GROUNDRULES

MINERALS AND REAL LIFE

Minerals and Everyday Life

AGES 13-15

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: Minerals and Everyday Life

This theme shows students how important minerals are in their everyday lives. It also examines some of the properties of minerals that make them useful. Younger students will investigate the minerals present in food, toothpaste and different objects in their home and school. They will identify the resources used to make a pencil, whether these resources are mined or grown, and how many countries it takes to make a pencil. They will explore the properties of copper by building a flashlight with copper wire. Older students will research the minerals and metals that are used to make various components of a computer. They will determine why these mined resources are useful to computers and extrapolate their findings to other electronic devices. They will keep a diary of items and associated minerals they use in a day to determine their daily "mineral consumption". The 15 to 18 year-old students will explore the benefits and impacts of coal. They will research the new technologies of methane capture, liquid gasification and carbon capture/sequestration, which are designed to reduce greenhouse gases generated by coal combustion.

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.

MINERALS AND EVERYDAY LIFE | AGE: 13 TO 15 | LENGTH:1.5DAY | CURRICULUM: earth science, minerals

CONSUMPTION OF MINERAL RESOURCES

Description

Students will learn how dependent they are on mineral resources from mines by keeping a list of all the items they use during one school day and determining which minerals are used in these items.

VOCABULARY:

1. Minerals
2. Non-renewable resource
3. Consumption

MATERIAL:

- *Ground Rules* film
- Paper and pencils

Introduction (Length: 15 minutes)

Watch Chapter 3 "Mining and the Modern World" of the *Ground Rules* film. Discuss the importance of minerals in our daily lives. Minerals have specific properties that make them useful to humans. All minerals come from the Earth's crust and must be mined.

As shown in the film, a variety of minerals are used to make common items. Recall a few examples of items mentioned in the film. What minerals were used to make them? Ask the students how many minerals they think they might use in a typical school day.

Activity (Length: 1 school day + 60 minutes)

The objective of this activity is to learn about consumption of mineral resources in our everyday lives.

1. Each student should make two hypotheses prior to this activity: how many minerals they think they use in a typical school day; and which minerals they think they use most often at school.
2. Over a full school day, each student should keep a list of all the items he/she uses. This should include items used in the classroom as well as items used during breaks and at lunch.
3. They should then identify some of the minerals used to make each of those items.
4. Each student should determine the number of different minerals he/she used in a school day and the five most common minerals used.






Discussion (Length: 45 minutes)

Create a summary table on the blackboard. Have the students help generate the column of items used in a school day by recalling some of the items on their list. As a class, identify the minerals used to make each of these items. Once a complete list has been generated, ask each student to come up and place a check mark beside all of the items they used in a school day. What were the most popular items used at school? Which minerals were used most often? How many different minerals were used by the class during a school day? How did the results compare to the student hypotheses? Did students overestimate or underestimate their consumptive habits? Extrapolate to how many different minerals they think they might use in a 24 hour period (at school and at home).

Discuss the implications of their findings. How dependent are we on mined minerals? Are these renewable or non-renewable resources? As long as we continue to use these items in our daily lives, we will be dependent on mining. How will we be able to sustain our consumptive habits in the future?

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.

MINERALS AND EVERYDAY LIFE | AGE: 13 TO 15 | LENGTH: 1 HR | CURRICULUM: minerals, composition of objects

MINERALS AT SCHOOL

Description

Students will explore items within their classroom, school or schoolyard and determine which minerals were used to make them, where these minerals are mined, and how the properties of these minerals are useful.

VOCABULARY:

1. Minerals
2. Properties

MATERIALS:

- *Ground Rules* film
- Data sheet (provided)
- Resource books, information sheets or access to the internet

Introduction (Length: 10 minutes)

Watch Chapter 3 "Mining and the Modern World" of the *Ground Rules* film. Discuss the importance of minerals in our daily lives. Minerals have specific properties that make them useful to humans. All minerals come from the Earth's crust and must be mined.

Explain that a variety of minerals have been used to make common items in their classroom, school and schoolyard. Select an example of a classroom object that will not be used in the activity. Ask the students what minerals are used to make that object. Why were those minerals selected? What properties of those minerals made them useful for the purpose of creating that item?

Activity (Length: 40 minutes)

The objective of this activity is to determine the mineral content of common items around the classroom, school or schoolyard.

Preparation:

1. Create 10 stations inside the classroom, school and/or schoolyard that highlight different items, such as foundation/sidewalk, bricks, nails, wall board, paint, windows, door knobs, floor tiles, plumbing, wiring, toilets/sinks, desks, chairs, playground equipment, television, computers, pencils, blackboards, etc.

Activity:

1. Divide the class into groups of 2 students.
2. Each group must select 10 items within the classroom or schoolyard. Record the 10 items in the first column on the data sheet. In brackets, also record the parts of this item (for example, a door is composed of a door knob, hinges and the door itself).
3. Using resource books, information sheets or the internet, each group must identify the minerals that make up each item. For items that are composed of many minerals, they






should list no more than 5 minerals. Record the minerals in the second column on the data sheet.

4. Next, each group should determine where the minerals in each item are mined. Record up to 5 countries for each mineral in the third column on the datasheet.
5. Finally, for each item, identify the property(ies) of each mineral that make it useful to the item evaluated (e.g., copper is useful for wiring because it can conduct electricity). Record the properties in the fourth column on the datasheet.

Discussion (Length: 10 minutes)

Have each group present their findings to the class for 2 of the items on their list. Try not to duplicate items already reported by previous groups.

Did anyone pick an item that is composed of more than five minerals? Televisions or computers are two items in a classroom that are composed of many minerals.

Did anyone pick an item that is not composed of any minerals? One example may be a wooden table or desk. But even this type of item may have nails or staples that are composed of minerals. Finding an item that is not composed of minerals should be hard to do and will emphasize the importance of minerals in our everyday lives.

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.

Minerals at School Data Sheet

Item	Minerals	Mining Locations	Properties
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

GROUNDRULES

MINERALS AND EVERYDAY LIFE | AGE: 13 TO 15 | LENGTH: 1 HR | CURRICULUM: earth science, mineral uses, lifecycle

MINERALS IN MY HOUSE

Description

Students will play a matching game to learn what minerals are used in common household items.

VOCABULARY:

1. Minerals
2. Properties
3. Lifecycle
4. Recycling

MATERIALS:

- *Ground Rules* film
- Sets of "mineral content" cards
- Masking tape

Introduction (Length: 15 minutes)

Watch Chapter 3 "Mining and the Modern World" of the *Ground Rules* film. Discuss the importance of minerals in our daily lives. Minerals have specific properties that make them useful to humans. All minerals come from the Earth's crust and must be mined.

As shown in the film, a variety of minerals are used to make common household items. Recall a few examples of household items mentioned in the film that will not be used in the activity. Why were those minerals selected? What properties of those minerals made them useful for the purpose of creating that item?

Activity (Length: 30 minutes)

The objective of this activity is to determine the mineral content of common household items.

Preparation:

1. List 10 common household items on the board.
2. Prepare a set of cards containing the minerals used to make those 10 items. One mineral should be written on each card.

Activity:

1. Place all the mineral cards face down on a desk near the blackboard.
2. One at a time, have each student come up to the board, pick a card from the pile and attach it with masking tape beside the household item they think contains that mineral. Remind the class that several minerals may be used in one item.
3. Repeat #2 until all the mineral cards are used.
4. Go through each item and ask the class if the minerals placed beside it are correct. Invite students to come up to the board to correct any mistakes.
5. Continue #4 until the class thinks they have everything correct.
6. Review the correct answers with the class.






Discussion (Length: 15 minutes)

Pick one or two of the items for further discussion. For each item, ask the class why they think those specific minerals were used to make the item. What are the properties of those minerals that make them useful to the household item? Discuss the lifecycle of the minerals used in those items. Where in the world are those items mined? Ask the class if the item can be disposed in a regular landfill after its useful life. Can some of the minerals be separated from the item and recycled?

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.

Household Items and Minerals (from Chapter 3 of Ground Rules)

Wallboard – gypsum, clay, perlite, vermiculite, aluminum hydrate, borates
Paint – titanium dioxide, kaolin, calcium carbonate, mica, silica, wollastonite
Glass – silica, quartz, lead, titanium, sodium carbonate
Door Knob – nickel
Speakers – aluminum, cobalt, silver, silica, iron, titanium, graphite, mica, carbon, strontium, neodymium
Plastic – calcium carbonate, talc, wollastonite, barium sulfate, clay, mica
Keys – nickel
Stainless steel – iron, nickel, molybdenum, chrom
Non-stick coating – fluorite
Ceramic tiles – clay, feldspar, fluorite, lithium, silica, talc
Countertop – titanium dioxide, calcium carbonate, aluminum hydrate
Knife – chromium
Table salt – halite, iodine
Sugar – limestone, lime
Toothpaste – calcium carbonate, limestone, sodium carbonate, fluorite, mica, zinc
Cosmetics – calcite, hematite, kaolinite, mica, silica, talc, titanium, zinc
Carpet – calcium carbonate, limestone
Textiles – antimony, feldspar, tungsten
Dish soap – halite, sodium carbonate
Can opener – iron, nickel, chromium, molybdenum
Incandescent light bulbs – tungsten
Window panes – silica, lime, sodium carbonate, calcium carbonate, halite, feldspar
Brick – kaolin, shale, barium, manganese
Jewelry – gold, silver, platinum, diamonds
Soda cans – aluminum

Others

Baby powder – talc
Cement - limestone
Insulation - vermiculite
Matches – sulfur
Sun block – zinc
Thermometer – mercury
Utensils – nickel, iron, silver

MINERALS AND EVERYDAY LIFE | AGE: 13 TO 15 | LENGTH:1 HR | CURRICULUM: earth science, health

MINERALS IN TOOTHPASTE

Description

Students will learn about the uses of various minerals in toothpaste through experimentation.

VOCABULARY:

1. Acid
2. Plaque bacteria
3. Tooth decay
4. Fluorspar (fluoride)
5. Mica
6. Sodium carbonate
7. Zinc

MATERIALS:

- *Ground Rules* film
- 3 different brands of toothpaste containing different ingredients
- Toothbrushes (1 per group)
- Small ceramic tiles, beige colored (3 per group)
- Container of water
- Safety goggles
- Felt-tipped black marker
- Small white porcelain squares (available at most hardware stores)

Introduction (Length: 20 minutes)

Ask the class if they can name a mineral used in toothpaste. Pass around a few tubes of different brands of toothpaste and ask the class to look at active ingredient list. Make a list on the blackboard and see which ingredients are most common among the different brands.

Watch Chapter 3 “Mining and the Modern World” of the *Ground Rules* film. Pause the film at the scene where the mother is brushing her teeth. Note that toothpaste is composed of several minerals including calcium carbonate, limestone, sodium carbonate, fluorite, mica and zinc.

Discuss how there are many minerals found in toothpaste and that every brand of toothpaste contains a slightly different mixture of minerals. However, all toothpastes contain abrasive minerals to rub the plaque away. The most common abrasive minerals used in toothpaste include silica, limestone and calcium carbonate. Most toothpaste brands also contain the mineral fluorite, which is composed of calcium fluoride. This mineral makes the tooth more resistant to decay.

Sodium carbonate is used in some toothpastes whiten teeth.

Zinc is sometimes used in toothpastes as an anti-bacterial agent to prevent gingivitis (gum disease).






Toothpastes may also contain other minerals and ingredients to make the toothpaste sparkly (mica), to make it white (titanium), to make it thick (sand), to whiten teeth (sodium carbonate) and to fight bacteria (zinc).

Discuss some of the common minerals found in toothpaste, what types of rocks they are found in, and where they are mined. Here is some information on four common mineral ingredients:

1) Fluorite (also called fluorspar)
Fluorspar or fluorite are two names given to minerals composed of calcium fluoride (CaF_2). Fluoride makes the entire tooth structure more resistant to decay and promotes remineralization, which aids in repairing early decay before the damage can even be seen. Fluorspar/fluorite is found in a variety of geologic environments. It occurs in granite (igneous rock) and in large deposits in limestone (sedimentary rock). It can also be found in the cracks and holes in sandstone. Fluorspar is not mined in the United States. More than 15 countries produce fluorspar. China, Mexico, and South Africa are the largest producers. There is a fluorspar mine in Newfoundland, Canada. China supplies about two-thirds of the fluorspar used in the United States.

2) Mica
Mica is the mineral added to toothpaste that makes the substance sparkle. Large flakes and sheets of mica minerals are found in some metamorphic and igneous rocks. The commercially important micas are muscovite and phlogopite. India and Russia are the world's largest producers of sheet mica. A very small amount of mica is produced in the United States. The largest sheet of mica ever mined in the world came from a mine in Quebec, Canada. Sheet, scrap and flake mica are commercially important. Other primary uses for scrap and flake mica are in joint compound, paint, roofing, well drilling additives, and rubber products.

3) Sand (silica)
Sand is added to toothpaste to make the paste thicker. Most sand and gravel is composed of the mineral quartz, with varying amounts of feldspar, rock fragments, and other mineral materials. The commercial use of sand and gravel falls into two categories: construction sand and gravel, and industrial sand and gravel. Industrial sand and gravel, which is often termed "silica," "silica sand," or "quartz sand," includes sand and gravel with high quartz content. Such sand and gravel is used, for example, in glassmaking. Construction sand and gravel typically has a lower silicon dioxide content than does industrial sand and gravel. It is mixed with other materials, such as cement in concrete foundations, roads, and buildings, or is used as is in road bases. Construction sand and gravel is mined in all U.S. states and industrial sand and gravel is mined in 37 U.S. states. Canada is one of the leading nations processing and producing industrial sand and gravel. The Unites States imports a substantial amount of sand from Canada.

4) Sodium Carbonate
Sodium carbonate is commonly known as washing soda. It is used as a whitening agent in toothpaste, usually in combination with hydrogen peroxide. Sodium carbonate is soluble in water, but can occur naturally in arid regions, especially in the mineral deposits formed when seasonal lakes evaporate. Sodium carbonate is mined in several areas of the United States and Canada. The most important use for sodium carbonate is in the manufacture of glass. When heated to very high temperatures, combined with sand (silicon dioxide) and calcium carbonate, and cooled very rapidly, glass is produced.

Activity (Length: 30 minutes)

The objective of this activity is to determine which brands of toothpaste, and which minerals, are most effective in removing a stain from ceramic tiles and porcelain.

Preparation:

1. Divide the class into groups of 2 or 3.
2. Give each group 3 ceramic tiles, 3 porcelain tiles, one toothbrush and a container of water.
3. Each group should create two copies of the following table: one for the ceramic tiles and one for the porcelain tiles.

Toothpaste Data Table

Toothpaste Brand	Minerals Present	Prediction	Observations

Activity:

1. List all of the ingredients in each toothpaste brand in the first column, and the amounts of each of these ingredients (if listed).
2. Mark each ceramic tile with a black felt-tipped marker.
3. Make predictions on how effective each toothpaste brand will be in removing the marker stain.
4. Put a pea-sized amount of the first toothpaste brand onto the toothbrush. Brush one of the marked ceramic tiles in one direction 50 times. Ensure that students use the same amount of force for each stroke. Record observations in the fourth column. How well did that toothpaste brand remove the stain?
5. Using the container of water, rinse off the toothbrush thoroughly.
6. Repeat steps 4 and 5 with the other two brands of toothpaste.
7. Mark the porcelain tile with a black felt-tipped marker.
8. Repeat steps 3 to 6 with each of the porcelain tiles and toothpaste brands.

Discussion (Length: 10 minutes)

Which brand of toothpaste was the most effective in cleaning the ceramic tiles? What are the active ingredients in that toothpaste brand? Were the students' hypotheses correct?

Why did the experiment include porcelain tiles? Artificial teeth are made of porcelain. Was the same brand of toothpaste also the most effective in cleaning the porcelain tiles?

Discuss the purpose of fluoride in toothpaste. What are the disadvantages of including more fluoride in toothpaste? Discuss the condition called fluorosis in which excess fluoride ingestion can lead to discoloration in developing teeth. This is why toothpaste should never be swallowed and why levels of fluoride in tap water are typically low.

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.

MINERALS AND EVERYDAY LIFE | AGE: 13 TO 15 | LENGTH:1.5 HR | CURRICULUM: earth science, mineral uses

WHAT PARTS OF A COMPUTER ARE MINED?

Description

Students will explore the minerals and metals that are used to make various components of a computer. They will explore the reasons why these materials are useful to computers and extrapolate their findings to other electronic devices.

VOCABULARY:

1. Minerals
2. Properties

MATERIALS:

- *Ground Rules* film
- Resource books or access to the internet

Introduction (Length: 15 minutes)

Watch Chapter 3 "Mining and the Modern World" of the *Ground Rules* film. Discuss the importance of minerals in our daily lives. Minerals have specific properties that make them useful to humans. All minerals come from the Earth's crust and must be mined.

Ask them to recall how many minerals are used in a computer (mentioned on the film). Ask them if they can name any minerals used in a computer and why they think those minerals were useful for the purposes of building a computer. Discuss the fact that minerals have specific properties that make them useful for certain functions. If we want to build something, we must carefully choose the specific minerals that will provide the functions required.

Activity (Length: 45 minutes)

The objective of this activity is to determine the minerals and metals that are used to make a computer and to determine the properties of these elements that are useful for computers.

1. Divide the class into groups of 3 to 4 students.

2. Using resource books or the internet, have each group identify the minerals and metals used to build the following components of a computer:

    a. Computer monitor
    b. Computer chip
    c. Computer circuitry
    d. Computer case
    e. Electrical cords






3. Identify the properties of each material that makes it useful to the function of that component of the computer.

Discussion (Length: 30 minutes)

Review the answers and make a comprehensive class list of the minerals and their useful properties. Based on that list, ask the class to hypothesize what minerals would be useful for another electronic item, such as a television, portable media player, cell phone, etc.

Discuss the environmental implications of disposing of outdated computer equipment. Should computer equipment be disposed in a landfill? Why is computer waste one of the biggest waste issues facing the world?

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.

Minerals and Metals in a Computer

Computer Monitor:
- Silicon, lead, strontium, phosphorus, boron, indium, barium

Computer Chip:
- Silicon, gallium

Computer Case:
- Calcium carbonate, clays, mica, talc, sulfur

Computer Circuitry:
- Gold, aluminum, lithium, chromium, silver, nickel, gallium, lead, zinc, copper, steel, tungsten, titanium, cobalt, germanium, tin, tantalum

Electrical cords:
- Copper