GROUNDRULES

MINING

Mining

AGES 11-13

INTRODUCTION

As the demand for mined minerals increases, everyone—from students, to miners, to governments and global corporations—must understand how to work together to meet those needs while protecting the world in which we live.

Ground Rules: Mining Right for a Sustainable Future is a documentary film created by Caterpillar and Science North. It follows the development of new and operating mines as geologists, engineers and mine managers tackle complex problems. It draws on the experiences and achievements of modern mine sites to illustrate creative and core concepts of sustainable development and social responsibility.

This set of lesson plans was developed by Science North, commissioned by Caterpillar to accompany the *Ground Rules* film. It provides a tool for educators to further examine the themes and concepts presented in the film through a series of "hands-on" classroom activities. It introduces students to the various phases involved in mining, different types of mines, how ore is processed, how mineral deposits were formed, how modern mines can operate safely and sustainably, and why minerals are important to our everyday lives. This material also introduces students to a wide variety of mining careers.

The lesson plans have been designed to broadly complement the curriculum objectives for the United States, Canada, and Australia. However, the lesson plans are not region-specific and can be used by educators throughout the world. All of the lesson plans have strong linkages to the earth science curriculum, but many of the activities incorporate additional linkages to math, chemistry, data management, mapping, environmental studies, electricity, magnetism and problem-solving. The lesson plans can be easily adapted to meet specific local curriculum goals.

In each lesson plan, an introductory section provides the appropriate film chapter reference and describes the key concepts for the lesson. One or two activities are then described in a step-by-step format. These activities include experiments, demonstrations, games, building activities, and research projects. The lesson plans end with a discussion section that provides possible follow-up topics and questions for classroom discussion. Each lesson plan also includes curriculum linkages, a vocabulary list, a materials list, and approximate timelines for completion of each section. Teacher answer sheets or data sheets are appended, where appropriate.

The lesson plans are organized into five broad themes: Geology; Mining; Mining Processes; Ore Processing; and Minerals and Everyday Life. The lesson plans are further sub-divided into three age categories: 11 to 13 years; 13 to 15 years; and 15 to 18 years. In many cases, the same topics are covered in each age category. However, lesson plans in the older age categories contain additional activities, alternative age-appropriate activities, and/or enhanced complexity.

Theme: Mining

This theme teaches students about open pit and underground mining, including safety and environmental considerations. It also introduces students to a wide range of mining careers. Students will build models of open pit and underground mines, with increasing complexity in each age category. The 15 to 18 year-old students will build on these concepts to design a mine based on a cross-sectional diagram of a hypothetical ore body. Younger students will explore the potential safety hazards at mine sites, learn how to identify safety hazards, and learn about methods used by mining companies to keep their workers safe. All age groups will learn about environmental monitoring of water bodies at mine sites and will test up to four different water quality parameters through age-appropriate field and classroom activities.

Ground Rules – Online Viewing and Learning Resources

As noted, these lesson plans are designed to be used with *Ground Rules: Mining Right for a Sustainable Future*. Multiple options are available for using the film in your classroom:

- **Order a free copy of the Ground Rules DVD**, containing both the English, Spanish and French versions of the film, from the Caterpillar web site, http://www.cat.com/groundrules.

- **View the full-length version of the film** in English, Spanish, French, as well as English with Chinese subtitles, online at http://www.cat.com/groundrules.

- **View individual chapters of the film** in English, Spanish and French, as referenced by individual lesson plans, on our You Tube channel, http://youtube.com/catgroundrules.

The full set of these lesson plans is available at http://www.cat.com/groundrules, and additional information and activities will be posted there as they become available.

Finally, follow *Ground Rules* online! Share your classroom experiences, feedback and ideas with us. Post photos of your projects and tell us about your successes!

Facebook: http://tinyurl.com/yzhxrva

Twitter: http://twitter.com/catgroundrules

About Caterpillar
For more than 80 years, Caterpillar Inc. has been building the world's infrastructure and, in partnership with its worldwide dealer network, is driving positive and sustainable change on every continent. With 2008 sales and revenues of $51.324 billion, Caterpillar is a technology leader and the world's leading manufacturer of construction and mining equipment, diesel and natural gas engines and industrial gas turbines. More information is available at www.cat.com.

About Science North
Science North, which opened in 1984 and is located in Greater Sudbury, is Northern Ontario's most popular tourist attraction and an educational resource for children and adults across the province of Ontario, Canada. Science North's drawing power lies with its unique approach to learning. The science centre has become world-renowned for its unique brand of hands-on science education and entertainment experiences which involve people in the relationship between science and everyday life.

Science North's attractions include a science centre, IMAX® theatre, butterfly gallery, special exhibitions hall, a digital Planetarium, and Dynamic Earth – a second science centre that offers visitors an up-close look at mining and the geological forces that continually shape the Earth. The same philosophies used to teach visitors about science at Science North are incorporated into every exhibit at Dynamic Earth, which first opened in 2003. This mining and geology centre combines above and underground experiences that allow visitors to work and play with real mining equipment and technologies. The site is also home to Sudbury's famous Big Nickel.

An agency of the provincial government of Ontario, Science North is overseen by the provincial Ministry of Culture. More information is available at http://sciencenorth.ca.

MINING | AGE: 11 TO 13 | LENGTH:1.5 HR | CURRICULUM: earth science, mining

BUILDING AN OPEN PIT MINE

Description

Students will build an open-pit mine and learn how ore is extracted from shallow ore bodies.

VOCABULARY:

1. Open pit
2. Overburden
3. Benches
4. Slope
5. Truck route

MATERIALS:

- *Ground Rules* film
- Mixture of sand and pebbles
- Water
- Carving tools (scoops, spoons, spatulas, plastic knives)
- Ruler
- Large plastic or wooden boxes
- Small toy dump trucks and scoops
- Large buckets/pails (ore buckets)

Introduction (Length: 30 minutes)

Watch Chapter 2 “Modern Mining” and Chapter 4 “Engineering Challenges” of the *Ground Rules* film. Chapter 2 shows an open pit copper mine in Chile, while Chapter 4 shows an open pit gold and copper mine in Papua Indonesia. Pause the film to look at the structure of the open pit mines featured in each of these film chapters.

Under what circumstances are open pits used? Ask the students what they notice about the structure of these open pit mines. Discuss the function of the benches or stepped sides of the pit. Discuss the width to height ratio of the open pit structures. What would happen if the pit was deep and narrow? Explain that an open pit mine has to be wider than its depth to maintain a safe structure.

What equipment is used in the open pit mine? How does the size of this equipment compare to the equipment used in an underground mine?

What was the greatest challenge in building the open pit mine in Papua Indonesia? The ore body is at the top of a mountain. In some ways, this poses as great or an even greater challenge than sinking shafts to mine underground. Discuss the similarities and differences of open pit mining at the top of a mountain versus mining a deposit that is deep below the earth’s surface (e.g., tramway to reach the top versus cage and shaft to reach the bottom; hauling the ore down the mountain versus hauling the ore up to the surface; building a road to the top versus sinking a shaft and digging tunnels underground). The blasting and loading processes to remove the ore are similar.






Activity (Length: 45 minutes)

The objective of this activity is to build a model of an open pit mine and learn how ore is extracted from shallow ore bodies.

1. Divide the class into groups of 3 or 4 students. Each group will build a model of an open pit mine. The goal is to build an open pit mine as deep as possible within the constraints of the box width.
2. Fill a large box approximately half full with the sand-pebble mixture. Add some water and mix it in to make a mixture that can be molded. Spread the mixture flat and pack it down.
3. Using a variety of tools, begin to carve out the open pit mine. Create the benches on the sides. Use a ruler to measure and build benches of uniform height and width. Remember to make some wider benches to be used for truck routes.
4. Discard the material dug out from the mine into the ore buckets.
5. Dig as deep into the mine as you can before the sides get too steep.
6. Use the wider benches to create a truck route from the top of the mine to the bottom. Use the toy trucks to determine the sizes of the truck routes (must be wide enough for two truck lanes).

Discussion (Length: 15 minutes)

What were the challenges involved in creating the open pit mines? How much time did it take to dig out the mine, build the benches and truck routes? Discuss how much time it would have taken you to do this using the toy trucks and shovels (i.e., when the scale of the equipment used is proportional to the mine). Discuss the importance of large equipment to increase the efficiency of the open-pit mining process. What are the challenges of operating such large equipment?

Visit cat.com/groundrules for more information, to provide feedback, to view the *Ground Rules* film on-line, or to order a copy of *Ground Rules* on DVD.

GROUNDRULES

MINING | AGE: 11 TO 13 | LENGTH:1.5HR | CURRICULUM: earth science, mining

BUILDING AN UNDERGROUND MINE

Description

Students will build a 3-dimensional model of an underground mine using toilet rolls. They will learn how ore is extracted from deep ore deposits.

VOCABULARY:

1. Mine shaft
2. Headframe
3. Cage
4. Skip
5. Drift
6. Ventilation shaft
7. Stope
8. Ore body
9. Ore pass

MATERIALS:

- *Ground Rules* film
- Toilet rolls and paper towel rolls
- Scissors
- Tape
- String
- Bar magnet
- Pencils and paper
- Cardboard
- Markers
- Small metal objects (coins, washers, bolts)
- Straws, sticks or long-handled narrow spoons
- Miscellaneous craft items

Introduction (Length: 30 minutes)

Watch Chapter 5 “Going Underground” of the *Ground Rules* film. Pause on the animated picture of the underground mine. Ask the students what the vertical and horizontal tunnels are called. What is one way (shown in the film) that underground mining has been made safer in recent years? (remote controlled vehicles)

Under what circumstances are underground mines used?

Describe the process of underground mining. What are the components of an underground mine? What is the purpose of the headframe? Describe the cables and winch system that are located in the headframe to lower the cage of miners into the mine and haul out the ore in the skip. What is the purpose of the ventilation shaft? Explain that the ventilation shaft can also be used as an emergency escape route.

How do workers access the ore body from the shaft? Discuss the process of tunneling into the rock to create drifts to access the ore body. What is a stope? Discuss the process of blasting to loosen the ore.

How is the ore removed from the mine? Discuss the use of ore passes to deliver the ore from various drifts to the bottom of the mine where it may be crushed and raised to the surface in the skip.






If there are local underground mines in your area, use these as examples to illustrate the concept of underground mining.

Activity (Length: 45 minutes)

The objective of this activity is to build a model of an underground mine, showing all of the features that are present in underground mines.

1. Divide the class into groups of 3 to 4 students. Each group will create a unique model of an underground mine.
2. Begin by sketching a design on paper. Include the main shaft, a ventilation shaft, at least 2 drifts, 1 stope per drift, and an ore pass that connects the drifts.
3. Using the toilet and paper towel rolls, tape, and scissors, create a 3-dimensional structure of the sketched underground mine. Create the mine shaft, ventilation shaft, drifts and the ore pass. Cut holes into the tubes when you need to attach pieces vertically to the middle of tubes (e.g., for the ore pass).
4. Create a stope on each drift by cutting a 1 inch (2.5 cm) diameter hole in the top of one section of the drift tube.
5. Using cardboard and various craft materials, design a headframe with sides but no bottom or top. Attach it to the top of the mine shaft with tape.
6. Attach string to the bar magnet (this will simulate the skip). Cut the string long enough to reach from the top of the mine shaft to the bottom. Test it out by lowering it through the top of the headframe into the mine shaft and pulling it out.
7. Stand the model up vertically in a physical support or have one student hold it firmly.
8. Test out the model by adding some small metal objects (ore) to one of the stopes in one of the drifts (through the opening on the top of the toilet tube). Use sticks, straws or long handled spoons to push or pull the ore to the ore pass opening on that drift. Allow the ore to fall to the bottom of the ore pass and into the bottom of the main shaft.
9. Lower the magnet on a string (to simulate the lowering of the skip), pick up the ore at the bottom of the mine shaft and bring it to the surface.

Discussion (Length: 15 minutes)

What were the challenges involved in building the underground mine models? When each model was tested, were there any areas where the ore was blocked from passing through? Discuss the challenges involved in building a real underground mine. How is the ore moved from the stopes to the ore pass in a real underground mine?

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GROUNDRULES

MINING | AGE: 11 TO 13 | LENGTH: 2 HR | CURRICULUM: earth science, chemistry, environment

ENVIRONMENTAL MONITORING - pH AND TEMPERATURE

Description

Students will learn about environmental monitoring of water bodies at mine sites. They will collect water samples from a local water body and test them for pH and temperature.

VOCABULARY:

1. Acidic
2. Basic
3. Neutral
4. pH
5. Temperature
6. Water quality
7. Samples
8. Acid rain
9. Sulfur dioxide

MATERIALS:

- *Ground Rules* film
- Litmus paper or universal indicator and color chart
- Waterproof thermometer
- Lemon juice and eye dropper
- Milk of magnesia or toothpaste
- Distilled water
- Tap water
- Rain water (optional)
- Hip or chest waders, rubber boots, life jackets
- Clipboard and notepaper
- Small plastic bottles with lids
- Data sheet (provided)

Introduction (Length: 30 minutes)

Watch Chapter 7 "Mining and the Environment" of the *Ground Rules* film. This chapter shows an example of how potential environmental impacts of a mine site were minimized at the McArthur River Mine in Australia.

Ask the students to name some of the possible environmental impacts of a mine (for example: water quality, air quality, land disturbance, removal of vegetation/habitat).

What major environmental challenge did Xstrata have to overcome before it could open the McArthur River Mine? (re-routing of the river). Discuss the challenges associated with rerouting the river (maintaining biodiversity, maintaining natural features of a river channel, water quality).

What does an environmental technician do at a mine site? Explain that in this activity, the students will be the "environmental technicians" of a hypothetical mine site. They will collect water samples and test them for pH and temperature.

Why is water temperature important to measure? Abnormally warm water may reduce the ability of the water to hold dissolved oxygen which is necessary for aquatic life. Dissolved oxygen can also be measured directly with a special probe.



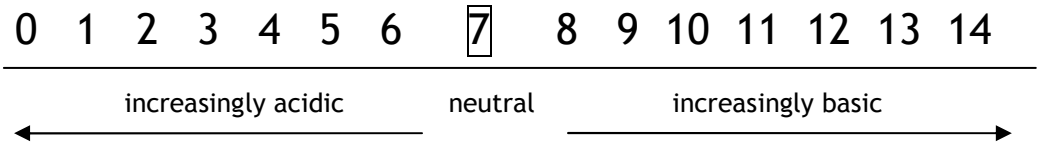



Introduce the pH scale and explain what is meant by the terms acidic, basic and neutral. The pH scale ranges from 0 to 14, with 7 being neutral. Numbers below 7 are acidic, while numbers above 7 are basic. The pH scale is logarithmic, so each number represents a 10-fold change. For example, a change from pH 7 to pH 6 means the acidity of the solution has increased by 10 times.

Explain that water quality monitoring at a mine site is conducted in order to evaluate possible changes that have occurred as a result of mining activities. Explain that each water body has a unique natural chemistry and there is not a standard pH value that is considered "normal" for all water bodies. Therefore, before the mine site is developed, water quality in each local water body that may be impacted by the mine is tested, so that there is a record of what is "normal" for each water body. This is often called baseline water quality. Then, after the mine is in operation, the water can be tested on a regular basis and compared to the baseline values to see if there has been a change in water quality. A change in pH may indicate a change in the chemistry of the water body.

The pH of normal rainwater is slightly acidic (pH 5.6) due to the presence of carbon dioxide gas. The pH of many water bodies ranges from 6 to 8. Fish and aquatic organisms begin to be affected when the pH drops below 5.

pH Scale:



Activity (Length: 30 minutes field location;30 minutes classroom)

The objective of this activity is to collect and test water samples from a local water body for pH and temperature.

1. Optional: Collect some rainwater in a small plastic bottle prior to the activity. Secure the lid tightly and keep in a cool place until the day of the activity.
2. Visit a local water body (lake or stream). For safety reasons, avoid fast-flowing rivers. Bring small plastic bottles, a thermometer, life jackets, notepaper and clipboards and waders/rubber boots.
3. For safety reasons, wear a life jacket at all times while water sampling.
4. Hold the thermometer in the water for a minute. Record the temperature on the clipboard notepaper. Test the water in a few places and record the temperature each time.
5. Wade into the water and collect a few samples of water in plastic bottles. Be careful to collect only water in the bottle (no sediment or plant material). Secure lids tightly.
6. Return to the classroom.
7. Transfer the temperature readings to Section A of the data sheet and answer the second question.
8. Test the pH of the water samples with litmus paper or universal indicator. Fill out Section B, Question 1 on the data sheet.

9. Test the pH of lemon juice, milk of magnesia/toothpaste, distilled water and tap water (optional: also test pH of rainwater). Record the pH measurements. Answer Questions 2 to 5 in Section B on the data sheet.
10. Pour ½ cup of distilled water into a clean sample bottle. Add a few drops of lemon juice. Test the pH. Continue adding a few drops at a time and testing again. Each time, record the total number of drops added and the pH measurement in Section C on the data sheet until you reach a pH of 5. Answer the remaining questions on the data sheet.

Discussion (Length: 30 minutes)

Review the answers to the questions on the data sheet. How might a mine site affect the temperature of a nearby water body? This could occur if the mine discharges warm water into a local water body. Explain that modern mines have a responsibility to protect the environment surrounding the mine. If they discharge water to the environment, they must ensure that the quality and temperature of the water is suitable to protect aquatic organisms and their habitat.

How might emissions from a mine site affect the pH of a nearby water body? Explain that a chemical called sulfur dioxide may be released to the air during the smelting process. In the atmosphere, sulfur dioxide combines with water and produces acid rain. When acid rain falls onto a water body, it can make the water acidic over time. Explain how modern mines install pollution control equipment to minimize the amount of sulfur dioxide released.

Other parameters that might be measured to monitor water quality in a water body near a mine site may include: dissolved oxygen, conductivity and turbidity. In addition, samples may be collected a few times per year and sent to a laboratory for chemical analysis.

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Environmental Monitoring Data Sheet

A) Water Temperature

1. Record the water temperatures measured in the waterbody. What is the average temperature? Did the temperature vary depending on where the sample was taken?

2. Would fish and other aquatic organisms be able to live in water that is this temperature?

B) pH

1. Record the pH measurements for the water samples collected from the water body.

2. Record the pH measurement for the lemon juice. Is this acidic, basic or neutral? Write lemon juice beside the correct pH value on the pH scale.

3. Record the pH measurement for the milk of magnesia/toothpaste. Is this acidic, basic or neutral? Write milk of magnesia/toothpaste beside the correct pH value on the pH scale.

4. Record the pH measurement for the tap water. Is this acidic, basic or neutral? Write tap water beside the correct pH value on the pH scale.

5. Record the pH measurement for the distilled water. Is this acidic, basic or neutral? Write tap water beside the correct pH value on the pH scale.

6. Optional: Record the pH measurement for the rain water. Is this acidic, basic or neutral? Write tap water beside the correct pH value on the pH scale.

C) Lemon Juice Experiment

1. Fill out the table below.

Total Drops of Lemon Juice Added	pH of the Water
0	

2. How does the pH of the water change as you add more drops of lemon juice? What is happening?

3. Approximately how many drops of lemon juice are required to reach a pH of 5?

4. Describe how the lemon juice experiment compares to the real world. What chemical is emitted from smelting operations that might have a similar effect as lemon juice in water? How does the chemical get from the smelter to the waterbody?

GROUNDRULES

MINING | AGE: 11 TO 13 | LENGTH: 2 HR | CURRICULUM: earth science, careers

MINING CAREERS

Description

Students will explore the different types of careers available in the mining sector. They will identify careers shown on the *Ground Rules* film and write job descriptions.

VOCABULARY:

1. Career
2. Geologist
3. Engineer
4. Safety Inspector
5. Technician
6. Trades
7. Laborer
8. Apprentice
9. Job description
10. Skills

MATERIAL:

- *Ground Rules* film
- Pens and paper
- Resource books or internet access
- Optional: guest(s) from a local mining company

Introduction (Length: 45 minutes)

Watch the entire *Ground Rules* film one chapter at a time. Each chapter explores a unique aspect of mining:

Chapter 1: Exploration
Chapter 2: Open pit mining and ore processing
Chapter 4: Engineering and open pit mining
Chapter 5: Underground mining
Chapter 6: Community relations
Chapter 7: Environmental aspects of mining
Chapter 8: Reclamation
(note that Chapter 3 does not specifically include any mining occupations)

Pause the film after each chapter to allow the students to record their answers. Ask the students to list as many mining jobs as they can for each chapter (those that are shown in the film, plus any others they can think of). Review the answers and make a master list of potential mining careers on the board. Discuss the number and variety of positions available.






Activity I (Length: 30 minutes)

The objective of this activity is to identify what skills are necessary for various mining careers.

1. Have each student identify a mining career that they are interested in.

2. Using resource books, internet access, or discussions with friends and relatives that are employed in the mining industry, each student should identify the following:

    a. The day to day activities involved in this position.
    b. The skills required to perform work duties.
    c. The education and training required for the position.
    d. The safety training required for the position.

Activity II (Length: 30 minutes)

The objective of this activity is to learn about specific local mining careers.

1. If possible, invite a guest(s) that works in a local mining industry to visit the classroom.
2. Before the classroom visit, students should prepare a list of 5 questions they would ask the visitor(s) to find out more about the type of work they do.

Discussion (Length: 15 minutes)

Discuss the variety of options that are available for jobs in the mining industry.

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GROUNDRULES

MINING | AGE: 11 TO 13 | LENGTH: 2 HR | CURRICULUM: earth science, mine safety

MINE SAFETY AND HAZARD IDENTIFICATION

Description

Students will explore the potential safety hazards at mine sites and learn about methods used by mining companies to keep their workers safe. In the second activity, they will explore safety hazards at their school and identify safety measures to prevent accidents.

VOCABULARY:

1. Hazard
2. Personal protective equipment (PPE)
3. Safety measure
4. Safety training

MATERIALS:

- *Ground Rules* film
- Mine safety cards
- Masking tape
- Paper and pencils

Introduction (Length: 30 minutes)

Watch Chapter 2 "Modern Mining" and Chapter 5 "Going Underground" of the *Ground Rules* film. Both of these chapters address many safety protocols that are used in modern mines.

As a class, identify some of the safety hazards in open pit mining and underground mining. Make a list of the hazards on the board. What are some of the protective items miners wear to keep themselves safe? Explain that these items are called personal protective equipment or PPE for short.

Activity I (Length: 30 minutes)

The objective of this activity is to determine the appropriate safety measures to implement for each mining hazard.

Preparation:

1. Prepare a series of mine safety cards (one safety measure per card).

Activity:

1. Place the cards face down at the front of the class.
2. Ask the students to come up one by one and take a card.
3. Each student must tape the card on the board beside a mining hazard that can be prevented by implementing the safety measure on the card.






Activity II (Length: 30 minutes)

The objective of this activity is to identify safety hazards in the school.

1. Divide the students into groups of 3 or 4 students.
2. Send each group to a different area of the school (either inside or outside).
3. Each group has 15 minutes to identify as many hazards as they can in that area of the school. Then the groups should come back to the classroom and identify possible safety measures to implement to prevent accidents associated with the hazards they identified.

Discussion (Length: 30 minutes)

Activity I:
Review the answers as a class. Are there any errors? Could some of the cards be placed beside another hazard? Discuss the importance of health and safety training prior to working at a mine site and the importance of "thinking safety" at all times during mining.

Activity II:
What hazards were identified by students at school? What are some safety measures that could be implemented to prevent accidents associated with these hazards?

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