GROUND**RULES**

MINERALS AND REAL LIFE

Minerals and Everyday Life

AGES 15-18

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: 15 TO 18 | 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 at home in a 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 household items. Recall a few examples of household 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 day.

Activity (Length: 1 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 day; and which minerals they think they use most often in a day.
2. Over a 24 hour period, each student should keep a list of all the items he/she uses.
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 day and the five most common minerals used in a day.






Discussion (Length: 45 minutes)

Create a summary table on the blackboard. Have the students help generate the column of items used in a 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 day. What were the most popular items used? Which minerals were used most often? How many different minerals were used by the class during a 24 hour period? Discuss how the results compared to the student hypotheses. Did students overestimate or underestimate their consumptive habits?

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: 15 TO 18 | LENGTH: 3 HR | CURRICULUM: earth science, resource lifecycle

LIFECYCLE OF COAL

Description

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.

VOCABULARY:

1. Coal-fired power plants
2. Coal combustion products
3. Methane capture
4. Liquid gasification
5. Carbon capture and sequestration
6. Non-renewable energy
7. Renewable energy

MATERIAL:

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

Introduction (Length: 15 minutes)

Watch Chapter 8 “Reclamation” of the *Ground Rules* film. This chapter shows how coal is mined at a mine site in the United States and how the site is reclaimed after mining.

What is the major use of coal? Discuss our dependence on coal as an energy source. As the film states, approximately 40% of the world’s electricity is generated by coal. What are some of the benefits and impacts of coal consumption?

Explain that the students will be conducting a research project to learn more about the benefits and impacts of coal to their everyday lives.






Activity (Length: 120 minutes)

The objective of this activity is to learn about the benefits and impacts of coal usage in everyday life and about the technologies that are being used now or may be used in the future to reduce the environmental impacts of coal combustion.

1. Using resource books or internet access, answer the following questions:

    a. What are the benefits of coal to our everyday lives? List several current and historical uses of coal. Which countries are the most dependent on coal as an energy source today?

    b. Describe the process of coal combustion used in a typical coal-fired power plant. What are the impacts of coal combustion?

    c. What are the solid combustion products left over after combustion of coal? Which of these combustion products can be recycled or reused? Which of these products can be disposed in a landfill?

    d. What substances are released to the air during coal combustion? What types of pollution control technologies are used in coal-fired power plants to reduce air pollution and acid rain?

    e. Briefly describe the processes of methane capture, liquid gasification and carbon capture/sequestration. How can these processes be used to reduce greenhouse gas emissions from coal combustion?

    f. How dependent are you on coal combustion? What is the energy source used to generate the electricity you use on a daily basis? Where is the electricity generation facility located? Is this a renewable or non-renewable energy source?

Discussion (Length: 45 minutes)

Review the answers to the questions. Discuss some of the new technologies for reducing the impacts of coal combustion.

Methane Capture:
Methane is stored in large quantities in coal deposits. When these deposits are mined, the methane gas is released to the atmosphere. Methane gas is a potent greenhouse gas (21 times the global warming potential as carbon dioxide). Methane can be captured and directed to a flare where it is burned off or it can be used as fuel to generate power at the mine site. Either way, when methane is burned, it produces two molecules of water and a molecule of carbon dioxide. So, greenhouse gases are still produced, but in the form of carbon dioxide which is less potent than methane.

Liquid Gasification:
In this process, coal is converted to a liquid product. The solid coal is put into a gasifier where heat, pressure and oxygen break up the coal and produce a gas containing carbon monoxide and hydrogen (often called “syngas”). The syngas is then condensed into a liquid

product that can be used to make liquid fuels like diesel and gasoline. Carbon dioxide is released when the coal is liquefied and again when the synthetic fuels are burned.

Carbon Capture and Sequestration:
In this process, carbon dioxide emissions from coal-fired power plants are captured and transported by pipeline to suitable storage facilities. In geological sequestration, the carbon dioxide is injected into certain types of underground geological formations that would essentially trap the carbon dioxide and prevent it from releasing to the surface. Carbon dioxide is also sometimes injected into oil fields to enhance the recovery of oil. It can also be injected into un-minable coal deposits where it adsorbs strongly to the surface of the coal. Sequestration in the oceans is also a possibility, but there may be many undesirable environmental effects with this method. Sequestration of carbon dioxide in mineral formations is currently being studied. Carbon dioxide can be reacted with minerals that contain magnesium and calcium to form carbonates, which are stable and unlikely to re-release the carbon dioxide. However, the natural formation of carbonates is a slow process, so researchers are studying ways to enhance the speed of the process.

Research is still being conducted on all of these technologies to find ways to further reduce emissions of greenhouse gases from coal combustion.

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MINERALS AND EVERYDAY LIFE | AGE: 15 TO 18 | LENGTH: 2.5HR | CURRICULUM: earth science, minerals

MINERAL DESIGN

Description

Students will use the information they have learned about the properties of some common minerals to design a new "invention". They will select the minerals that will be used in the design based on the desired structure and functions of the invention.

VOCABULARY:

1. Mineral properties
2. Structure
3. Function

MATERIAL:

- *Ground Rules* film
- Resource books or internet access (mineral property information)
- Optional: list of potential "inventions"

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. Why were those minerals selected? What properties of those minerals made them useful for the purpose of creating that item?

Activity (Length: 90 minutes)

The objective of this activity is to use the information they have gained about mineral properties to design a new invention.

1. Prepare a list of "inventions" the students might choose to design or allow the students to choose their own "invention".
2. Divide the class into groups of 2 or 3 students.
3. Each group should begin by sketching a design of their invention and describing the physical structure and primary functions of the invention.
4. They should determine which minerals they will need to incorporate into the invention to perform the required functions and which minerals they will be required in the physical structure of their invention.
5. Each group should make a presentation to the class, describing their invention, which minerals would be used to create the invention, and why these minerals were selected.






Discussion (Length: 45 minutes)

Have each group present their "invention" design to the class. How could these designs be improved? Did any of the groups miss an important mineral which would have been essential to the structure or function of their invention? Which minerals were most commonly used among the groups?

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MINERALS AND EVERYDAY LIFE | AGE: 15 TO 18 | LENGTH:2.5 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. They will describe the lifecycle of one key mineral used to make a common household item.

VOCABULARY:

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

MATERIALS:

- *Ground Rules* film
- Sets of "mineral content" cards
- Masking tape
- Resource books or access to 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.

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 I (Length: 60 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.

Activity II (Length: 60 minutes + writing and presenting time)

The objective of this activity is to describe the lifecycle of the key minerals used to make one household item. Students will determine how and where the minerals are mined, how they are processed, and how they can be recycled or disposed of after use.

1. Divide the class into groups of 2.
2. Using the list generated in Activity I, ask each group to select one household item for further research.
3. Using resource books or the internet, have students conduct research on the minerals used to make that item. They should identify how and where the minerals are mined, how they are processed, and how they can be recycled or disposed of after use.
4. Each group should write a short report on their findings and present it to the class.

Discussion (Length: 15 minutes)

Activity I:
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?

Activity II:
Have each group present their findings to the class. Discuss the lifecycle of minerals from mining to recycling or disposal. Are mined resources renewable or non-renewable? Can mineral resources be conserved?

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: 15 TO 18 | LENGTH:3 HR | CURRICULUM: earth science, mineral uses, lifecycle

WHAT PARTS OF A COMPUTER ARE MINED?

Description

Students will explore the rocks, 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 they will research the complete lifecycle of some of the minerals.

VOCABULARY:

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

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 I (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.

Activity II (Length: 60 minutes + writing and presenting time)

The objective of this activity is to describe the lifecycle of one mineral used in a computer. Students will determine how and where the mineral is mined, how it is processed, how it is built into the component part required in a computer, and how it can be recycled after use.

1. Using the list generated in Activity I, ask each group to select one mineral for further research.
2. Using resource books or the internet, have students conduct research to identify how and where the mineral is mined, how it is processed, how it is made into the component part required in a computer, and how it can be recycled after use.
3. Each group should write a short report on their findings and present it to the class.

Discussion (Length: 60 minutes)

Activity I:
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.

Activity II:
Have each group present their findings to the class. Discuss the environmental implications of disposing of outdated computer equipment. Should computer equipment be landfilled? Why is computer waste one of the biggest waste issues facing the world? Discuss the effort required to disassemble and recycle all of the different components of a computer. It is labor intensive and can also be a health risk if proper health and safety equipment is not used in the process. Discuss the global implications of computer waste. A large amount of computer waste from North America is shipped to China for disassembly and recycling.

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