the time when a plant or animal dies it is completely destroyed. Sometimes, however, the remains of an animal are buried before they can be destroyed, and if the conditions are just right, the remains are preserved as fossils.
Here is one way that fossils are made:
1. An animal dies and sinks to the sea floor.
2. The body begins to decay and is buried under layers of sediment such as mud or sand.
3. These layers become rock.
4. The hard parts of the animal are replaced with minerals such as iron pyrites or silica. These minerals form the fossil. Most fossils are found in sedimentary rocks. Usually fossils show the hard parts of the animal or plant, like bones or shells. This is because the soft parts are destroyed quickly after death.

What is coal and how is it used?

Coal is a fossil fuel created from the remains of plants that lived and died about 100 to 400 million years ago when parts of the earth were covered with huge swampy forests. Coal is classified as a nonrenewable energy source because it takes millions of years to form. Colorado is ranked sixth in the United States for coal production.

Millions of years ago, dead plant matter fell into the swampy water and over the years, a thick layer of dead plants lay decaying at the bottom of the swamps. Over time, the surface and climate of the earth changed, and more water and dirt washed in, halting the decay process. The weight of the top layers of water and dirt packed down the lower layers of plant matter. Under heat and pressure, this plant matter underwent chemical and physical changes, pushing out oxygen and leaving rich hydrocarbon deposits. What once had been plants gradually turned into coal.

Coal Mining There are two ways to remove coal from the ground: surface mining and underground mining:

Surface mining is used when a coal seam is relatively close to the surface, usually within 200 feet. The first step in surface mining is to remove and store the soil and rock covering the coal (called the "overburden"). Workers use a variety of heavy equipment--draglines, power shovels, bulldozers, and front-end loaders-to expose the coal seam for mining.

After surface mining, workers replace the overburden, grade it, cover it with topsoil, and fertilize and seed the area. These steps help restore the biological balance of the area and prevent erosion. The land can then be used for croplands, wildlife habitats, recreation, or as sites for commercial development.

Underground mining is used when the coal seam is buried several hundred feet below the surface. In underground mining, workers and machinery go down a vertical "shaft" or a slanted tunnel called a "slope" to remove the coal. Mine shafts may sink as much as 1,000 feet deep.

One underground mining method is called **room-and-pillar mining.** With this method, much of the coal must be left behind to support the mine's roofs and walls. Sometimes as much as half the coal is left behind in large column formations to keep the mine from collapsing.

A more efficient and safer underground mining method, called **longwall mining,** uses a specially shielded machine which allows a mined-out area to collapse in a controlled manner. This method is called "longwall" mining because huge blocks of coal up to several hundred feet wide can be removed.

Processing and Transporting Coal

After coal comes out of the ground, it typically goes on a conveyor belt to a preparation plant that is located at the mining site. At the prep plant, the coal is cleaned and processed to remove dirt, rock, ash, sulfur, and other impurities. Removing the impurities increases the heating value of coal.

After the coal is mined and processed, it is ready to go to market. Transportation is a very important consideration in coal's competitiveness with other fuels because sometimes transporting the coal can cost more than mining it.

Huge trains transport most coal (almost 60 percent) for at least part of its journey to market. It is cheaper to transport coal on river barges, but this option isn't always available. Coal can also be moved by trucks and conveyors if the coal mine Is close by. Ideally, coal-fired electric power plants are built near coal mines to minimize transportation costs.

Coal Reserves

When scientists estimate how much coal, petroleum, natural gas, or other energy sources there are in the United States, they use the term **reserves.** Reserves are coal deposits that can be mined using today's mining methods and technology. Experts estimate that the United States has about 265 billion tons of coal reserves. If we continue to use coal at the same rate as we do today, we will have enough coal to last 285 years. This vast amount of coal makes the United States the world leader in known coal reserves.

Where is all this coal located? Coal deposits can be found in 38 states. Montana has the most coal--about 120 billion menial tons. Other top coal states in order of known reserves are: Illinois, Wyoming, Kentucky, West Virginia, Pennsylvania, Ohio, Colorado, Texas, and Indiana. Western coal generally contains less sulfur than eastern coal (which is good for the air when coal is burned), but not always.

The federal government is by far the largest owner of the nation's coalbeds. In the west. the federal government owns 60 percent of the coal and indirectly controls another 20 percent. Coal companies must lease the land from the federal government in order to mine this coal.

Coal Production

Coal production is the amount of coal mined and taken to market. Where does mining take place in the United States? Although coal is mined in 27 states, more coal is mined in eastern states, especially coal that is taken from underground mines, than in western states. However, the West's share of total coal production has increased steadily since 1968 when it provided just five percent of U.S. production. Today the West provides 45 percent of the nation's total production.

Total U.S. production of coal reached one billion tons in 1990, an historic high. The leading coal producing states are Wyoming, Kentucky, West Virginia, Pennsylvania, and Texas.

Some coal produced in the United States is exported to other countries. Last year, foreign countries imported seven percent of all the coal produced in the U.S. The five biggest foreign markets for U.S. coal are Japan, Canada, Italy, Brazil, and Belgium.

How Coal Is Used

What do we use coal for? Electricity is the main use. Last year 88 percent of all the coal used in the United States was for electricity production. (Other energy sources used to generate electricity include nuclear power, hydropower, and natural gas.)

Another major use of coal is in iron and steelmaking. The iron industry uses coke ovens to melt iron ore. **Coke,** an almost pure carbon residue of coal, is used as a fuel in smelting metals. The United States has the finest coking coals in the world. These coals are shipped around the world for use in coke ovens.

Coal is also used by other industries. The paper, brick, limestone, and cement industries all use coal to make their products.

Contrary to what many people think, coal is no longer a major energy source for heating American homes or other buildings. Less than one percent of the coal produced in the U.S. today is used for heating. Coal furnaces, which were popular years ago, have largely been replaced by oil or gas furnaces or by electric heat pumps.

Title: Exploring How Rocks are Formed
Time: 1 class period
Lesson Objective: Students are introduced to the three types of rocks: igneous, sedimentary, and metamorphic and perform activities which will help them understand the conditions leading to rock formation.

Colorado Department of Education Standards met:
Standard 1: Students apply the processes of scientific investigation and design, conduct, communicate about, and
evaluate such investigations.
Standard 2: Physical Science: Students know and understand common properties, forms, and changes in matter and energy.
Standard 4: Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.
(Focus: Geology, Meteorology,
Astronomy, Oceanography)

Materials needed:
For each student:
A rock (from the classroom collection)
Journal
Hand lens or microscope

For each group of 4 students:
Computers with internet access
1/2 cup peanut butter
12 crackers
Plastic knife and spoon
12 pieces of saltwater taffy (three different colors)
8 pieces of waxed paper
4 candy molds
Large spoon

For the class:
Chalkboard/white board
samples of igneous, sedimentary, metamorphic
hot plate
equivalent of 2 cups of almond bark (to melt)

Lesson Procedure:
1. Discuss with the students the concept that rocks vary in appearance according to how they are formed. Go over the information on the three kinds of rocks and how they are formed. Make a class chart with the names
and definitions of the three types of rock and examples of each. Have the students copy the information into their journals. Talk about what a “cycle” is, and how one kind of rock can become another kind of rock.

2. Have each student get his or her rock from the class collection and examine it with a hand lens. Ask them to think about which of the three types of rocks they have. Visit the ISM Geology Online GeoGallery at http://geologyonline.museum.state.il.us/geogallery/search.php?mode=simple and look at the rocks. Ask: “Is your rock shown on the Web site? What is your rock’s name?” “What type of rock is your rock?” (The rocks on the web site are listed according to type.).

Exploring How Rocks are Formed Lesson (continued)

3. Have the students put the rocks back in the classroom collection. Pass around samples of the three types of rocks and allow the students to examine them. If possible, have samples of slate, marble, and gneiss.

4.Tell the class they are going to do an activity showing how the three types of rock are formed. Put the students in groups of four. Give four candy molds sprayed with cooking oil and a plastic spoon to each group. For the first part of the activity, allow the class to gather around the table as you melt the almond bark in a pan on the hot plate. Tell the students that the melted chocolate represents magma. Have them return to their groups, and take the container of "magma" to each group. Allow the students to spoon the melted mixture into their candy molds. While their "igneous rocks" cool, distribute the materials to make sedimentary rocks (peanut butter, crackers, knives), and metamorphic rocks (taffy, waxed paper). The students make cracker and peanut butter stacks to illustrate the layers in their "sedimentary rocks". Each student should then take three pieces of different colored taffy, unwrap them, and stack them on a piece of waxed paper. The student then places the other piece of waxed paper on top of the stack and presses down hard to make "metamorphic rock". To end the activity, call out the name of a rock type and have the students hold up the correct rock model they have made. They can then eat their rock creations.

Questions: Ask the students to write the answers to these questions in their journals:
1. How can an old rock become a new rock?
2. How is metamorphic rock formed?

Extensions:

- Language Arts: Write a narrative story about how a rock is formed. Describe what happens to the rock as it goes through the processes that change it from one type of rock into another type. Throughout the story, describe how the rock feels as the changes are occurring. Use the following questions to help you write your story: Did you start as magma? (igneous rock). Are you on the surface (lava), near the surface, or deep beneath it? Do you cool fast or slowly? Do you have crystals? What do you look like?

- Or—Are you sedimentary rock? You are being broken into smaller pieces and carried away. What is this called? What is causing it? What is carrying you away? Where are you going? Where do you end up? You are surrounded by other rock fragments. Are they the same type and size? Are more piling up above you? You are now sedimentary rock. What changed you? What do you look like now?

- Or—Are you changing? (metamorphic). What kind of rock are you at first? What changes must happen to you to turn you into metamorphic rock? Where will this change occur? How do you get there? What do you look like when you have changed?

This lesson downloaded from Illinois State Museum Geology Online project "Exploring How Rocks are Formed." http://geologyonline.museum.state.il.us/tools/lessons/4.3/lesson.pdf

Title: Marshmallow Moosh
Time: 45 minutes
Lesson Objective: Investigate the effect of weight on compression, which leads sedimentary and igneous rocks to morph, or change into, metamorphic rocks.

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Math Standard 3: Students use data collection and analysis, statistics, and probability in problem solving situations and communicate the reasoning used in solving these problems.

Materials needed:

Tall bottles or graduated cylinder	ruler
Large colored marshmallows	pen
Cardboard	scissors
Compass	masking tape
Various weights	

Activity:
1. Stack several different colored marshmallows—one on top of the other—in the tall cylindrical container.

2. Cut a cardboard disk to fit snugly inside of the container on top of the marshmallow stack.

3. Place the disk on top of the marshmallow column.

4. Using the ruler and masking tape, mark the bottle in 1 cm units. A wide-mouthed graduated cylinder would be ideal, as it already has measured markings on it.

5. Record the initial height of the uncompressed marshmallows.

6. Place various weights on top of the cardboard disk (on top of the marshmallow column) and measure the height of the marshmallows with each weight on top. Record these values on the compressed marshmallows.

7. Record the compression value for each weight value. Discuss how compression is affected by the weights. Are all the marshmallows equally compressed? Does the number of marshmallows affect compression?

This lesson downloaded from Kentucky Coal and Energy Education Project "Marshmallow Moosh"
http://www.coaleducation.org/lessons/primary/origin/marsh.htm

Title: Learning About the Properties of Minerals
Time: 1 class period
Lesson Objective: To identify properties of minerals and be able to identify certain minerals using specific tests.

Colorado Department of Education Standards met:
Science Standard 1: Students apply the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations.
Science Standard 2: Physical Science: Students know and understand common properties, forms, and changes in matter and energy. *(Focus: Physics and Chemistry)*
Science Standard 4: Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. *(Focus: Geology, Meteorology, Astronomy, Oceanography)*
Reading and Writing Standard 3: Students write and speak using conventional grammar, usage, sentence structure, punctuation, capitalization, and spelling.
Reading and Writing Standard 4: Students apply thinking skills to their reading, writing, speaking, listening, and viewing.

Materials needed:
Various samples of rock for each student purchased from education supply catalog or website
Hand lens or microscope
Science notebook or journal, pencils

For a group of 4 students:
Colorado minerals numbered as follows: (1) flourite, (2) gypsum, (3) calcite, (4) quartz
Penny
Paperclip
Empty glass baby food jar

Lesson procedure:
1. Ask students to define in their own words "rock" and "minerals." Ask them what they believe rocks and minerals might be made of. Tell the students that minerals are the building blocks of rocks, because all rocks are made up of one or more minerals. Spend some time discussing the differences between minerals and rocks. Have them write the definition of a mineral in their science journal. Tell them that minerals are materials which are not plants or animals and are found in nature. Minerals are used as the building blocks for rocks. Rocks may be made of only one mineral or several minerals.

2. Have the students examine their rocks with the hand lens or microscope. How many differences can they see in their sample? What determines differences? Guide them to a discussion of color, texture, and luster. Have the students return their rocks to the class collection.

3. Tell the students they are going to have the opportunity to examine some Colorado minerals to see if they can identify them by their properties. Put the students in groups of four and give each group a set of four numbered minerals. Have them write a thorough description of each mineral in their journals. Tell them to be sure to include properties of color, texture,

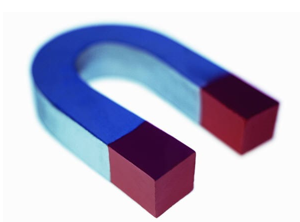
Learning About the Properties of Minerals (continued)

3. and luster for each mineral Allow about ten minutes for this activity. Follow with a class discussion of mineral properties. Write “Mineral 1”, “Mineral 2”, “Mineral 3”, and “Mineral 4” on the chalkboard and have groups offer characteristics of each mineral. Ask, “What if I were to ask you to hold up the mineral that is white? Which one would you hold up? What if I were to ask you to hold up the rough one? The shiny one?” Students should point out that more than one mineral has each of those properties. Draw their attention to this fact on the chalkboard. (Words such as shiny, rough, and white should appear numerous times.) Tell the students they will perform one more test to identify these minerals.

4. Before beginning the scratch test, ask each group to predict which mineral they think is the hardest. Record the predictions in their journals.

5. Give the group time to test the minerals by scratching them with their fingernail, the penny, and the paper clip. Ask them to attempt to scratch the surface of the glass jar with each mineral. After they have tested the minerals and placed X’s in the proper places on their Hardness Rating Sheets, give each group a copy of the Mohs Hardness Scale and have them use it to determine the name of each mineral in its appropriate place on their sheets. They should then finish the sheet by writing the minerals’ names in order of hardness (hardest to soft) on the sheet. Have a class discussion and write on the chart tablet each group’s list of minerals in the order they determined.

This lesson downloaded from http://geologyonline.museum.state.il.us/tools/lessons/4.4/lesson.html



Mohs Hardness Scale

Hardness	Mineral	Common Tests
1	Talc	
2	Gypsum	Fingernail will scratch it
3	Calcite	A copper coin will scratch it
4	Flourite	
5	Apatite	Glass or a penknife will scratch it
6	Feldspar or Othoclase	
7	Quartz	
8	Beryl or Topaz	
9	Corundum	Will scratch glass
10	Diamond	Will scratch all minerals

Hardness Rating Sheet

Directions: Put an X in the box where the object will scratch the mineral or be scratched by the mineral.

	Fingernail	Penny	Paperclip	Glass
Mineral 1 ____________________ (name)				
Mineral 2 ____________________ (name)				
Mineral 3 ____________________ (name)				
Mineral 4 ____________________ (name)				
Write the four minerals in order of hardness 1. 2. 3. 4.				

Title: The Formation of Coal
Time: Approximately four class periods, over four or five weeks
Lesson Objectives: Students will observe change over time through the simulation of forming coal through fossilizing plant materials, and practice the skills of hypothesizing, observing, and describing the process and results of an experiment.

Colorado Department of Education Standards met:
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Science Standard 4: Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.. *(Focus: Geology, Meteorology, Astronomy, Oceanography)*

Materials required of teacher:
One small aquarium for classroom setup, or several 2-liter soda bottles with the tops cut off, for multiple small-group experiments
Enough fine- to medium-grain sand to cover 2 inches of each aquarium
Fern fronds (leaves)
Twigs
Plant leaves
Screen(s) or sifter(s)
Fine silt or mud
Student science journals/paper, pencils, crayons, colored pencils, etc.

Discussion Questions:
- What does it mean to simulate a process?
- What is a fossil? What is a fossil fuel?
- What do you know about how coal is formed?

Teacher background information: Coal is formed when peat is altered physically and chemically. This process is called "coalification." During coalification, peat undergoes several changes as a result of bacterial decay, compaction, heat and time. Peat deposits are quite varied and contain everything from pristine plant parts (roots, bark, spores, etc.) to decayed plants, decay products and even charcoal if the peat caught fire during accumulation. Peat deposits typically form in a waterlogged environment where plant debris accumulated; peat bogs and peat swamps are examples. In such an environment, the accumulation of plant debris exceeds the rate of bacterial decay of the debris. The bacterial decay rate is reduced because the available oxygen in organic-rich water is completely used up by the decaying process. Anaerobic (without oxygen) decay is much slower than aerobic decay.

For the peat to become coal, it must be buried by sediment. Burial compacts the peat and, consequently, much water is squeezed out during the first stages of burial. Continued burial and the addition of heat and time cause the complex hydrocarbon compounds in the peat to break down and alter in a variety of ways. The gaseous alteration products (methane is one) are typically expelled from the deposit, and the deposit becomes more and more carbon-rich as the other elements disperse. The stages of this trend proceed from plant debris through peat, lignite, sub-bituminous coal, bituminous coal, anthracite coal to graphite (a pure carbon mineral). The peat-to-coal ratio is variable and dependent on the original type of peat the coal came from and the rank of the coal.

Lesson Procedure: The Formation of Coal (continued)
1.Begin by reviewing the definition of simulation. Explain to students that to simulate a process is to imitate it or create a model that shows how that process occurs. When we simulate a process like coal formation, for example, we study what conditions exist for coal to form from fossilized plant materials. A simulation does not need to be an exact replication of a process for it to demonstrate how something happens in the natural world. Tell students they

will create their own (or a classroom) "fossil" over the course of the next four weeks and will observe how that fossil forms.

2.Explain that coal is an example of a fossil fuel. Remind students that a fossil fuel is a fuel that has formed in the earth from the remains of plants or animals that lived as long as 400 million years ago. Ask students: Can you think of other fossil fuels (e.g., oil, natural gas)? Coal is formed from a combination of plant material, heat, pressure, and time. The process of coal formation takes millions of years to complete and is still taking place today. Although students will not actually create coal in this activity, they will see how the fossilization process occurs.

3.Begin the experiment by separating students into small groups or by creating a single aquarium for the class to study. Line the aquarium(s) with plastic wrap so that you can lift the entire formation out when it is dry. Next, pour water into each aquarium to a depth of 4 to 6 inches. Then spread about 2 inches of sand on the bottom, followed by small leaves, sticks, and pieces of fern.

4.Once each aquarium is set up, have students record their observations in their journal. Students should describe what the aquarium looks like, as well as what textures and colors they notice in the sand and foliage. Ask them what changes they think might occur over a few weeks if the aquarium is left untouched. Have them record their hypothesis in their journal. Tell them to watch the aquarium change over the course of the next four weeks. Each day, have them record any changes in color and water level.

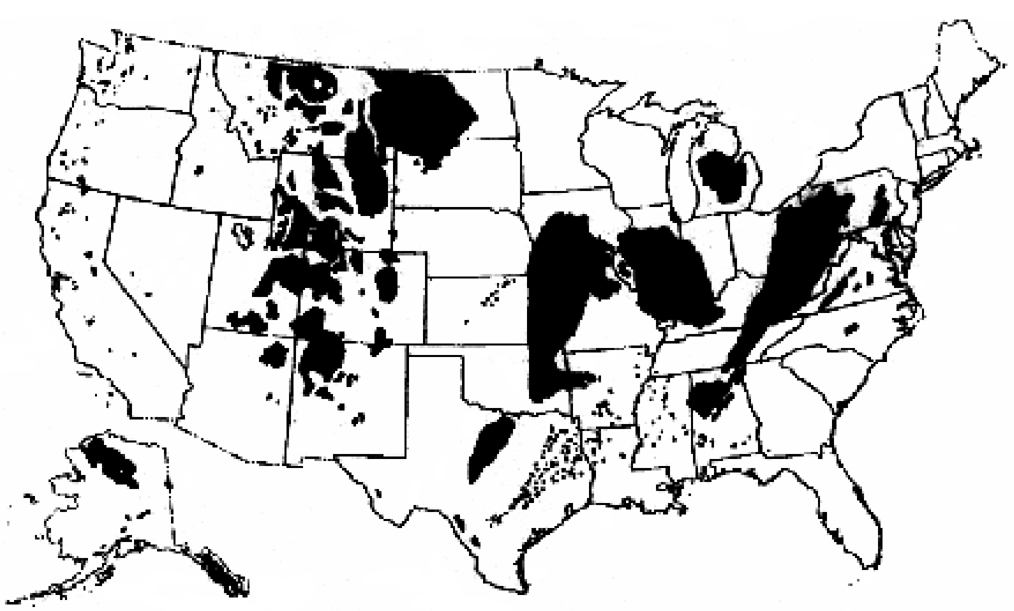
5.After two weeks, use the screen or sifter to gently sift fine silt or mud on top of the plant layer to a depth of 2 inches. This replicates the natural fossilizing process of contributing heat and pressure to the vegetation. Make sure students continue to document any changes they see. They should adjust their hypotheses if necessary.

6.Wait another two weeks and drain any water that remains. Let the formation sit and dry for another week or two. Once it is dry, carefully lift the entire formation out of the container(s). Tell the students they have simulated the early stages of coal formation. Gently break the formation into layers to reveal the fossil-like imprints from the plants.

Assessment:
Have students prepare a summary of the simulation, including how it was set up and how it changed (before and after intervention). Then have each student determine whether his or her hypothesis was correct.

This lesson downloaded from: American Coal Foundation “Coal Formation grade K-8” http://www.teachcoal.org/lessonplans/coal_formation.html

The map below shows the areas of coal formation in the United States



Tile: Chocolate Chip Cookie Mining
Time: One class period (60 min.)
Lesson Objective: To demonstrate the principles involved in making a profit through mineral resource development and in mining responsibilities to the environment

Colorado Department of Education Standards met:

Economics standard 1: Students understand that because of the condition of scarcity, decisions must be made about the use of scarce resources.
Economics standard 2: Students understand how different economic systems impact decisions about the use of resources and the production and distribution of goods and services.
Economics Standard 3: Students understand the results of trade, exchange, and interdependence among individuals, households, businesses, governments, and societies.
Science Standard 4: Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. *(Focus: Geology, Meteorology, Astronomy, Oceanography)*
Mathematics Standard 1: Students develop number sense and use numbers and number relationships in problem-solving situations and communicate the reasoning used in solving these problems.
Mathematics Standard 5: Students use a variety of tools and techniques to measure, apply the results in problem-solving situations, and communicate the reasoning used in solving these problems.
Mathematics Standard 6: Students link concepts and procedures as they develop and use computational techniques, including estimation, mental arithmetic, paper-and-pencil, calculators, and computers, in problem-solving situations and communicate the reasoning used in solving these problems.

Materials required of the teacher:
3 types of chocolate chip cookies: Mothers, or another low-priced store brand (fewer chips), Chips Ahoy (more chips), and Chips Deluxe (most chips)
Toothpicks
Paper clips
Graph paper
Pencils
Clock or stop watch

Lesson procedure:
1. Explain the object of cookie mining: to make a profit. Each student buys property (a cookie), equipment (toothpicks or paper clips), pays for the mining operation and reclamation. In return, the students receive money for the ore (chocolate chips) mined.

2. Each student (or team of students) layer starts with $100 worth of Cookie Mining Money, a Cookie Mining Sheet, and a sheet of the grid paper.

3. Each student must buy his/her own "mining property" or cookie from the bank. Teacher or another adult may serve as the bank.
Write the cookie prices on the chalkboard:
Store brand chocolate chip cookie - $20.00
Chips Ahoy cookie - $25.00
Chips Deluxe cookie - $30.00

Chocolate Chip Cookie Mining Lesson (continued)

4. After the mining property is bought, have the students give their "mine" a name, and record it, along with the price of their cookie on the sheet.

5. Have the student place their cookie on the grid paper and trace the outline of the cookie. They should then count each square that falls inside the circle, counting partial squares as a full square, and record that number on the sheet.

6. Students must now buy mining equipment. They can purchase more than one piece or type of equipment. If a mining tool breaks, it is no longer usable, and a new tool must be purchased. Write the prices on the board:
Toothpick - $20.00 each Paper clip - $30.00 each
Have students calculate and record the price of mining equipment on their worksheets.

7. Now it is time to mine the chips out of the cookies. In order to be a responsible mining company, workers must ensure that the results of their work are pure from contamination of the soil. Thus, no student may use his/her fingers to hold a cookie. The only things that can touch the cookie are the mining tools and the paper the cookie is sitting on. The teacher may wish to assign another adult or teacher aide to serve as the Environmental Protection Agency to monitor progress. Teacher may wish to impose fines on students breaking the rule. The time allotted to the mining experience may or teacher aide may serve as the EPA to ensure the stability of the environment is reclaimed properly. Time spent mining is to be determined by teacher. When time is up, students should record the time spent mining on the sheet.

8. Students should now calculate the number of chips extracted from the cookie and the tools and land costs on the worksheet. Students receive $2.00 from the bank for each chocolate chip mined. Broken chips can be combined to form one whole chip. Any profits or losses should be noted on the worksheet.

9. The player with the most money at the end of the game wins, and everyone gets to eat the remainder of their cookie!

Discussion/Conclusion:

- Did it matter which cookie was bought? Which cookies were harder or easier to mine, and why? Which cookies were more expensive? (financially and time-wise)
- What about the mining equipment? Which tools, or combination of tools were most effective? Did certain tools break?
- When you tried to reclaim your cookie, what happened? Was it difficult to return this cookie back to the same exact size that it was before mining the chips?
- Do you think mining companies face the same issues? How do they deal with these issues?

Name____

1. Name of cookie mine ____

Start up mining expenses
2. Price of mine $______________________
(Sample #1 $20.00, Sample #2 $25.00, Sample #3 $30.00)

3. Mining Equipment:

Toothpick _______x $20 = _______

Paper clip _______ x $30 = _______

Total Equipment Cost $_________________

Mining costs

4. Mining cost
_______ minutes x $1.00 = _______

5. Reclamation cost
_______ squares x $1.00 = _______

Total cost of mining $_______________

Profit from mining

Ore removal
Number of "ore" pieces _______ x $2.00 = _______

Calculating net profit/loss

Startup cost		$100
total mining costs (#3 + #4 + #5)	—	________
less total reclamation costs (#6)	—	________
plus value of ore (#7)	+	_________

Total Net Profit/Loss ________________

Mining Buck

$1

Mining Buck

$5

Title: Minerals And Their Products
Lesson Objective: Introduce students to specific minerals and their uses.
Colorado Department of Education Standards met:
Science Standard 5: Students understand that the nature of science involves a particular way of building knowledge and making meaning of the natural world.

Background information: Minerals are the basic ingredient of many every day products. Life as we know would not exist without minerals. Everything that can not be grown (neither a plant nor an animal) is made from minerals or is mined our of the ground. We consume minerals in amounts that range from billions of tons of sand and gravel a year to only thousands of pounds of rhenium—a metal used in producing unleaded gasoline. In the United States alone, it takes more than 2 billion tons of minerals each year to maintain our standard of living. From those minerals we get the products we need to live and those that make life more comfortable. Contact Women in Mining Education Foundation and Mineral Information Institute for free lesson ideas and packets of classroom materials www.womeninmining.org or www.mii.org.

1. Colorado is rich in mineral resources and fuels. These natural resources produce well paid jobs and tax revenue for the state and local government. Mining helps to maintain our standard of living

2. Coloradoans use 38 million tons of cubic feet of gravel, sand and aggregate a year. These materials are mined for construction materials in buildings, roadbed, driveways, etc.

3. Combined mineral and petroleum development add about $1.8 billion per year to Colorado's economy. That's about the same amount of money produced in one year from hunting, fishing and wildlife watching related tourism.

4. Toothpaste, includes calcite, for polishing, and fluorite, the source of cavity-fighting fluoride

5. Talc, another heavily mined mineral, is used is making baby powder, eye shadow, blush and other cosmetics, paint, paper, roofing and ceramics.

6. Telephones use more than 30 different mined minerals, Televisions use 35.

7. Surface mining in the United States accounts for 9,140 square miles, or approximately 0.25% of America's land surface. Most of these are coal, sand, gravel or building stone mines or quarries. That is less area than the coverage by the interstate highway system.

8. Gold is used for more than just jewelry, bullion and coins. The metal's ability to reflect heat protects astronauts, satellites and critical electronic components from damage from hazardous x-rays in space. Dentistry uses gold in filings, crowns and bridges, which last a lifetime in our mouths. Gold compounds are used in treating rheumatoid arthritis and radioactive gold is used in the treatment of several types of cancer. Gold leaf is used in surgery and patching damaged blood vessels, nerves, bones and membranes. Gold is also used in glass windows to insulate buildings, allowing for less air conditioning.

9. Minerals provide the building blocks for the houses and apartments we call home and we find its products from the basement to the attic: concrete foundations, gypsum wallboard, metal air conditioners, copper pipes. They are used to create cosmetics, metal tools, appliances such as ovens, refrigerators, pots and stainless steel kitchen utensils, brass doorknobs and picture frames, Minerals are found in every room of our homes.

Title: Observing Cystals
Time: 4-5 days
Lesson Objective: To introduce students to the formation of crystals

Colorado Department of Education Standards met:

Science Standard 1: Students apply the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations.
Science Standard 3: Life Science: Students know and understand the characteristics and structure of living things, the processes of life, and how living things interact with each other and their environment. *(Focus: Biology—Anatomy, Physiology, Botany, Zoology, Ecology)*
Science Standard 4: Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. *(Focus: Geology, Meteorology, Astronomy, Oceanography)*

Materials required of the teacher:

Disposable 5 oz cups
Disposable spoons
Hot water
Food coloring
Magnifying lens or microscope (one per student)
Transparent or double sided tape
safety glasses
crystal forms of salt, alum, and Epsom salt
blank paper, pencils
petri dishes or small saucers
3 x 5" index cards
teaspoons

Note: Epsom salt and alum are available in drugstores. Cupric sulfate is poisonous and should therefore be handled with care. Petri dishes can be purchased through Delta Education. <http://www.deltaeducation.com/>

Lesson Preparation:
Prepare sets of four cards for each group of students, each with a different crystal specimen adhered with double sided tape. Label each card with the name of its crystal (salt, Epsom salt, and alum). Each group of students will need a set of cards.

Lesson procedure:
1. Divide students into groups. Distribute a set of cards and magnifying glasses or microscopes for each group.
2. Have students look closely at the crystal shapes. Have them draw the shape of each crystal on a piece of paper.

3. Explain that these crystals form naturally and that you are going to show them how they become crystals.

- Pour about 3 teaspoons (15 mL) of hot water into a cup
- Add about 1/4 teaspoon (1g) of cupric sulfate to the water.
- Stir with the spoon until it dissolves completely. If necessary, continue to add more cupric sulfate until no more will dissolve.
- Pour all this solution into the petri dish or small saucer.
- Set the dish on a tray with a label nearby of the chemical used
- Repeat with other chemicals, using a new cup and spoon each time

4.. Tell the students that they will be watching the dishes for the next several days to see what appears.

Other suggested teacher resources:

Books:

Calhoun, Yeal. (2005). *Earth Science Fair Projects: Using Rocks, Minerals, Magnets, Mud and More.* Enslow Publishers.
Young scientists learn about the earth's layers and the rock cycle, the forces that change our planet's surface, and how rocks, minerals, and crystals form. For students interested in competing in science fairs, the book contains lots of great suggestions and ideas for further experiments. Illustrations.

Fardon, John. (1994) *Dictionary of the Earth.* Dorling Kindersly Ltd.
Explains over 2,000 key words related to the Earth sciences with full color illustrations and photographs. Organized by subject area with index and cross-references.

Gans, Roma. (1997). *Let's Go Rock Collecting.* HarperCollins.
Describes the formation and characteristics of igneous, metamorphic, and sedimentary rocks, how to recognize them and how to collect them.

Pellant, Chris. (2007). *Granite and Other Igneous Rocks.* Gareth Stevens, Pub.
Pellant, Chris (2007). *Marble and Other Metamorphic Rocks*. Gareth Stevens, Pub.
Pellant, Chris (2007). *Sandstone and Other Sedimentary Rocks*. Gareth Stevens, Pub.
Young readers are fascinated by rocks and minerals, and this series provides a colorful, comprehensive guide. Each volume uses clear text and close-up photographs to explain how rocks and minerals are formed, how they are used, and what makes each one unique.

West, Christa (2002). *Hands On Projects about Rocks, Minerals and Fossils.* Powerkids Press.
The natural world comes alive in this exciting, imaginative series! The fact-filled text is accompanied by step-by-step, photo-illustrated instructions that help kids to make a model of Earth, a seismometer, different types of faults, and other hands-on projects. By linking the scientific information with the projects, lessons are reinforced in a fun, creative way that students will love.

DVD's and Videos:

Rock and Minerals [video recording] (1994) DK Vision, London. 35 minutes.
This 35 minute video is a mixture of live action and animation serving as a background for a narrated introduction to the Earth's geological history and the use of stones and minerals by humans for buildings, tools, and ornaments throughout their cultural development.

Eyewitness Rock & Mineral [DVD videorecording] (2006) DK Publishing, London. 57 minutes.
Learn amazing facts about rocks, gems, and the Earth itself. Part of the Eyewitness video series.

Rockfinders [DVD videorecording]. (2003) Thinkeroo, LLC Bristol. CT 30 minutes.
Hosts Todd Alan Crane and Max Orbit travel to a cave, a mine and a quarry introducing several types of rocks and minerals and the process the created them , and shows children how to create a rock collection.

Websites:

Smithsonian Institution National Museum of Natural History Earth Science page
http://www.mnh.si.edu/earth/main_frames.html

Free software download for Mac: "Rocks! 1.0" http://mac.tucows.fi/macteach_size.html
Mineral Information Institute http://www.mii.org/lessons.php

http://www.coaleducation.org/lessons/sme/elem
http://www.rogersgroupinc.com/ourcommunities/rockology
http://www.utm.edu/departments/ed/cece/third/3L4.shtml

Online stores to purchase bagged rocks and minerals:

http://www.rocksandminerals.com/ http://www.geoprime.com

Minerals and their Products Glossary

GALENA: (Lead ore, a metallic mineral and the heaviest of the common metals.) The U. S. is the world's largest producer. Lead is used in car batteries, gasoline additives, solders, electrical and electronic applications, TV glass and tubes , protective coatings, crystal glass, X-ray and gamma radiation shielding, soundproofing , construction and for ammunition.

MOLYBDENUM: (Molybdenite is the most common molybdenum bearing mineral.) 47% of this mineral is used in steel alloy. In pure form it is used because of its high melting temperature. Uses include, automobiles, pipes, stainless steels, chemical processing equipment, dies, paint pigments, corrosion inhibitors, smoke and flame retardants. The filament supports in light bulbs is made from molybdenum.

AZURITE: This mineral is a secondary copper mineral, usually azure-blue in color. It is usually associated with malachite and is used either as an ore of copper or as an ornamental stone. Copper is used in plumbing, wiring, to make brass and coinage.

FLOURITE: This mineral's name is derived from the Latin "fluere, to flow," because it melts easily. It is used as a flux in the smelting of metallic ores for the manufacture of steel, aluminum and hydrofluoric acids. It is an ingredient in fluoride toothpaste's and added to some drinking water.

GILSINITE: A bituminous mineral also known as unintahite, a natural asphalt. A brittle dark brown or black appearance and is found in commercial quantities only in one area of Utah. Used in varnishes, automobile battery boxes, flooring material, oil drilling fluids, paint and inks.

TRONA: Trona is the basis for soda ash which is a basic part of glass manufacturing, baking soda, sodium carbonate and bicarbonate. Ceramic tiles, porcelain fixtures, and upset stomach remedies all are from trona. Wyoming is the largest producer of trona in this country.

SULFUR: Sulfur has a very distinct color and smell and is used in the manufacturing process for rubber, matches, medicines, petroleum refining, gun powder, paper production as well as in photography. It is also a very important soil additive.

CHALCOPYRITE: A copper iron sulfide, often found with some silver and gold. It is one of the most widely distributed copper minerals. An abundant and important ore of copper which is used in plumbing, wiring, vitamins and for coinage.

HALITE: Sodium chloride is usually colorless or has tints of gray, yellow, red, or blue through it. Has a salty taste and is usually brittle. Readily soluble in water and is widespread in evaporate deposits of chemical sedimentary rocks. Is used extensively in the chemical industry (vinyl for pipe and auto seat covers) and as a source of chlorine and sodium.

MAGNETITE: An iron oxide, metallic, magnetic iron-black mineral. It is probably the most important mineral civilized man has ever dug and is the second most common metal on earth. It is the basis of the industrial revolution on which our society now depends. Used in cars, ships, bridges, buildings, stainless steel.

COAL: (Actually a sedimentary rock but often referred to as a "mineral" resource.) There are four types of coal, anthracite, bituminous, sub-bituminous and lignite. Coal provides about 60% of our nation's electricity. It is also used in the cement, food, paper, automobile, textile and plastic industries. By-products are used for paint, nylon and aspirin. The fly ash left from the burning of coal is now being processed into building blocks and other construction products.