GROUNDRULES

MINING PROCESSES

Mining Processes

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: Mining Processes

This theme covers the processes involved in mining, from exploration and site development to reclamation. The core lesson plan is a game in which students explore the various phases involved in the development of a mine and the economic aspects of these phases. Through this game, students will gain an understanding of the decision-making processes involved in determining whether an ore body can be profitably mined. The game increases in complexity with age category. The orebody mystery is an exploration game in which students collect playdough core samples, analyze them for mineral content, and map the extent of an ore body. Younger students investigate the concept of mechanical advantage by looking at simple mining tools, as well as the concepts of mass, volume, density and specific gravity in relation to gold panning. In the reclamation activity, students will experiment with growing plants on reclaimed landscapes. The 15 to 18 year-old students will develop a closure and reclamation plan for a hypothetical mine site and make decisions with respect to engineering challenges, environmental impacts and social implications involved in developing a mine.

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 PROCESSES | AGE: 15 TO 18 | LENGTH: 2 HR | CURRICULUM: earth science, environment

DEVELOP A CLOSURE AND RECLAMATION PLAN

Description

Students will develop a closure and reclamation plan for a real or fictitious mine site. They will determine what the area will be used for after reclamation, what steps they will take to reclaim the land and what resources they will require. They will draw a diagram of the reclaimed landscape.

VOCABULARY:

1. Reclamation
2. Closure plan
3. Progressive reclamation

MATERIALS:

- *Ground Rules* film
- Access to the internet
- Paper and pencils or computer graphics program
- Mine site case study with diagram of mine site during operation (can be fictitious)

Introduction (Length: 30 minutes)

Watch Chapter 8 “Reclamation” of the *Ground Rules* film.

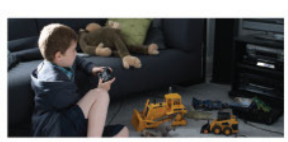
Ask the students what is meant by reclamation. Reclamation refers to the process of restoring the land that was disturbed by a mining operation to create an environment that is safe and productive for use by future generations. Discuss the possible safety and environmental issues that could result if the mine site was not reclaimed.

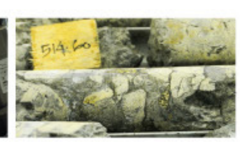
For modern mines, reclamation has to be planned out in advance of opening the mine. This is called “Closure or Reclamation Planning”. Mining companies have to prepare a plan and have it approved by the government.

Ask the students what they noticed about the natural vegetation in the New Guinea site compared to the natural vegetation in the Wyoming site? Ask them which site they think would be easier to reclaim. Discuss the fact that the goal of reclamation is to create a landscape that is as close to the natural landscape as possible, but that this will be much harder to achieve in a rain forest than in a prairie region.

Review examples of mine sites in your country, state or province that have been reclaimed. What type of landscape was created after reclamation? What types of structures were reclaimed and how were they reclaimed? (the Mineral Information Institute has several profiles of reclaimed mine sites; www. mii.org)





Activity (Length: 60 minutes)

The objective of this activity is to develop a plan for closure and reclamation of a mine site. Students can work alone or in groups.

Preparation:

1. Prepare a case study for this activity based on a fictitious mine site or a real mine site that is active or has been rehabilitated in your country, state or province.
2. Obtain or create a simple diagram of the mine site during operation.
3. If the mine site is fictitious, create a description of the mine (what type of mine, what product was mined, where it is located, details about the nearest community, etc.). If it is an actual mine site, the students can research this information on their own.

Activity:

1. Using the information provided by your teacher, design a closure and reclamation plan for the mine site.
2. Describe how the area will be used following closure and reclamation.
3. Describe how each of the features of the mine will be closed and reclaimed (open pit mine, underground mine, tailings ponds, waste rock stockpiles, buildings, access roads, airstrips, etc.).
4. What resources will you need to construct the reclaimed landscape? (e.g., trees, grass, soil). Do any natural resources have to be saved before the mine is constructed (e.g., topsoil)?
5. Draw a diagram showing the mine site after reclamation.

Discussion (Length: 30 minutes)

Have each student/student group present their reclamation plan to the class.

If this activity is completed for an actual mining operation that has been rehabilitated, compare the students' plans with the actual reclaimed landscape.

If the mine is currently in operation, perhaps a mining company representative could come to the class to explain what the company is planning for future reclamation of the site.

Discuss the term "progressive reclamation". Explain that in some cases, reclamation of some structures can occur while the mine is still in operation. For example, in strip mining of coal deposits, once the coal has been removed from a section and mining operations have moved onto another section, the previously mined section can be reclaimed. In hard rock mines, stockpiles of waste rock can be reclaimed by laying soil on top and planting vegetation.

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 PROCESSES | AGE: 15 TO 18 | LENGTH: 1.75HR | CURRICULUM: earth science, math, problem-solving

THE MINING PROCESS GAME

Description

Students will explore the various phases involved in the development of a mine and the economic aspects of these phases. They will gain an understanding of the decision-making processes involved in determining whether an ore body can be profitably mined.

VOCABULARY:

1. Exploration
2. Claim
3. Drilling
4. Ore body
5. Waste rock
6. Mineral valuation
7. Gross and net profit

MATERIALS:

- *Ground Rules* film
- Approximately 500 poker chips (same color)
- Five colors of paint (yellow, blue, green, red and black) and brushes
- Graph paper
- Colored markers (same colors as paint)
- Timers
- Calculators
- Worksheet (included in lesson plan)

Introduction (Length: 30 minutes)

Watch Chapter 1 “Exploration” and Chapter 2 “Modern Mining” of *Ground Rules*.

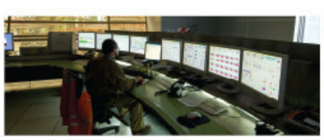
Discuss the stages involved in the development of a metal mine. Emphasize the decision-making processes involved in deciding whether to develop a mine.

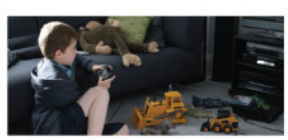
The first stage in the development of a mine is called “Mineral Exploration”. This phase involves identification of an ore body, mapping the location and extent of the ore body, staking a claim, drilling to collect core samples, analyzing the core samples for mineral content and chemistry, and determining the resource potential of the property.

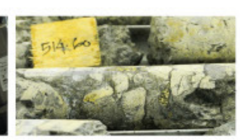
Introduce the concept of costs and benefits. In mining, there are a variety of costs, such as exploration work, regulatory processes, equipment, engineering challenges, mining labour, training, health and safety, and reclamation.

The benefits of mining arise from the value of the metals extracted. The grade or concentration of the metal as well as its form of occurrence will affect the costs associated with mining the ore. Therefore, the costs involved in extracting the ore must be weighed carefully against the value of the metal deposit to determine if the mine can be profitable. Mining companies usually conduct feasibility studies to determine the viability of potential mines.

Discuss the concept of mineral valuation. Different minerals have different values (for example, a pound of gold is worth much more than a pound of lead). The value of the mineral is determined by the demand for that mineral to make the things that we use in our everyday lives.





Discuss the process of extracting ore. Only a portion of the ore body contains the metals of interest. During the mining process, the metals of interest are extracted from the surrounding rock. The remaining waste rock must be disposed of in an environmentally responsible manner. Typically, the volumes of waste rock are far greater than the volumes of the metal. The company has to decide where to stock pile the waste rock and how to incorporate this into the reclaimed landscape at the conclusion of the mining process.

Activity I (Length: 60 minutes + 30 minutes preparation time)

The objective of the activity is to develop a profitable mining operation. Students should work in groups for this activity because in the real world, these decisions are made by teams of people.

Student Preparation (15 minutes):

1. Divide the class into three or four groups, representing mining companies.
2. Let each group name their company and create a company sign (that will be used for staking their mining claim).
3. Using the graph paper, each group should prepare a "base map" of the room where the activity will take place. The map should show all major features like doors, windows, desks, tables, cabinets, etc. To increase mapping precision, the map may be drawn to scale and compass direction, although this is not essential to the activity.

Teacher Preparation (30 minutes):

1. Assign each of the five paint colors to a mineral type. For example: yellow = gold, blue = silver, green = copper, red = iron, black = lead.
2. Paint a spot of one color on one side of approximately 25 to 30 poker chips. Do the same for the other four colors. The remaining unpainted poker chips will represent waste rock.
3. While students are out of the room, put the poker chips in clusters on desks, tabletops or countertops in various locations around the room (1 or 2 more clusters than there are groups of students). Each cluster represents a property which may or may not contain a valuable ore body. You can group different colors together to represent the ore bodies because several different minerals are often found together in nature (but each property should have a dominant mineral type and less of the other minerals).
4. Randomly place approximately 25% of the painted poker chips with the painted side up and the rest with the painted side down.
5. Add approximately three times as many unpainted poker chips to each cluster (i.e., waste rock).
6. Keep an answer sheet that indicates how many of each color of poker chips are used in each cluster.
7. Provide the following information to each company:
   a. A set of colored markers (matching the paint colors).
   b. A list of the poker chip colors and their corresponding mineral type. Students should add a legend to their map indicating which colors represent which mineral types (using the colored markers).
   c. The value of 1 poker chip of each type (use amounts in mine valuation section of the worksheet or similar values reflective of the relative value of these mineral types in the real world).

Activity:

Prior to starting the activity, explain that the poker chips represent minerals and waste rock and that some of the painted poker chips are upside down, so the full extent of the deposit is unknown. The objective of the activity is to develop the most profitable mine. Remind the students that time costs money in the mining process, so all phases of mining must be done as quickly as possible, but with careful thinking as well!

Phase 1: Site Reconnaissance

1. Set the timer for 10 minutes.
2. Using colored markers, two representatives from each company will visit each potential "property" and record dots on their base map where the known (i.e., chips with painted side face up) and unknown (i.e., face down) poker chips are located. THE POKER CHIPS CANNOT BE MOVED OR TURNED OVER AT THIS TIME. This is called an exploration map. THE POKER CHIPS CANNOT BE MOVED OR TURNED OVER AT THIS TIME.
3. When mapping is completed, stop the timer.
4. Each company must record on their worksheet the number of minutes used in the exploration phase and calculate the cost of exploration on their worksheet.

Phase 2: Staking the Claim:

1. Set the timer for 10 minutes.
2. During this time, each company should look over their exploration map and decide where they are going to "stake their claim" (i.e., which property they are going to mine).
3. When the timer goes off, one representative from each company will place their company sign on the property they want to claim.
4. If two or more companies claim the same property, a competitive bid will take place. Use a coin toss (or similar method) to decide who makes the opening bid ($20,000). Each company involved in the competitive bid will take turns deciding whether to find another property or to present their own higher bid price in increments of $20,000. The winner of the competitive bid process will control that property and record the bid price they paid for the property on their worksheet. The loser(s) must stake a claim on another property.

Phase 3: Exploration Drilling:

1. Set the timer for 10 minutes.
2. Each company must drill up to six holes on their property. Drilling consists of turning over up to 6 unknown poker chips to expose the mineral types on the underside of the poker chips. The group decides how many and which poker chips they will turn over.
3. Drilling must be completed before the timer goes off.
4. Calculate the cost of drilling on the worksheet.

Phase 4: Mine Development:

1. Each company will mine their whole property by turning over each remaining unknown poker chip.
2. Record the number of poker chips mined (i.e., the total number of poker chips). This includes unpainted poker chips (i.e., waste rock) and previously face-up poker chips because it also costs money to extract these from the ground.
3. Calculate the cost of mine development on the worksheet.

Phase 5: Mine Valuation:

1. Record the number of poker chips of each mineral type on the worksheet. Calculate the value of each mineral type and the total mineral revenue.

Phase 6: Waste Rock Disposal and Reclamation

1. Count the number of waste rock chips and record on the worksheet.

2. Decide where you are going to dispose of your waste rock. The waste rock chips have to be disposed in an area that is as close to your mine as possible, but the waste rock chips must have enough room to be stacked in a cone/pyramid shape with no spillage off desks, etc. (Furniture cannot be moved and waste rock cannot be piled on the floor)
3. Stack your waste rock chips in a cone/pyramid shape.
4. Measure the straight line distance from the centre of your mine site to the centre of the waste rock pile.
5. Calculate the cost of waste rock disposal on the worksheet.

Phase 7: Calculate Mine Profit:

1. Fill in the cost-benefit table on the worksheet.
2. Calculate the total costs, total benefits and gross profit.
3. Calculate reclamation costs and net profit.

Discussion (Length: 15 minutes)

Which company had the most profitable mine? Discuss the reasons why this mine was more profitable. For example, the ore body was richer in minerals that have high monetary value, exploration costs were minimized, competitive bids were avoided, etc. Discuss the decision-making processes involved in each stage of mine development. What was the most difficult decision to make?

Discuss the waste rock disposal and reclamation costs. What factors need to be considered for these activities? For example, how to stock pile the waste rock, where to put it while the mine is in the development phase and how to incorporate these into the reclaimed landscape.

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.

Worksheet

Company Name ______________________________ Date _________________

Phase 1: Site Reconnnaissance

Field/Mapping costs: $15,000 per minute (maximum 10 minutes)

__________ minutes x $15,000/minute = $ __________________

Phase 2: Staking The Claim

Fill in one of the following:

a) If you were the only company to stake the claim for your property, enter 0:
$ _________

b) If you paid a competitive bid to secure your property, enter bid price paid:
$ _________

Phase 3: Exploration Drilling

Drilling costs: $30,000 per poker chip (maximum of 6 per site)

__________ poker chips x $30,000/chip = $ ________________

Phase 4: Mine Development

Mining costs: $5,000 per poker chip

__________ poker chips x $5,000/chip = $ _________________

Phase 5: Mine Valuation

Gold:	_________	poker chips x $400,000	=	$ ______________
Silver:	_________	poker chips x $50,000	=	$ ______________
Copper:	_________	poker chips x $20,000	=	$ ______________
Lead:	_________	poker chips x $10,000	=	$ ______________
Iron:	_________	poker chips x $5,000	=	$ ______________
		Total Mineral Revenue (Sum)	=	$ ______________

Phase 6: Waste Rock Disposal

Waste rock disposal costs: $100 per waste rock chip x distance transported

Total cost for disposal of waste rock =

$100 x _______ waste rock chips x _________ cm = $ _____________.

Phase 7: Calculate Mine Profit

MINING PHASE	**AMOUNT**
Benefits	
Total Mineral Revenue	$
TOTAL PROJECT BENEFITS	**$**
Costs	
Site Reconnaissance	$
Competitive bid paid	$
Drilling	$
Mining	$
Waste rock disposal	$
TOTAL PROJECT COSTS	**$**
GROSS PROFIT (project benefits – project costs)	**$**
Reclamation costs (10% of gross profits)	$
NET PROFIT (gross profit – reclamation costs)	**$**

OREBODY MYSTERY

Description

Students will explore the processes of core drilling and geological testing. Students will collect core samples, analyze them for mineral content, map the extent of the ore body and determine its approximate area and volume.

VOCABULARY:

1. Exploration
2. Core sample
3. Mineral
4. Ore body
5. Waste rock
6. Grid sampling

MATERIALS:

- *Ground Rules* film
- Two colors of playdough
- 2 inch pieces of clear drinking straws
- A blunt stick (lollipop stick) that will fit inside the straw and is longer than 2 inches
- Graph paper and pencils
- Calculators
- Rulers
- Real rock core samples (optional)
- Magnifying glasses (optional)
- Blunt knife (optional)

Introduction (Length: 30 minutes)

Watch Chapter 1 “Exploration” of *Ground Rules* film.

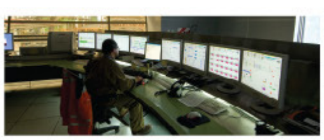
Discuss the stages involved in the development of a metal mine. How do geologists determine where mining should occur?

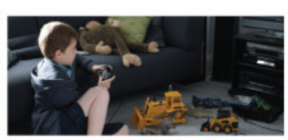
Ask the students if they know what an ore body is? Explain that an ore body is a large deposit of minerals. Geologists are looking for these deposits during the “exploration” stage of mining development.

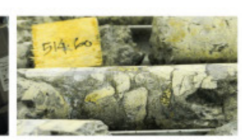
The exploration phase involves identifying an ore body, mapping the location and extent of the ore body, staking a claim, drilling to collect core samples, analyzing the core samples for mineral content and chemistry, and determining whether the property is suitable for mining.

Introduce the concept of costs and benefits. In mining, there are a variety of costs, such as exploration work, regulatory processes, equipment, engineering challenges, mining labor, training, health and safety, and reclamation.

The benefits of mining arise from the value of the metals extracted. The grade or concentration of the metal as well as its form of occurrence will affect the costs associated with mining the ore. Therefore, it is important to gain an accurate understanding of the geological properties of an ore body.





Explain that drilling to collect core samples is an important step in the exploration phase of mining. During geological exploration at a potential mine site, a drilling rig would be used to drill into the rock and extract cores of rock. These core samples would be analyzed for mineral content, chemistry and various other geological variables. All of this information would assist the mining company in determining if the ore body is rich enough to support a profitable mine.

Optional: If you are able to obtain a real rock core sample, pass it around for the students to examine. You can also use magnifying glasses to have a closer look at details within the sample. Ask them to describe what they see. Is the core sample one solid color or are there bands of multiple colors? Can they see different types of minerals within the sample?

Activity (Length: 45 minutes)

The objective of the activity is to accurately map the extent of an ore body and determine its volume based on core sampling results.

1. Divide the class into groups of 3 to 4 students.
2. For each group, tape a piece of graph paper to the desk and have the students draw a rectangle that almost completely covers the graph paper, but leaves one or two rows of grid squares visible along the edge. The lines of the rectangle should be drawn along the graph paper grid lines. Label the horizontal edge of the rectangle with letters – one in each grid square (i.e., A,B,C,D…). Label the vertical edge of the rectangle with numbers (i.e., 1,2,3 …). Prepare two more sheets of graph paper with the exact same rectangle dimensions and labeling (one will be the answer sheet and one will be the recording sheet).
3. Give each group two colors of playdough and explain what each color of playdough represents (e.g., red represents the ore body and green represents the surrounding base rock).
4. Have each group build an ore body on top of the graph paper within the boundaries of the rectangle. Students will place the ore body playdough color in several places within the rectangle boundary, not extending to the edges. They should vary the thickness of the playdough in each pocket.
5. Have each group map the ore body onto the answer sheet of graph paper and give it to the teacher.
6. Next, they will spread the base rock color on top of the whole structure, extending to the edges of the rectangle. They should end up with a structure where they only see the base rock color of playdough from the top and sides.
7. Groups should switch positions so they are working on another group's ore body.
8. Within each group, students will take turns taking core samples from the ore body. Core samples are collected by pushing the straw straight down into the playdough structure, pulling it up, poking the core sample out with a stick and examining it. Use the grid squares and associated numbers and letters on the axes of the graph paper to accurately locate the position of your core samples.
9. Students will record core sample results on the recording sheet of graph paper. If no mineral colors are visible, enter O in the grid square.
10. If the ore body color is visible, students should measure the depth of the ore body using a ruler. Pick a consistent unit of measurement (e.g., millimeters) and record the depth measurement in the grid square.
11. Continue sampling until your group thinks they have enough information to map out the pockets of the ore body and determine each pocket's approximate volume.
12. Record the number of core samples taken.

13. Map the ore body on the recording sheet of graph paper and compare to the answer sheet for that ore body.
14. Count up the number of full and partial grid squares occupied by each pocket of the ore body to calculate the area of each pocket and the total area of the deposit. Count each partial grid square as one-half of a square.
15. Determine the approximate volume of each pocket using an average of the recorded depth measurements.

Optional Cross-Section Diagram:
Draw a straight line through the playdough structure. Have students collect core samples along the line and measure the distance from the top of each core sample to the ore body, and the depth of the ore body. Students can use this information to draw a cross-section of the ore body. Slice through the playdough structure along the line and compare the cross-section diagrams to the actual cross-section.

Discussion (Length: 15 minutes)

How accurate was each group in determining the shape of their ore body? Which group had the most accurate ore body map? Which group used the least number of core samples to generate their map? Based on the area and volume calculations, which property would be the most profitable to mine? Where should mining begin within that property?

Discuss how this exercise relates to core sampling in a real ore body. Why is it important to accurately determine the shape of the ore body? Why is it important to limit the number of core samples used to determine the shape of the ore body?

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.

Playdough Recipe

Combine 1 cup flour, ¼ cup salt, and 2 tablespoons cream of tartar with 1 cup water, 2 teaspoons food coloring and 1 tablespoon oil in a saucepan. Cook and stir 3-5 minutes, or until it sticks together in a ball. Knead for a few minutes on a lightly floured surface. Store in an air-tight container.

GROUNDRULES

MINING PROCESSES | AGE: 15 TO 18 | LENGTH: 1.75HR | CURRICULUM: mining, environment, botany, soils

RECLAIMING A MINE SITE

Description

Students will learn how overburden is stockpiled and incorporated into the landscape after closure of a mine. They will experiment with growing plants on reclaimed landscapes with various treatments. Students will test five variables: soil thickness, soil composition (layering or mixing), slope, nutrients and seed type.

VOCABULARY:

1. Overburden
2. Stockpile
3. Grading
4. Soil types
5. Seeding
6. Slope
7. Seed germination
8. Nutrients
9. Closure planning
10. Erosion

MATERIALS:

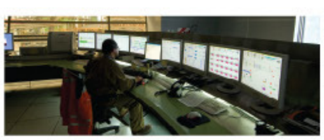
- *Ground Rules* film
- Mixture of gravel, sand and silt (overburden)
- Potting soil
- Bone meal, blood meal and potash, or mixed fertilizer, teaspoons
- Grass seeds, bean seeds
- Water and spray bottle
- Access to sunlight or a lamp
- Shoebox sized plastic tubs, small trowels
- Measuring cups, large mixing bowls
- Large plastic storage tubs or crates
- Rulers, calculators
- Toothpicks, landscape fabric
- Data sheet (provided)

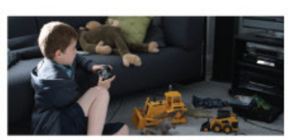
Introduction (Length: 15 minutes)

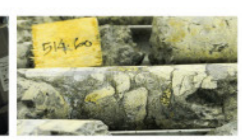
Watch Chapter 8 “Reclamation” of the *Ground Rules* film. Ask the students why mine sites have to be reclaimed after the mine has closed. Discuss the possible safety and environmental issues that could result if the mine site was not reclaimed.

Ask the students what was removed at the coal mine before they could get to the coal deposit. The top layer of soil (60 meters thick) had to be removed. This is called “overburden”. Ask the students what the mining company did with the overburden. They stockpiled it on the mine site and saved it for reclamation. Emphasize the fact that reclamation has to be planned out in advance of opening the mine. This is called “Closure Planning”. Mining companies have to prepare a closure plan and have it approved by the government. They also have to show that they will make enough profit during the operation of the mine to cover the costs of reclamation.

Ask the students what they noticed about the natural vegetation in the New Guinea site compared to the natural vegetation in the Wyoming site? Ask them which site they think would be easier to reclaim. Discuss the fact that the goal of reclamation is to create a landscape that is as close to the natural landscape as possible, but that this will be much harder to achieve in a rain forest than in a prairie region.





Explain that the students will be building model reclaimed landscapes and attempting to grow plants on top of them. Show the class what the overburden looks like (mixture of gravel, sand and silt). Ask them if they think plants will grow directly on top of this. Ask the students what plants need to grow – soil with nutrients, water, sunlight. Ask them how they think they can get plants to grow on top of overburden. Explain that they will be experimenting with different types of soil and nutrient mixtures to see which is the best for plant growth.

Activity I (Length: 30 minutes + 5 minute daily observations)

The objective of this activity is to investigate how plants will grow on top of a reclaimed landscape with various treatments. Students will test four variables: soil thickness, soil composition (layering or mixing), slope, and nutrients.

Building a Reclaimed Landscape

1. Divide the class into eight groups. Give each group a small plastic tub and a garden trowel. The teacher should also have a tub and trowel.
2. Each group should label their plastic tub with their group number (1 to 8) and the teacher should label his/her tub as 9.
3. Each group should calculate the area of the bottom of their tub by multiplying the length times the width.
4. Each group will have to determine the volume of overburden required to make a 5 cm (2 inch) layer in the bottom of their tub by multiplying the area of their tub by 5 cm (2 inches). Each group should measure out the appropriate volume of overburden.
5. Each group will prepare a different reclaimed landscape model with different thicknesses and mixtures of soil. Use the method in Step 4 to calculate soil volumes required to prepare various thicknesses of soil layers.
6. Each group should describe the composition of all of the reclaimed landscapes on their data sheet.

Group 1 (flat landscape, thin soil layer):

1. Pour the measured overburden into the bottom of the plastic tub and smooth it out to make an even surface of uniform thickness. Measure the depth of the layer with a ruler in several places throughout the tub to ensure that it is uniform thickness.
2. Measure out a volume of potting soil that will make a layer exactly 1 cm (1/2 inch) thick when placed on top of the overburden layer.
3. Spread the potting soil directly on top of the overburden layer being careful not to mix the two layers.

Group 2 (flat landscape, thin soil layer, fertilizer):

1. Pour the measured overburden into the bottom of the plastic tub and smooth it out to make an even surface of uniform thickness. Measure the depth of the layer with a ruler in several places throughout the tub to ensure that it is uniform thickness.
2. Measure out a volume of potting soil that will make a layer exactly 1 cm (1/2 inch) thick when placed on top of the overburden layer. Put in a mixing bowl.
3. Add 1 teaspoon each of bone meal, blood meal and potash (or 1 teaspoon of a mixed fertilizer). Mix the fertilizer thoroughly into the potting soil.
4. Spread the mixture in a layer on top of the overburden mixture being careful not to mix the two layers.

Group 3 (flat landscape, thick soil layer):
1. Pour the measured overburden into the bottom of the plastic tub and smooth it out to make an even surface of uniform thickness. Measure the depth of the layer with a ruler in several places throughout the tub to ensure that it is uniform thickness.
2. Measure out a volume of potting soil that will make a layer exactly 4 cm (1 ½ inches) thick when placed on top of the overburden layer.
3. Spread the potting soil directly on top of the overburden layer being careful not to mix the two layers.

Group 4 (flat landscape, thick soil layer, fertilizer):
1. Pour the measured overburden into the bottom of the plastic tub and smooth it out to make an even surface of uniform thickness. Measure the depth of the layer with a ruler in several places throughout the tub to ensure that it is uniform thickness.
2. Measure out a volume of potting soil that will make a layer exactly 4 cm (1 ½ inches) thick when placed on top of the overburden layer. Put in a mixing bowl.
3. Add 3 teaspoons each of bone meal, blood meal and potash (or 3 teaspoons of a mixed fertilizer). Mix the fertilizer thoroughly into the potting soil.
4. Spread the mixture in a layer on top of the overburden mixture being careful not to mix the two layers.

Group 5 (flat landscape, mixed overburden and soil):
1. Put the measured overburden in a mixing bowl.
2. Measure out a volume of potting soil that will make a layer exactly 2.5 cm (1 inch) thick when placed on top of the overburden layer. Add to the mixing bowl.
3. Mix the potting soil and overburden thoroughly. Pour into the plastic tub. Smooth the surface. Measure the depth of the layer with a ruler in several places throughout the tub to ensure that it is uniform thickness.

Group 6 (flat landscape, mixed overburden and soil, fertilizer):
1. Put the measured overburden in a mixing bowl.
2. Measure out a volume of potting soil that will make a layer exactly 2.5 cm (1 inch) thick when placed on top of the overburden layer. Put in a mixing bowl.
3. Add 2 teaspoons each of bone meal, blood meal and potash (or 2 teaspoons of a mixed fertilizer).
4. Mix the potting soil-fertilizer-overburden mixture thoroughly. Pour into the plastic tub. Smooth the surface. Measure the depth of the layer with a ruler in several places throughout the tub to ensure that it is uniform thickness.

Group 7 (sloped landscape):
1. Pour the measured overburden into the bottom of the plastic tub and smooth it out into a smooth, inclined slope with an angle of 45º.
2. Measure out a volume of potting soil that will make a layer exactly 1 cm (1/2 inch) thick (if it was lying horizontal in the tub).
3. Spread the potting soil evenly over the surface of the overburden layer being careful not to mix the two layers and to maintain the 45º slope.
4. If potting soil tends to slide downhill, add toothpicks and strips of landscape fabric in two rows perpendicular to the slope.

Group 8 (sloped landscape, fertilizer):
1. Pour the measured overburden into the bottom of the plastic tub and smooth it out into a smooth, inclined slope with an angle of 45º.
2. Measure out a volume of potting soil that will make a layer exactly 1 cm (1/2 inch) thick (if it was lying horizontal in the tub). Put into a mixing bowl.

3. Add 1 teaspoon each of bone meal, blood meal and potash (or 1 teaspoon of a mixed fertilizer). Mix the fertilizer thoroughly into the potting soil.
4. Spread the potting soil-fertilizer evenly over the surface of the overburden layer being careful not to mix the two layers and to maintain the 45° slope.
5. If potting soil tends to slide downhill, add toothpicks and strips of landscape fabric in two rows perpendicular to the slope.

Adding the Plants (all groups)

1. Each group and the teacher should sprinkle 4 teaspoons of grass seed as evenly as possible across the surface of their reclaimed landscape.
2. Gently pat the seeds into the surface of the soil.
3. Using the spray bottle of water, the teacher should spray a generous amount of water evenly over the surface of his/her reclaimed landscape. The total number of sprays used should be counted and recorded.
4. Each group should then spray their reclaimed landscapes with the same number of sprays.
5. Place all of the tubs near a window or under a lamp that is turned on during the day and off at night.

Daily Observations (all groups)

1. Water the model reclaimed landscapes every day using a spray bottle, making sure to apply the same number of sprays to each tub. Give them extra water on Fridays so they will have enough to get through the weekends.
2. Each group should make daily observations of all of the reclaimed landscape models on their data sheet. Continue making daily observations until the grass is growing well on at least one of the models.

Activity II (Length: 30 minutes + 5 minute daily observations)

The objective of this activity is to build a larger reclaimed landscape model with variable topography incorporating two different kinds of seeds. This activity can be conducted simultaneously with Activity I or it can be conducted after Activity I, incorporating the knowledge gained from the first activity. The activity can be conducted in groups or as one large class project.

In a large plastic storage tub or crate, design a reclaimed landscape with variable topography. Include hills and valleys, slopes of different angles, and flat areas. Use whatever combinations of potting soil, fertilizer and other soil types as you would like. The only condition is that the entire volume of overburden removed from your mine site must be used – no more and no less (the teacher should determine an appropriate amount based on the size of the container being used). Apply grass seed to the entire landscape. Plant some bean seeds in some locations. Use landscape fabric and toothpicks where needed to keep topsoil in place on slopes. Carefully measure and record the details of the treatments used. Record volumes, areas, slopes and other pertinent information about the reclaimed landscape. Place model in an area that receives sunlight or under a lamp. Water the landscape daily and record daily observations.

Discussion (Length: 30 minutes)

Activity I:
What variables were kept constant in this experiment? Water, light, grass seed, overburden layer volume. What variables were tested in this experiment? Potting soil thickness, layered vs. mixing of potting soil and overburden, slope, and nutrients. What other variables could have been tested? Different types of seeds, different amounts of fertilizers, different slope angles, etc.

On which reclaimed landscape(s) did the plants grow the best/worst? On which reclaimed landscape(s) did plants grow the fastest? On which reclaimed landscape(s) did plants look the healthiest? Were the students hypotheses correct? What do plants need to grow on a reclaimed landscape? Based on the results of the experiment, if you were planning a reclaimed landscape, how would you design it?

Did the potting soil layer in the sloped landscapes stay in place throughout the experiment? Discuss erosion and the challenges this presents when reclaiming sloped landscapes.

Explain that this experiment is a simple demonstration of reclamation of a flat or sloped landscape to a grassland ecosystem. Discuss what would be required to reclaim a landscape to a forest ecosystem.

Activity II:
Discuss the observations made in this experiment. On which area(s) of the reclaimed landscape did the grass grow the best? How did plants grow on slopes compared to flat areas? Which slopes worked the best?

How did the bean seeds grow compared to the grass seeds? Which type of seed germinated faster? Why might germination time be important for a reclaimed landscape? Discuss wind erosion and removal of top soil. The bean plants in this experiment may represent trees on a reclaimed landscape. It is important to get vegetative cover established on reclaimed landscapes as quickly as possible to retain the soil (grasses) and then it will be possible to add other types of slower growing plants, such as trees.

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.

Reclaim a Mine Site Data Sheet

A) Initial Observations and Hypotheses

Date: ___________

1. Describe the composition of the reclaimed landscapes

   Landscape 1:

   Landscape 2:

   Landscape 3:

   Landscape 4:

   Landscape 5:

   Landscape 6:

   Landscape 7:

   Landscape 8:

   Landscape 9:

   Which landscape is the control? Why?

2. On which landscape do you think plants will be able to grow the best? Why?

3. On which landscape(s) do you think plants will not grow at all. Why?

4. What do think will be the challenges involved in growing plants on a sloped surface compared to a flat surface?

B) Daily Observations

Number of days until plants start to grow in at least one of the reclaimed landscapes: __________

On the first day plant growth is visible in at least one of the reclaimed landscapes, start making daily observations by filling in a table for each day. Copy the following table for each day as required until the end of the experiment.

Date: _________________

Observations	1	2	3	4	5	6	7	8	9
Growth visible? (Y/N)									
% of surface covered with plants (%)									
Height of tallest plant (mm)									
Do plants look healthy? (Y/N) Describe.									
Other observations									

WHAT ARE THE GROUND RULES?

Description

Students will participate in the planning process for a fictitious mine site in a remote area. They will consider the engineering challenges, environmental impacts and social implications involved in developing the mine.

VOCABULARY:

1. Engineering challenges
2. Impacts & Benefits
3. Communication
4. Social context
5. Environmental context

MATERIALS:

- *Ground Rules* film
- Fictitious or real mine site description
- Paper and pens

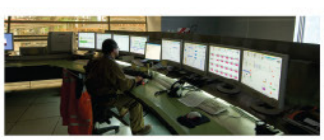
Introduction (Length: 30 minutes)

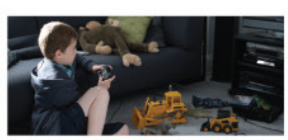
Watch Chapters 4 “Engineering Challenges”, 6 “Mining and the Community” and 7 “Mining and the Environment” of the *Ground Rules* film.

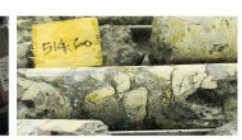
Discuss the challenges associated with developing the Grasberg Mine in Papua Indonesia (Chapter 4). Ask the students to recall some of the challenges: road to the top of the mountain, creating a whole new town site, finding people to work at the mine and providing them with the necessary skills and safety training, building the mill and plant site at such a high elevation and in a narrow valley, building a tramway to get workers to the ore body, getting the big mining trucks and equipment up to the mine site. Discuss the pros and cons of hiring already trained, skilled workers from abroad versus training local people to do the work. Why would a mining company want to spend so much money building a town site and educating local people to work at its mine?

Discuss the social context of mining using the example of the Newmont gold mine in Ghana (Chapter 6). What are some of the reasons why a community might not want a mine site to be located nearby? What are some of the possible benefits mining can provide to impoverished communities? (education, health care, employment) How can mining change the way of life of a community? What is the social groundwork that must be undertaken prior to even thinking about developing a mine site? (developing a working relationship with local people) Discuss the importance of open communication between the mining company and the local people. What are some of the challenges associated with communication? (language, cultural differences) Discuss the impacts and benefits of the mine on the economy of the local community.

Discuss the environmental context of mining using the example of the McArthur River Mine in Australia (Chapter 7). What does an environmental manager do at a mine site? What are some of the possible environmental impacts of a mine? (water quality, air quality, land disturbance, removal of vegetation/habitat). What major environmental challenge did Xstrata have to overcome before it could open the mine? (rerouting of the river). Discuss







the challenges associated with rerouting the river (maintaining biodiversity, maintaining natural features of a river channel, water quality).

Activity (Length: 60 minutes)

The objective of this activity is to gain an understanding of the types of engineering, social and environmental challenges associated with developing a mine site in a remote location.

Preparation:
Use information from an actual mine site or create a fictitious mine site in a remote area. Prepare a situation for the class to investigate. Write a short description of the proposed mine site. Name the location of this mine site and briefly describe the physical, social and environmental context.

Activity:
1. Divide the class into three teams: engineering team, environmental team and social team.
2. Give the students a few minutes to read over the situation description.
3. The engineering team must develop a plan to overcome all of the physical challenges associated with developing a mine site in that location.
4. The environmental team must develop a list of the potential environmental impacts of the proposed mine and develop a plan to mitigate against or monitor those impacts.
5. The social team must determine the potential social impacts and benefits of the mine site on the local community. Then they must develop a communication plan.
6. Have the groups present their plans to the class.

Discussion (Length: 30 minutes)

After each team presents their plan, the other two teams can ask questions and determine if the presenting team's plan would work. Did they miss any important considerations? Although each of the teams developed the plans in isolation, this wouldn't be true in the real world. The three teams would have to talk to each other to make sure that their plans would work together smoothly. Would the three plans developed in this activity work together? What aspects might be in conflict? What aspects might be complementary? What might be the most difficult challenge to overcome in this example?

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.