Saskatchewan's Mineral Resources
Lesson: Finders, Miners?

Overview
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.

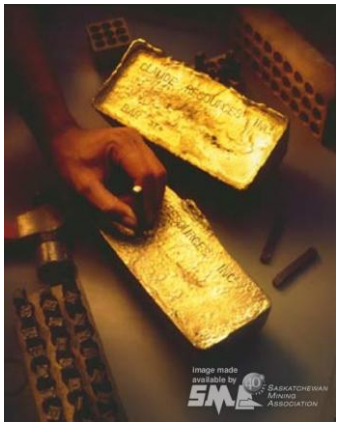
Source: This lesson has been adapted from a lesson in Ground Rules, a series of lesson plans developed by Caterpillar and Science North, as well as Saskatchewan Mining Association's *Mining For Peanuts* in the Teacher Resource Unit and the Women in Mining's *Mining In A Nutshell* lesson.

Duration: Two - three class periods

Materials:

- Approximately 500 poker chips (same colour if you can find them!)or 500 squares of cardstock or foam sheet, or 500 pennies or 500 bottle caps. As long as the colour of paint does not show through. These represent ore samples.
- Five colours of paint (not same colour as poker chips) and brushes
- Graph paper
- Coloured markers (colours to match poker chip colour and paint colours)
- Worksheet (included in lesson plan)
- Timers
- Calculators
- Ore body Cluster sheet

Instructional Methods: Guided inquiry, discussion



Learning Outcomes and Indicators

SCIENCE
Grade 4: Rocks, Minerals and Erosion
RM4.2 Assess personal, societal, and environmental impacts of human uses of rocks and minerals.
g) Discuss economic benefits associated with mineral extraction and refining, including related careers, in Saskatchewan.
h) Analyze issues related to the extraction and utilization of minerals from the perspectives of various stakeholders (e.g., company owner, employee, scientist, Elder, environmental group, and end user).

Grade 7: Earth's Crust and Resources
EC7.2 Identify locations and processes used to extract Earth's geological resources and examine the impacts of those locations and processes on society and the environment.
f. Provide examples of technologies used to further scientific research related to extracting geological resources (e.g., satellite imaging, magnetometer,

and core sample drilling).
g. Evaluate different approaches taken to answer questions, solve problems, and make decisions when searching for geological resources within Earth (e.g., trial-and-error prospecting versus core sampling).

Energy and Resources 10,20,30
Foundational Objectives:
To become familiar with the technology of the energy and mining industries.

Source: **Saskatchewan Evergreen Curriculum**

Big Picture Question

1. How do you develop a mine?

Background Information

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.

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.

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.

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.

Vocabulary

claim
exploration
waste rock
drilling
ore body

THE ACTIVITY
(Guided Inquiry, Discussion)

Mining Operation Activity (120 minutes)
The objective of the activity is to develop a profitable mining operation.

Teacher Preparation (30 minutes)
1. Assign the paint colours to 5 mineral types. For example: yellow = gold, green = copper, blue = diamond , red = potash, black = uranium
2. Paint a spot of colour on one side of approximately 25 to 30 poker chips for each colour. The remaining unpainted poker chips will represent waste rock.
3. While students are out of the room, put the poker chips in clusters in various locations around the room (1 or 2 more clusters than there are groups of students*).* Each property should have one dominant mineral type and less of the secondary mineral(s); make sure the deposits differ from one another. *Each cluster represents a property which may or may not contain a valuable ore body. You can group the different colours together to represent the ore bodies because several different minerals are often found together in nature.*
4. Place approximately 25% of the painted poker chips with the painted side up and the rest with the painted side down. Do not reveal the

numbers of each "mineral" to your students.
5. Add approximately three times as many unpainted poker chips to each cluster. The unpainted chips represent waste rock.
6. Keep an answer sheet that indicates how many of each colour of poker chips are used in each cluster (see suggested ore body cluster sheet)

Mapping: (30 minutes)
1. Divide the class into eight 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 such as 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. Have students leave room for a legend. Be sure to have each map oriented in the same way – e.g. the chalkboard is North on the paper.

Phase 1 Site Reconnaissance: (15 minutes)
Explanation (5 min)
1. Ensure each group has a set of coloured markers (matching the paint colours and poker chip colour).
2. Provide a list or explain the poker chip colours and their corresponding mineral type.
3. Ask students to add a legend to their map indicating which colours represent which mineral types (using the coloured markers).
4. Explain the value of 1 poker chip of each mineral type (use dollar amounts for gold and copper in mine valuation section of the worksheet or similar values reflective of the relative value of these or other mineral types in the real world).
5. 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.
6. 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!

Activity:
1. Set the timer for 10 minutes.
2. Using coloured 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.

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. *Some companies may not use the full ten minutes therefore their costs will be lower.*

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). *Have companies prioritize where they would like to stake. They should have more than one option in case their choice is already taken.*
3. When the timer goes off, one representative from each company will place their company sign on the property they want to claim.
4. Only one company can claim each property. The first company to place their sign on the property has the claim. If there is a tie, use a coin toss to settle it.
5. Students will move their chairs around their mining claim.

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:
Now that each company has mapped and drilled its property, it is time to put the information to the test by mining.
1. Each company will mine their whole property by turning over each remaining unknown poker chip.
2. Record the number of mined poker chips (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 and calculate the value of each mineral type.
2. Record the number of waste rock poker chips on the worksheet and calculate the waste disposal costs.

Phase 6: 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: 20 minutes)
1. Which company had the most profitable mine?
2. Discuss the reasons why each mine was more or less profitable. For example, it had more gold ore in it than copper, exploration costs were minimized, etc.
4. Discuss the decision-making processes involved in each stage of mine development.
5. What was the most difficult decision to make?
6. While the students are still in their groups, Show the students the Mineral Resources Development Cycle and assign one of the 8 sections (Available Land Resources; Exploration; Environmental Assessment; Construction; Operation Extraction; Operation Processing; Closure, Reclamation and Monitoring) to each group for them to review. Reform groups with one person from each of the 8 topics in each new group and have them go through the mining cycle and share their section.
7. Discuss some of the reason why it takes so long for a mine to be developed.

Assessment Method and Evidence

✓ **Hands on Activity**
- The students will be able to describe the major steps that a company must follow from the initial discovery of a mineral deposit through to mining.
- Students will be able to show that with careful planning and decision making that a mineral resource can be mined for a profit provided that there was enough ore to be mined.
- Students will be able to explain that ore minerals can have different values; therefore some mines may be more profitable than others.
- Students will understand that there is a requirement and a cost to reclaiming an old mine site.
- Students will discover that some of the issues related to mining extraction from the point of view of the company owner are: the cost, the length of time for a mine to be developed, the differing values of the ore; that not all ore deposits are profitable when taking into consideration reclamation costs.
- Students will be able to explain that drilling can help in the exploration and definition of an ore deposit.
- Students will have to work together to make decisions on the best property to develop, where to drill hole locations as well as whether or not to use up all their resources in the exploration process in a similar way that a mining company relies on the views of many people to make these decisions.
- Students will be able to explain some of the costs involved in the running of a mine.

✓ **Discussion Questions**
- Students will be able to explain that the value of a commodity (mineral), its abundance, costs of exploration, mine development and reclamation all determine whether or not a mine will be

profitable.

- Students will be able to explain why it can take up to 13 or more years to develop a mine.
- Students will start to think about the role of environmental assessment in the development of a mine. They will be able to show that environmental assessment starts with the initial stage of exploration and once a mine is developed it will continue on forever.
- Students will be able to explain the mining cycle from the mapping and exploration stages through mine development, processing, and reclamation stages.

Extension

1. If you do not have allergies to peanuts in the classroom try the Mining for Peanuts activity available in the SMA Teacher Resource Book or available on line at the Women in Mining website. **http://www.womeninmining.org/activities/Mining_in_a_Nutshell_Advanced.pdf** This activity is similar but takes it a step further with processing, manufacturing, consumption and recycling phases.
2. Watch the videos from Ground Rules "Ground Rules: Mining Right for a Sustainable Future" follows the development of new and operating mines as geologists, engineers and mine managers tackle complex problems and draw on the experiences and achievements of other mine sites to illustrate creative and core concepts of sustainable development and social responsibility. The entire video may be viewed online at **http://www.cat.com/groundrules.**
3. Follow the news reports or go online to follow the development of Cameco's Cigar Lake uranium deposit: (**http://www.cameco.com/mining/cigar_lake/)**, Shore Gold's Star diamond prospect: (**http://shoregold.com/properties/star_diamond/**) or BHP's Jansen potash deposit: (**http://www.bhpbilliton.com/home/investors/news/Pages/Articles/Environmental-Impact-Statement-Approval-for-the-Jansen-Potash-Project.aspx)**

Resources

Ground Rules: Mining Right for a Sustainable Future: Lesson plans and links to video Available at: https://mining.cat.com/groundrules

Mineral Resources Education Program of BC: Available at: http://www.bcminerals.ca/s/MinDevCycle.asp?ReportID=474152

Saskatchewan Mining Association Teacher's Resource Unit (2001). This document is out of print.

Women in Mining Lesson Plans: Available at: http://www.womeninmining.org/activities/Mining_in_a_Nutshell_Advanced.pdf

Vocabulary

Claim: A claim covers the minerals rights over a portion of land or water held either by a prospector or a mining company. The claim must be recorded in a government claim recording office.

Drilling: The operation of making deep circular holes with a drill for prospecting, exploration, or mining purposes.

Exploration: Exploration aims at locating the presence of economic deposits and establishing their nature, shape, and grade. The search for economic deposits is by (1) geological surveys; (2) geophysical prospecting (may be ground, aerial, or both); (3) boreholes and trial pits; or (4) surface or underground headings, drifts, or tunnels.

Ore body: A mineral deposit that can be worked at a profit under existing economic conditions or: A solid and fairly continuous mass of ore that is individualized by form or character from the adjoining country rock.

Waste rock: Barren or sub marginal rock or ore that has been mined, but is not of sufficient value to warrant treatment and is therefore removed ahead of the milling processes.

WORKSHEET

Company Name: _____ Date: _____

Phase 1: Site Reconnaissance

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

_____ minutes x $15,000/minute = $_____

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 = $ _____

Expenses Sub –total = $_____

Phase 5: Mine Valuation

Mineral Revenue:

Gold	$500,000 X _____	= $_____
Silver	$150,000 X _____	= $_____
Uranium	$80,000 X _____	= $_____
Copper	$10,000 X _____	= $_____

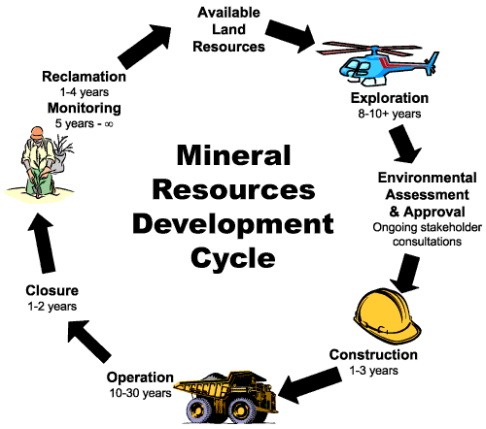
Total Mineral Revenue (Sum) = $ _____

Waste Rock Disposal Costs:

_____ poker chips x $2,000 = $ _____

Phase 6: Calculate Mine Profit

MINING PHASE	AMOUNT
BENEFITS	
Total Mineral Revenue (Phase 5)	**$**
Total Project Benefits	**$**
COSTS	**$**
Site Reconnaissance (Phase 1)	**$**
Drilling (Phase 3)	**$**
Mining (Phase 4)	**$**
Waste Rock Disposal (Phase)	**$**
Total Project Costs	**$**
GROSS PROFIT (project benefits – project costs)	**$**
Reclamation costs (10% of gross profits)	**$**
NET PROFIT (gross profit – reclamation costs)	**$**



Available Land Resources:
Unlike other resource industries, mineral resources are hidden. Finding a deposit worth mining is very difficult. Large areas of land are necessary for mineral exploration. The location of deposits depends upon the geology of an area and these potential areas can sometimes be directly below sensitive areas and ecosystems. This is the reason why we have to carefully weigh and balance the consumer demand that drives resource extraction.

Establishing a mine is a very lengthy, expensive and complex process. The following steps aim to describe that process.

Exploration (8-10 years):
Finding a new ore deposit that can be mined is not quick or easy. Smaller mining companies secure investment dollars to carry out most mineral exploration. They employ geologists and prospectors to gather field data, and utilize satellite imagery, geophysical surveys, and innovative technologies to help make a discovery.

Exploration work relies on many others besides geologists, and the larger or more advanced the project, the more skilled workers are involved. Pilots, drillers, assayers, equipment operators, surveyors, mechanics, camp cooks, and many others all play essential roles in the discovery of mineral deposits.

Environmental Assessment & Approval:
This process begins at the exploration stage with the acquisition of land use permits needed to build an exploration camp or create grids for surveys. The process of environmental assessment and permitting is an extremely complex one that can take years to complete.

When a company decides to develop a deposit into a mine it is at this stage that they must include a complete reclamation, land-use end goal, and monitoring plan. The proposal must be submitted to government agencies (the Environmental Assessment office) at the provincial and federal government levels for approval. The company must also go through rigorous processes to involve the community in which the project is to take place.
It is only after these permits and community approvals are received that construction plans can proceed.

Construction (1-3 years):
After discovery and evaluation, feasibility studies and acquiring permits and licenses, the physical construction of the operation can begin. Suppliers of transportation, utilities, building materials, equipment and hundreds of other goods and services are brought in to take the project into production.

Overall responsibility of the design, planning and construction of the operation is usually undertaken by a mining company's engineering department which works with the various contractors and consultants to build the mine.

Operation (10-30 years):
Extraction:
Surface mining methods are used to extract ore close to the surface of the Earth. Large-scale equipment - drills, shovels or draglines, and trucks - are used to make operations efficient and economical. When they move in, the ore is dug up and sent to the mill for processing and reclamation procedures are initiated.

Underground mining methods are used to extract ore that is deeply buried. They require specialized equipment to move people and material and carry on work underground in restricted space.

Processing:
These are the steps required to change raw, broken rock into useable material or to liberate and separate valuable minerals from waste rock.

For granite rock mined for crushed stone aggregate, only crushing and sizing are done prior to selling it.

Metallic ore deposits, in contrast, are conveyed to a mill complex on site where the ore is pulverized to fine sand which is directed through one of several separation processes: froth flotation, density separation, gravity separation, magnetic separation. The recovered valuable mineral material, called concentrate, is sent to smelters for further refining.

Closure:
Closure of a mine doesn't necessarily mean that ore has been exhausted or completely taken out of the ground. More often than not, closure of a mine is brought about by a variety of factors related to market prices and demand. Anything from rising production costs to a crash in commodity prices can make the project no longer financially viable and mine closure is imminent.

Whatever the reasons for closure, the operation cannot be shut down immediately. Closing down a mine can take months and lots of careful planning.

There is a transition period that needs to be observed so that the company can make sure everything is in place for reclamation and monitoring. The company also has to ensure the community in which they operate will also have a smooth transition into life after the operation is shut down.

Reclamation (1-4 years; Monitoring (5 years to infinity):
Environmental management is an essential part of all mining operations from start to finish. Bonds are posted with the provincial government before mining begins to insure that reclamation and monitoring of the environment will continue long after the mine has closed. Baseline studies to evaluate vegetation, wildlife, air and water quality are also carried out prior to mining, as is the design of a complete mine site reclamation plan. The goal is to leave the site in a safe and productive state, as similar in appearance to the surrounding landscape as possible.

Source: Mineral Resources Education Program of B.C.

Suggested Ore Body Clusters

#1 10 Gold (2, 8); 13 waste (Total 23)

#2 1 Gold (1, 0); 35 Uranium (5, 30); 14 waste (Total 50)

#3 2 Silver (1, 1); 28 waste (Total 30)

#4 5 Gold (1, 4); 2 Copper (1, 1); 30 waste (Total 37)

#5 2 Gold (1, 1); 10 Uranium (5, 5); 13 waste (Total 25)

#6 15 Uranium (3, 12); 10 waste (Total 25)

#7 4 Copper (1, 3); 21 waste (Total 25)

#8 20 Copper (5, 15); 10 Gold (2, 8); 20 waste (Total 50)

Note: 2 Gold (1, 1) means 2 gold poker chips, one up, one down

Gold = yellow
Silver = blue
Copper = green
Uranium = black