Materials Needed

For this investigation your group will need:

- hard-boiled egg
- tools, including: toothpicks, plastic knife, tongue depressor
- filter paper
- paper towels
- cereal samples in sealed plastic bags
- crushed sulfide ore
- steel shot
- small plastic jar with tight-fitting lid
- terrycloth towel
- fine mesh screen or kitchen sieve
- clear plastic cup (8 oz. size)
- liquid bubble bath
- bicycle pump (or other air pump) with connector
- file card
- balance
- ruler
- calculator

You will also require materials to extract iron from the cereal. Consult with your teacher about what other materials are available.

Wear safety goggles throughout this investigation.

Investigation 6:

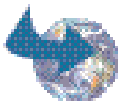
Extracting Minerals

Key Question

Before you begin, first think about this key question.

How are minerals mined and removed from the ground?

You have modeled the process of looking for minerals. What happens when minerals are found? Share your thoughts with your classmates. Be sure to include a record of the discussion in your journal.



Investigate

Part A: Modeling the Mining Process

1. You will use a hard-boiled egg and some "mining tools" (toothpicks, filter paper, etc.) as the starting point to construct a model. You will need to think of how you can use the egg to model the mining process.

   To do this you will need to consider all of the concerns that are important to a mining

operation, including the costs of the time spent mining, restoration of the surface area being mined, and proper disposal of the unwanted material removed from the ground. Your teacher will provide you with guidelines to help you to include these things in your model. Observe your egg and discuss its structure in your group.

Obtain an egg and a set of "mining tools." Study them and generate your modeling ideas.

a) Which part(s) of the egg could represent a mineral deposit? Why is that?

b) What could the rest of the egg represent?

c) Using your set of mining tools and the egg, how could you best model the mining process? (Be sure to think about the key mining issues as you discuss this.)

d) What will you use to measure your success as a mining company when you are finished?

Working with the others in your class, and with your teacher, come up with a plan for how you could model the mining process with your egg and tools.

2. Put your mining plan into action. Be sure to keep a record of important data, like the time it takes to carry out the parts of the plan.

   a) Record all your data in your log.

3. To find out how successful you were in the mining process, revisit your original class plan. Put into action whatever steps are necessary to measure your success.

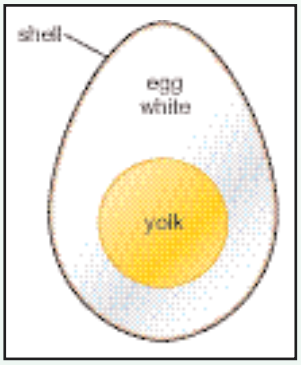
   Compare notes with other groups in your class. How did the other miners do? Trade information about mining techniques and see how you could have improved your method.

   Check to see if there is anything missing in your plan to model the mining process.

4. Look again at the issues and questions about mining that you considered in **Step 1.** Check to see which have been dealt with and answered by your model. Discuss these questions and any others you think are important:

   a) How did the egg mining illustrate the key issues in the mining for minerals?

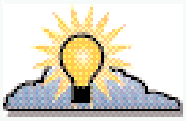
Report any food allergies to your teacher before beginning this investigation. Do not eat any part of the foods being used in the investigation. Wash your hands after each part of this Investigation. Clean all spills well.



b) How was the egg model unlike the Earth and the mining process?

c) What do mining companies need to think about when they are deciding whether to mine in a particular area or for a particular mineral?

d) What suggestions can your group provide to improve the egg model or make it more realistic? Can you think of an alternative?



Inquiry

Models

Scientists and engineers use models to help them understand ideas and relationships. In the last investigation, you used a model to help you understand some of the difficulties of exploring for minerals. In this investigation, you will be working to design a model that will help to demonstrate some of the key issues in mining and separating minerals from the rock in ore.
Keep in mind that few models are perfect. They are both alike and unlike what they represent, in a number of ways.

Part B: Separating Minerals from Gangue

1. Now you will focus on how minerals are separated from gangue. (Gangue is a term used to refer to all of the undesired parts of an ore.) For an example, think about hematite, one of the minerals from which metallic iron is extracted.

   Iron is a much-desired element for the manufacture of many products (steel, in particular).

   a) Make a list of objects that are made from iron and steel.

   Discuss with your group what you think are the properties of iron that would help you to separate it from a mixture.

   b) Make a list of these properties.

   In your group, decide which property of iron you think would be most useful in separating it from a mixture.

   c) Support your reasoning with evidence and logic.

2. You will now be given samples of cereals in sealed plastic bags. Some cereals have iron added to them as a mineral supplement. Using your knowledge of the properties of iron, come up with a plan for how you could find out which cereals have had iron added and how you could get the iron out of the cereals.

   a) Write down your plan and check it with other groups.

3. When you think that your plan makes good sense, assemble your materials and carry out the plan.

   It will probably take more than one try for you to find out which cereals contain iron, and how to get it out.

   a) Be sure to record your results for each trial, whether or not each is successful.

Data Table Showing Results for Iron in Cereal			
Cereal Name	**Method of Identifying Iron**	**Method of Extracting Iron**	**Amount of Iron**

4. Share your methods and results with other student groups in your class.
   a) What seemed to be the best method of finding cereals that contained iron?
   b) What seemed to be the most effective method of extracting the iron?
   c) Which cereals contained the most iron?
   d) What relationship could you find between the amount of iron you could collect and the particle size of the cereal?
   e) Write out what seems to be the best procedure for getting the most iron out of cereal. Think over these questions as you do this:

- Should the cereal be in large pieces or small pieces to get the most iron out?
- Should the cereal be wet or dry to get the most iron out?
- Which tools are the most efficient ones to use in getting the iron out? Why is that?
- Which containers are the best ones to use when extracting the iron? Why is that?
- From what you just learned, what should mining companies do with rocks to get the most minerals out? Remember that companies must also consider the costs of the processing of the ore.

Part C: Froth Flotation

1. In copper mining, a method called froth flotation is sometimes used. This method is used when the ore is chalcopyrite, which is the most commonly mined copper ore.

   In this part of the investigation you will have a chance to apply your knowledge of the extracting procedure for minerals and elements on some actual rocks and minerals. You are going to replicate the froth flotation method of what happens in the mining industry. Your group will do this on a small scale.

2. Be sure to read the directions carefully. Have one person in your group serve as the recorder, writing down observations of the processes that must take place for the mineral to be extracted.
   - Put some sulfide ore and steel shot into a plastic jar. You should have two to three times as much steel shot as ore. Keep a few pieces out and save for later comparison.

- Add enough water to cover the ore and shot so that it is submerged about one centimeter.
- Cover the jar securely with the lid. Wrap the jar in a towel and shake the jar for 2 min.
  - Screen the mixture by pouring it over the 0.5 cm wire screen. Be sure to use a large container to catch the water and the smaller pieces beneath the screen.

a) Record observations about the changes in size and shape of the ore and the steel shot.

- Return the pieces of rock and steel shot to the jar along with the water. Repeat three or four times, recording observations each time.
- Screen the mixture one last time to remove the ore and steel shot and place them on a paper towel to dry.
- Pour the liquid into a 250 mL plastic cup. Add 15 mL of water to the jar and swish it to retrieve any minerals stuck to the side, and add this to the cup.
- Take the "slurry" of water, which now contains copper minerals, and add about 75 mL of bubble-making liquid and stir well.
- Use an air pump and connector to blow into the mixture.

b) Observe and record the way bubbles appear.

- Scrape the bubbles off with a piece of index card and place them on a paper towel to dry. Repeat this three more times.

c) Observe and record what you have put onto the paper towel, especially when it has dried.

3. When your group has completed the froth flotation investigation, share the results with other groups. Discuss and record answers to these questions:

a) What was similar about the cereal activity and the copper activity?

b) Was it easier to get the minerals out of large pieces of the starting material or small pieces? Why do you think that is so?

c) How do you think these processes can be adapted to extract minerals in the mining industry? What changes to the processes might have to be made?

As You Read…
Think about:

1. ***How is the ore near the Earth's surface removed?***
2. ***How is ore deep beneath the Earth's surface removed?***
3. ***What limits the depth of a mine?***
4. ***What are tailings?***
5. ***What properties can be used to separate minerals from ores?***

Digging Deeper

ORES

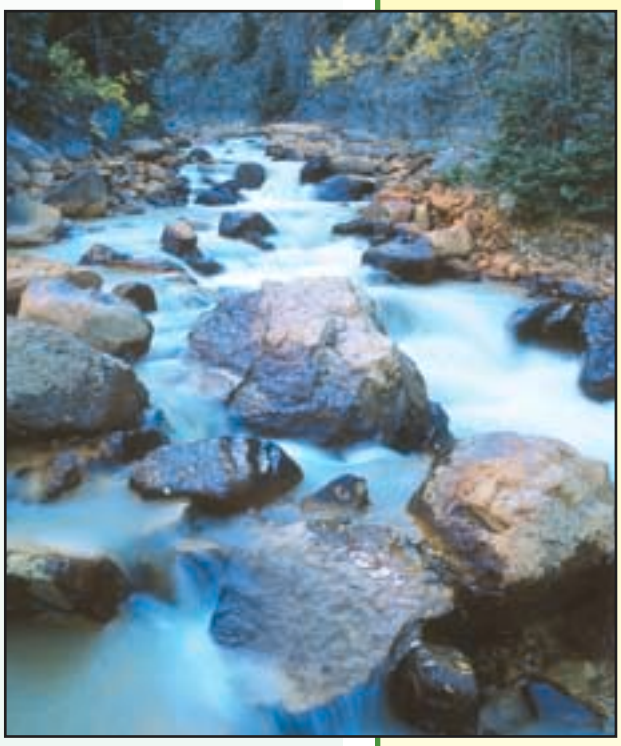
Ores that are near the Earth's surface can be obtained by scraping away the soil, blasting the ore into small pieces, and removing it with heavy equipment to smelting plants. That kind of mining is called surface mining. Ores that are located deep in the Earth must be mined from tunnels in deep rock. That kind of mining is called deep mining. The deepest mines in the world are the gold mines in South Africa. Some of those mines extend down to 3 km below the Earth's surface. As you might guess, the maximum depth of mining is limited partly by the strength of the tunnel walls against the great weight of rock overhead. An even more important factor, however, is temperature. Temperature increases downward in the Earth, and at a depth of about 3 km the temperature is so high that working conditions are difficult, even with ventilation. A few important ores, especially ores of iron and aluminum, occur in very large

bodies. These ores are relatively easy to find. Most of the important reserves of iron and aluminum are already known. Most other ores occur as smaller bodies, usually at some depth below the Earth's surface. Finding these ore bodies is usually much more difficult. Many of these ores are a kind of chemical compound called metal sulfides. Metal sulfides are combinations of the element sulfur with one or more metal elements, like copper, lead, zinc, mercury, nickel, and cadmium.

Ore Dressing

Most ores are in the form of hard rock. The first step is to blast the rock with explosives, so that the ore can be transported to smelting plants or separation plants. One important exception is aluminum ore. The ore of aluminum, called bauxite, consists of a mixture of aluminum hydroxides. These compounds are produced by intense weathering of aluminum-bearing rocks at the Earth's surface in hot and humid climates. Bauxite is therefore a near-surface deposit, and it is often soft enough that it can be dug rather than blasted.

Finding a mineral deposit and mining the ore are only the first steps in obtaining a gemstone or producing a metal or other valuable mineral resource. Usually the desirable mineral of an ore must be separated from all of the other minerals in the ore. This process is called ore dressing. Some ores, like bauxite, can be smelted without further processing except for crushing. For most ores, however, the gem crystals, or the crystals that contain the metal, have to be separated from the other minerals in the ore. This leaves a concentrate that is richer in the desired mineral. The rest of the minerals in the ore, which are called gangue minerals, remain as a loose material called tailings. Sometimes the tailings are buried back in the ground, but often they are left on the surface as waste. With some ores, rainwater



can leach toxic chemicals from tailings left on the surface. These chemicals can find their way into streams and rivers. Protecting the environment from the effects of tailings is an important goal in mining. Tailings are especially troublesome because very often most of the material of the ore ends up in the tailings.

There are many techniques for separation and concentration of minerals from ores. Separation of minerals is based on some physical or chemical property of the minerals. Depending on its properties, each kind of ore is separated most efficiently by one technique or another. Here are some of the commonly used methods:

- ***Density:*** The crushed material is put into a liquid with a density that lies between the density of the ore mineral and the density of the gangue minerals. The ore mineral floats or sinks, and the gangue minerals do the opposite. This is called float–sink separation.
- ***Magnetic Properties:*** This is an important way that iron minerals are concentrated.
- ***Chemical Properties:*** The crushed material is put into a solvent. The ore mineral dissolves into this solvent and is poured off in solution, leaving the gangue minerals behind.
- ***Fracture Properties:*** With some ores, the ore mineral tends to break into either larger or smaller particles than the gangue minerals. Then the material is passed through a sieve or a filter to separate the ore minerals from the gangue minerals by particle size.

Review and Reflect

Review

1. Compare and contrast the extraction methods you used in this investigation.

Reflect

2. What do you think is the most difficult step in the extraction process, and what evidence do you have for this?

Thinking about the Earth System

3. Think about your model of mineral extraction with the egg. How does the extraction of minerals from the geosphere affect the biosphere?
4. Your model of the froth flotation process involved the use of water. How does mineral refining depend upon the hydrosphere?
5. Water used in mineral refining must be treated before being returned to the natural Earth system. How does the treatment of water reduce the impact that refining has on the hydrosphere? The biosphere? Show these relationships on your *Earth System Connection* sheet.

Thinking about Scientific Inquiry

6. Give an example of how you collected and managed data during an investigation.
7. Think about your investigation into the iron content of cereals. Describe how you collected evidence to test your ideas.
8. When did you show evidence and reasons to others during one of your investigations? Why is this important in scientific inquiry?
9. Think about how you used models in this investigation. How were your models different from the real-world processes?