ACTIVITY: Engineer and Build an Underground Mine Model

Engage your students and stimulate their imaginations with this engineering challenge. Student groups build their own models of an underground mine and use them to show how to extract ore *(a mixture)* from the ground to obtain the desired mineral *(a pure substance)*. Activity duration is two to three hours.

A poster series produced by the Minerals and Metal Sector of Natural Resources illustrates many aspects of mining and mineral processing. The four posters look at an underground mine, a surface mine, a concentrator, and the smelting refining process.
http://www.nrcan.gc.ca/minerals-metals/business-market/3828

Showcase your Mine! *Mining Matters* invites teachers and students to send us pictures of the finished "mines." We'd love to show off your work on our website.

Background

Mining is a temporary use of the land during which valuable material from the Earth is **extracted** (removed). When the rock is valuable because it contains metal or minerals, it is called an **ore body**. If the ore body is buried deep in the Earth, miners must dig tunnels to the ore body. Such an operation is called an **underground mine**. The *vertical tunnel* to the area of the ore body is called a **shaft**. Inside the shaft an elevator **(cage)** is used to transport the miners and equipment from the surface to the underground workings and a bucket **(skip)** is used to lift the broken rock and ore from underground. Other vertical tunnels called **ventilation shafts** bring fresh air to the mine. *Horizontal tunnels* called **drifts** provide access from the shaft to the ore body. **Explosives** such as dynamite are used to break up the rock. Broken rock is loaded into a *scoop*, a large machine that combines a front-end loader and a truck. It is driven back to the shaft where the **ore** is dumped and lifted to the surface in the skip.

Mined ore contains metals and minerals of value as well as other minerals of no value. The two are often evenly mixed in the ore and must be separated to form a **concentrate** of the valuable mineral. After separation, the minerals of no value are usually called **tailings**.

The **first step in separating** the valuable minerals almost always involves **crushing the rock** to a fine powder. The rock is broken up in large crushers and pulverized in large rotating drums containing hard balls or rods. The process of producing the fine powder is called **milling** and the process takes place in a **mill**. This process is like grinding wheat or oats to make flour.

Two procedures are commonly used to separate the valuable and non-valuable minerals from the milled ore. When mixed with liquid, heavier minerals sink and therefore can be separated from lighter minerals. This procedure is called **heavy media separation**. This process could be used to separate heavier chalcopyrite from lighter quartz. If the valuable minerals are magnetic, they can be separated from the minerals of no value by passing the crushed ore under a powerful magnet. This procedure is **magnetic separation**.

Once the valuable metals have been separated or concentrated, the leftover material (rock fragments, dust, and chemicals) is called **tailings**. Mining companies work hard to ensure that these tailings are managed effectively and responsibly. Such efforts are necessary because the real-life tailings might contain dangerous chemicals that could escape into streams and lakes. Some tailings contain minerals such as pyrite. As pyrite is exposed to water from rain and other sources, it can make the water somewhat acidic. This acid water can drain into streams and lakes and negatively affect the fauna and wildlife.

In the early part of the century, people, including mining people, did not understand that material such as tailings could cause serious damage to the environment. Now, mine tailings are kept in specially designed ponds. The base of the pond is lined with heavy plastic or dense clay. Any water leaving the pond is chemically treated to remove acids or dangerous chemicals. The tailings are eventually covered with soil and planted with grass and trees. Strict government rules are applied to tailings. Some mining companies have even stricter internal rules.

After underground mining is completed, the **reclamation process** includes filling all the opened areas with sand, cement, or waste rock. The shafts are **capped** (plugged) and the buildings at the surface are removed. The small areas used for the buildings are replanted with grass and trees and very little evidence of the mine remains.

Materials

Construction	Materials Needed for Each Group
Mine Site	Cardboard box
Headframe	Cardboard/construction paper/popsicle sticks
Buildings on Site	Cardboard/construction paper/miniature toy buildings
Trucks	Construction paper/miniature toy trucks
Trees	Construction paper/miniature toy trees/twigs
Shaft	Cardboard/construction paper/cardboard tubes
Cage/Skip	Cardboard/construction paper/string
Ventilation Shaft	Cardboard/construction paper/cardboard tubes
Drift	Cardboard/cardboard tubes
Ore host rock	Aluminum foil
Mineralization	Mixture of 50 ml flour, 50 ml water, 20 ml iron filings. Iron filings may be purchased from a provider of scientific supplies and equipment
Rock	Construction paper/newspaper/painted fibrefill
Other supplies	Masking tape or duct tape, paint, flashlight

Safety Matters

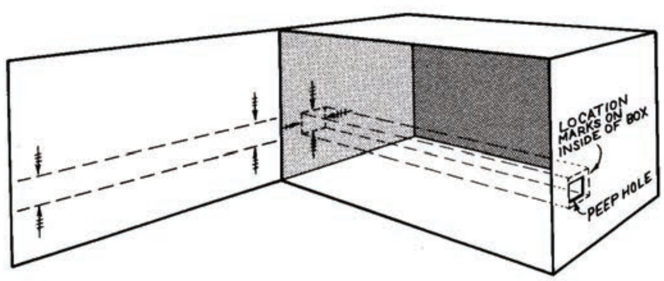
This activity requires that iron filings be mixed with flour and water. It is very important that the dish and mixing equipment used to prepare this mixture are cleaned *while the mixture is still wet*. NEVER dispose of iron filings down the sink. When airborne, iron filings present a health hazard by irritating the lungs and eyes. **Care should be taken to ensure that only the teacher handles unmixed iron filings**. Eye protection must be used. Respiration protection should not be needed in normal laboratory handling. Spills can be swept up and iron filings may be reused or placed in the garbage.

Activity 1: Building a Mine

1. Prepare your box, the mine site, by taping all sides closed.

2. Cut open one side of the box to make a "door."

3. Locate the position of a drift by measuring and drawing horizontal lines on the inside of the "door." Draw corresponding marks on the insides of the sides of the box as shown below. Cut a "peep hole" out of the right side of the box at your marks.



4. Your drift has two sides (back side and front side). Create both sides of your drift by either folding cardboard as shown in the completed model illustration or by cutting a stiff cardboard tube in half lengthwise. To get a straight edge when folding cardboard, it helps to use a strong straight edge, like the edge of a tabletop.

5. Using your drift location marks as guides, glue the front side of the drift to the "door." Attach the back side of the drift by gluing the folded tabs at both ends to the sides of the box. Ensure that the back side of the drift lines up with the "peep hole."

6. Make a shaft out of cardboard by folding four sides into a tube or by using a round cardboard tube. Make a hole in the top of the box slightly larger than the shaft, directly above the left end of the drift.

7. Cut a corresponding hole in the top of the drift. Lower the shaft through the surface to the top of the drift at the hole. In a real mine, the shaft is dug down through solid rock to the drift level and then the drifts are dug horizontally.

8. Make a smaller ventilation shaft in your mine by repeating Steps 6 and 7 on the right end of the drift.

9. Make a headframe (building at the top of the shaft) and place it over the shaft hole. A small building for fans should be made for the top of the ventilation shaft. Make a cage/skip out of string and construction paper. Be sure that it is small enough to fit through the shaft.

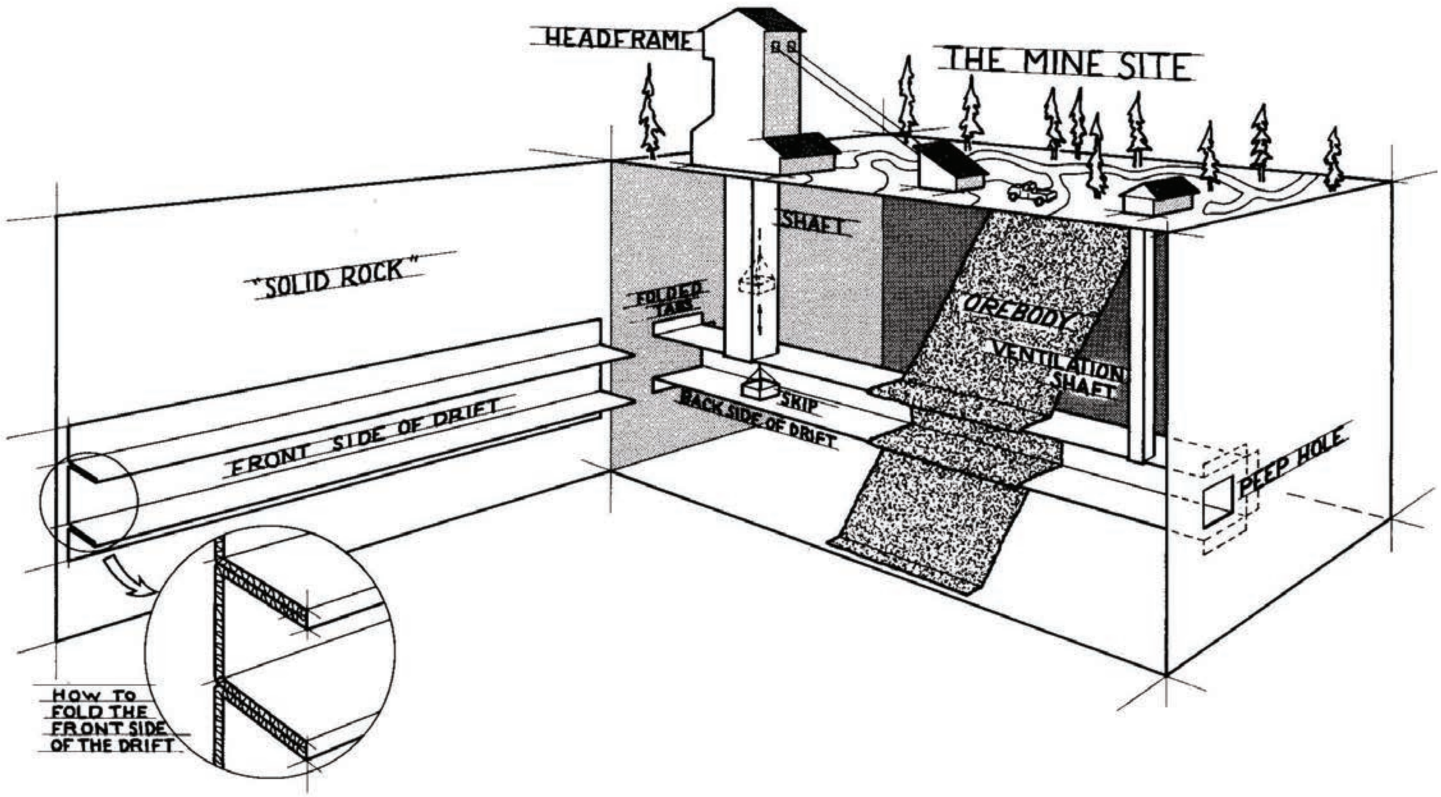
10. It's time to make the orebody! Take a sheet of aluminum foil (ore host rock) long enough to extend from the top of the box to the bottom of the box with at least 15 cm extra. Fold the foil to a width approximately 10 to 15 cm. Tape the foil to the inside of the box top and to the top of the drift. Press the foil into the drift along the top, back and bottom allowing the remaining foil to extend to the bottom of the box. Secure with tape at the bottom of the drift and box.

11. Have your teacher prepare the flour, water, and iron filing mixture (mineralizaton) as indicated in the Materials table. Spread the mixture on the foil before it gets too dry! Be sure to spread the mixture on the foil in the drift also. Allow this mixture to dry. The dish and mixing equipment used to prepare the mixture should be cleaned while the mixture is still wet. NEVER dispose of iron filings down the sink.

12. While the orebody is drying, carefully fill the remaining open spaces in the box with shredded newspaper or painted fibrefill. This will give the impression that the drift is actually passing through solid rock. Complete your model by painting the surface and placing trees and trucks to represent a real mine.

13. When the "door" of the model is closed, peek into the mine by shining a flashlight into the "peep hole." This really gives you the feeling of being underground.

Diagram of completed model



Activity 2: Mining Operations

1. Extract the mineralization (dried flour paste mixture) from your mine by chipping the ore from the host rock. Transport the ore to the skip and raise it to the surface.
2. Devise a method to recover the iron filings from the other mined material, remembering that iron filings are made from magnetite, a very heavy and magnetic mineral.
3. Think of ways to safely manage the leftover material (tailings) after you separate the iron filings from the flour paste mixture (e.g. water filtration, disposal methods). NEVER dispose of iron filings down the sink.
4. Use your model to deliver a presentation to your classmates about the processes of mining and milling. Describe how ore is taken from the ground (mined) and processed (milled).

Extensions

1. **Discuss:** Talk about the various challenges associated with underground mining. Research and deliver a presentation explaining how technology is being used to mitigate some of these challenges. Identify real life examples of these solutions in place.
2. **Compare:** How would your mine model change if you were asked to build a surface mine? Would the challenges be the same or different?
3. **Consider:** What happens if the valuable mineral was not magnetite (iron filings) but diamonds?
4. **Problem Solve:** Can you find a way to move the ore from the shafts underground to the surface? Are there any components of the model that can be mechanized?