SCIENCE OF MINING

A RESOURCE UNIT

A teacher-written and developed resource,
a project of the Mineral Resources Education Program of BC[1],
a partnership program
between classroom teachers and the minerals industry in British Columbia

Originally written and developed by Don McRae, Terry Fox Secondary, Coquitlam, 1993

Revised and updated by Eric Rustand, Norkam Secondary, Kamloops, BC 1999-present

MineralsEd
(Mineral Resources Education Program of BC)
900-808 West Hastings St., Vancouver, BC V6C 2X4
604-682-5477
www.MineralsEd.ca

MineralsEd (Mineral Resources Education Program of BC) is a partnership program between the classroom teachers and the minerals industry in British Columbia. MineralsEd's teacher-partners have developed the following classroom resources. We gratefully acknowledge the many contributors for their financial and in-kind support toward MineralsEd and the Resource Units:

- K-3 Integrated Resource Unit: Kids and Rocks
- Grade 5 Integrated Resource Unit on Mining
- Grade 7 Resource Unit: Earth Sciences
- Social Studies Grade 10/11 Resource Unit on Mining
- Science of Mining: A Resource Unit
- Earth Science 11/Geology 12 "Resources & Ideas"
- CAPP Resource "Careers in the Mineral Industry"
- Environment Video - "*Digging For Answers*" video of students investigation of minesite environmental reclamation
- Mining Process Video - Rocks & Dirt Just Aren't My Thing...Or Are They?
- Mining Technology: A Natural Sciences and Engineering Technology Program at BCIT

Credits:

Don MacRae
Alaska Resource Education

Video & Photo Credits:

Highland Valley Copper
Westmin Resources Ltd.

Teacher Writers:

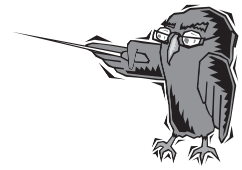
Ann Brace Elizabeth Greenway Elizabeth Hunter Dawn K. Vogt Mary Ringwald	K-3 Integrated Resource Unit: Kids and Rocks
Heather Hutchinson Patty Kiloh	Grade 5 Integrated Resource Unit On Mining
Kerrry Lockwood Andrea Eisler Alison Waterhouse	Grade 7 Resource Unit: Earth Sciences
Bruce Kiloh Dave Meronuk Phil Wright	Social Studies 10/11 Mining in BC "Careers In the Mineral Industry" CAPP Resource "Digging For Answers"
Don McCrae Eric Rustand	Science of Mining "Mining Technology" Video
Steve Kellas Jim Milross	Earth Science 11/Geology 12 "Resources & Ideas"
Dave Meronuk Patty Kiloh	"Rocks & Dirt Just Aren't My Thing ...."

Teck Resources Ltd.
Bill Basso
Mike Gushock
Robert T. McCall
Jerry Smath
Finning Ltd. - Common Ground - Modern Mining and You
Caterpillar - Common Ground - Modern Mining and You
Placer Dome Inc.
Fording Coal Limited
Gibraltar Mines Limited
Mining Association of BC
BHP- Island Copper Mine
Taseko Mines
Bruce Downing
Bob Hamaguchi
Bryan Welchman
Harry Glasswick
Dave Meronuck
Phil Wright
Tom Berger
Bruce Jenkins

Pen and Ink Illustrations:

Chrissie Nienaber-Roberts

Teacher Information



Environment 1: Resources

Teacher Plan:

- 5 minutes: Introduce the Idea of "What is a Resource?";
- 10 minutes: "Renewable or Non" (Activity #1a);
- 15 minutes: "Resources in your Classroom" (Activity #1b);
- 25 minutes: Poster Project "3R's Poster" (Activity #1c).

Notes:

This lesson looks at resources that we use in everyday life. Resources are categorized as either **Renewable** or **Non Renewable**.

Upon completing these activities the student will be able to:

1) Explain what a resource is.
2) Compare and contrast renewable resources to non renewable resources.
3) Identify what common objects are made of.
4) Devise some strategies for reducing the amount of resources used by a person in everyday life.
5) Recall what the 3R's are.

Photocopy:

- Pages 2 - 7 for student use.

Reading

Renewable and Non Renewable Resources

What is a Renewable Resource?

A **resource** is *something* you use to help yourself in everyday living. For example, you use the resource product gasoline to help you drive your car. You use metal scissors made out of mineral resources for cutting. You use wood resources to make the paper magazines you read. *Everything* you use to help you make it through each day can be considered a resource. So, what is **renewable** and what is **nonrenewable**?

Renewable
If the resource you are using can be produced over and over again (usually by being grown) then it is considered to be renewable. A good example of renewable resources would be trees. If they are managed carefully, trees will be replanted and regrown be cut again and again.

Non Renewable
If the resource you are using cannot be replaced once it is used, then it is considered nonrenewable. For example: there is only so much gold in the world and when miners have removed the last of the gold that is in the ground, that's it. All the gold that has been mined over the centuries is still out there, in the jewellery of people, teeth, computers and in the Fort Knoxes of the world.

Activity #1a: Renewable or Non?

Look at this list below. Decide whether the resource is renewable or non-renewable. The first one is done for you.

Resource	Type
Coal	non-renewable
Plastic	________________
Rutabaga (a kind of turnip)	________________
Cauliflower	________________
Milk	________________
Diamond	________________
Plywood	________________
Propane	________________
Copper	________________
Paper	________________
Silver	________________
Steel	________________
Spaghetti	________________
Iron	________________
Particle Board	________________

Hint: If you can grow it, is it renewable.

Hey, wait a minute! What about things that aren't grown but can't really be used up... like water, dirt, air, or sunlight?

These things are a kind of gray area. Air and water don't really get used up by us in a permanent way. The Earth recycles these materials so we can use them again and again. Dirt on the other hand, is a nonrenewable resource. It is so common, that it is unlikely we will ever run out of it. Don't confuse dirt with good quality soil though. Soil is very limited and in some countries is hard to come by. Sunlight is a nonrenewable resource but will last a very, very long time.

Name:_____________________

Activity #1b: Resources in your Classroom

Look around the room and decide whether the materials that make up your classroom are made from renewable or non renewable resources. Write whether the material is made from a **renewable** or **non renewable** resource and finally write what it is made of in the "Made From" column. Come up with at least 10 objects.
Example:

	Object	Renewable or Non?	Made From
eg.	Door	Renewable and Non	wood, metal handle
1.	________________	_________________	__________________
2.	________________	_________________	__________________
3.	________________	_________________	__________________
4.	________________	_________________	__________________
5.	________________	_________________	__________________
6.	________________	_________________	__________________
7.	________________	_________________	__________________
8.	________________	_________________	__________________
9.	________________	_________________	__________________
10.	_______________	_________________	__________________

When you are done, compare some of the items from your list with the lists of your partners. Some of the objects are hard to classify, aren't they? Items like computers are made up of so many different parts that it is hard to classify. Some objects are made of several different materials. Others may be hard to figure out what they are made of. Ask if you need assistance.

Finally! What did you learn?

What percentage (roughly) of your classroom is made up of renewable resources?

What percentage (roughly) of your classroom is made up of non renewable resources?

Activity #1c: 3R's Poster

Using resources in a city can put a considerable strain on its surroundings. For example, deforestation (cutting down trees) occurs near cities all over the world.
Near cities in Senegal, Africa, people chop down trees in order to make charcoal which is burned as a cooking fuel. Near cities in Canada, trees are cut down to make way for subdivisions, and in some cases for manufacturing pulp and chipboard. Mining for metals and fuels can severely alter the look of the landscape if it is not done in a responsible manner. Urban development pollutes the waterways with runoff from streets, parking lots and sewers. The list goes on and on.

So what can we do?!

The 3 R's

There are three things that can be done to reduce the amount of resources people use.
They are:

1. Reduce

This means use less. In other words:

- Don't buy food and let it rot in the fridge;
- Don't drive everywhere. Walk, use a bike, or carpool. All of these activities reduce the amount of gasoline you use for fuel;
- Do use an old chair for a few more years before throwing it out and buying a new one. This reduces the amount of materials needed to make that chair for you and reduces waste; and
- Do ask yourself before you buy something whether you really need it. If you buy things that you don't need, resources are wasted.

Using less resources means that:

- There are more resources left to share;
- Less waste will be produced by you; and
- There will be less damage to the environment through extraction of these resources.

2. Reuse

Problem: You need something to take your lunch to school in every day. You could:

a) use a plastic bag and throw it away every day; or
b) buy a lunch bag and reuse it over and over again.

Which of these two is more environmentally friendly?

Reusing things means not buying throwaway items. Some examples are...

- Use a canvas shopping bag over and over again instead of a new plastic bag every time;
- Use cloth diapers and washing them instead of disposable diapers.
- Use a water bottle filled with tap water rather than buying bottled water.

3. Recycle

Recycling is the R that most of us do a lot. It simply means taking something that we were going to throw in the garbage and putting it into a recycling bin instead. Examples would be: pop cans to the grocery store instead of the garbage; or putting glass bottles or newsprint into city recycling boxes; hauling electronics to electronic-waste recycling; donating outgrown clothes to the Salvation Army.

Did you Know?

Reducing your use of a resource is the **1st R** of the three R's: Reduce, Reuse and Recycle. It is considered the first because it is the most important. **Reducing** means that you use less. **Reusing** means that you still use resources but you make them last. **Recycling** means you use things and then use energy and resources to remake them again.

Using the three R's reduces the strain on our natural resources. Instead of having to cut down a new tree or create a new mine we can use what is already available. Whether you use just one of the three R's or all three you are making an effort to reduce pollution, impact on the landscape, energy required and the resources used.

Your Job!

Make up a poster showing how people can help by using one of the three R's. Check with your teacher what type of paper you will use.

Include:

- A slogan or headline on the top;
- A picture relating to the slogan;
- Some written information telling the reader why it's important to conserve our natural resources.

Poster Ideas (Just a few to give you some ideas):

- The importance of recycling pop cans or electronics;
- Riding a bus or cycling to reduce your use of fossil fuels (oil and gas);
- Using both sides of the paper when your teacher photocopies something for the class;
- Adapting your toilet into a low flush type to reduce the use of water.

Reading

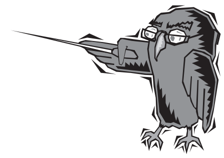
Resources and Mining

Mining is an activity that extracts mineral resources. Minerals are non renewable. When these resources are removed from the ground by the mining process, they can never be replaced. So, mining companies must continuously search for new areas with minerals that can be extract. Despite all of this mining, the surface of the Earth has had only 1/10th of 1% of its surface affected by mining. There are still a great many areas that have mineral resources to mine in the world. As long as there is a demand for minerals, there will be people willing to explore for them.

Despite a strong interest in the concept of the 3 R's by many people around the world, demand for mined minerals is still very high. Several factors have contributed to the demand, including: the growing world population; industrialization of developing nations; and a reluctance among people to let conservation of resources affect their standards of living and lifestyles. Since mining will continue because of demand, it becomes very important to address the issue of **How We Mine**. Mining companies have been improving methods of mining over the decades. Mines produce less waste than they did in the past. Other sections in this Resource Unit look closely at this issue.

Open Pit Mine

Teacher Information



Environment 2: Starting a New Mine

Teacher Plan

- 15 minutes: Introduce definitions necessary for lesson. Copy from board;
- 10 minutes: Read aloud with class "Motherload!" (page 4), discuss if necessary;
- 20 minutes: "What Do You Need to Live" (Activity #2a);
- 45 minutes: "Population Survey of Your Mine Site" (Activity #2b);
- 30 minutes: "Environmental Mine Plan" (Activity #2c).

Notes:

This lesson covers the concepts of Abiotic and Biotic factors and how these concepts apply to a Mining situation. It also introduces to the student the ideas of population sampling and environmental planning. There are 2 versions of the map for Assigment #2b, big and small. Use whatever your paper budget can afford. If you use the large ones, use the small ones for practice.

Upon completing these activities the students will be able to:
1) Perform a simple population estimate, using random sampling.
2) Compare and contrast abiotic and biotic factors.
3) Identify what common objects are made from.
4) Devise some strategies for reducing the negative impacts of mining.

Photocopy:

- Pages 4 - 6 and 8 -12 for student use.

Teacher Information

Starting a New Mine: What's Involved?

Introduction:

This lesson looks at some of the environmental considerations related to opening a mine. It covers such topics as abiotic and biotic factors in a creatures survival in Activity #2a. Population estimation is performed in Activity #2b. And, finally, some problem solving is addressed in Activity #2c. The contents of this lessons blends in well with the Environment and Ecology Section of Science 8. It is also a useful lesson for use in Earth Science 11, the Mining Section and in Science and Tech 11 in the Resources Unit.

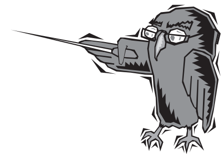
Background:

In the past, mining has been a dirty and destructive activity: mining activities used to release large amounts of metallic runoff from the rock piles; dust and grit was everywhere; and abandoned mine sites often sat for decades without reverting back to nature. In addition, activities such as smelting and refining released large amounts of pollution into the air that stripped the hillsides bare of trees and vegetation. When the heady years of early industrialization began to wane in the early 60's people began to become aware of the waste and pollution that had been building up for centuries. The result of this was the beginning of antipollution and environmental legislation that is continually being upgraded and toughened. Some of the new regulations began to take effect in Canada in the 1970's. Mines had to become good environmental citizens. Some of the legislation require mines to:

- reclaim waste rock piles and tailings ponds;
- prevent mine water from getting into streams and groundwater;
- minimize damage to fish-bearing streams and compensate for unavoidable impact;
- reduce impact on local wildlife and habitat and compensate for unavoidable impact;
- develop end-use plans for the minesite (e.g. will it become farmland or wildlife habitat?);
- research recovery methods.

Government monitors and enforces these regulations and mines make up Envionmental Mine Plans before the first rock is moved. In order to ensure the regulations are followed and that final reclamation does occur mining companies must post bonds for millions of dollars. This money is out of the mines' reach and even if a company goes bankrupt, the money in the bond is available to pay for reclamation costs.

Teacher Information



As you drive around the province, you may still see old abandoned mine sites that have not been reclaimed. These mines closed down and finished operating before regulations required them to reclaim the site. Newer mines that close down are much harder to spot as they are required to reclaim any land that has been disturbed, even as they mine.

Information:

Mines often have environmental problems that need specific solutions. Here are some examples that you can use to help students come up with solutions to environmental problems on their own mine site in Activity #3.

1. Line Creek Mine in southeastern BC planned to cover an existing stream containing trout with a waste rock pile from their coal mining activities. In order to compensate for this they enhanced and stocked another stream that was also on their property.

2. Highland Valley Copper mine, in southcentral BC, has a 100% recycling system for their water on the site. The whole site is self-contained with berms preventing water from leaving. If too much water is around as the result of spring runoff, the excess water is first cleaned by a water treatment plant and then released.

3. Mine sites will reclaim waste rock piles with plants which can be used as forage for wildlife. In fact many of the southeast coal mines are preferred by the elk of the region because there is no hunting on the mine properties and food is plentiful. Large herds spend a great deal of time on the mine site.

4. Research is constantly conducted to see which species of plants do well on reclaimed rock piles and tailings ponds.

5. Mines often transplant populations of animals to other areas on the mine site in order to protect them from the mining operations.

6. Vancouver sends some of its treated sewage to mine sites around the province in the form of "biosolids". Biosolids are used on mine sites as soil amendments and fertilizer for reclamation.

Reading

Motherload!

So you hit the big time did you? Found a mine with millions of dollars of ore in it? Well, I guess you had better get the shovels and trucks and start digging, eh? Not so fast! Mines are large operations that affect a great many people. Before any mine gets started, the possible affect on people in the region must be thoroughly investigated. Will it pollute the water? How will it affect the bear population in the region? Where will the workers live? Who's land is it? These, and many more questions must be answered in order for the mine to get the final go ahead from the government. Many of these topics are best addressed in a Social Studies class. In this lesson we will be looking at the environmental considerations that have to be looked at in order for a mine to be approved. In the process we will learn about populations and how scientists gather information about the local plant and wildlife.

Environmental Considerations

The Past:

In the old days (pre 1940’s) mines operated almost without restrictions. Mines would:

- Contaminate rivers and lakes with tailings and minerals;
- Have smelters that released so much smoke that you often ended up with great wastelands around them. (In fact, the land around the Sudbury, Ontario, nickel smelter was so barren that the US space program used it as a simulated moonscape for the astronauts to practice on.);
- Leave behind large areas covered with waste rock where no plants could grow.

The Changes:

Finally, as environmental concerns grew in the 1960’s and 70’s, governments started writing some tough new laws for mines. Some of these laws said:

- Mines must reclaim the land and return it to a condition as similar as possible to what it was before the mine started;
- Money must be put aside into a **reclamation** bond before the mine is built, so that it will be available when the mine shuts down. This money is not held by the mine, so even if the mine goes bankrupt, the money is still available for reclaiming the land;
- Mines must do a survey of the plants and animals that live on the mine site before the mine opens and must continually monitor them as the mine operates;
- Mines cannot release untreated waste water into rivers and streams. All mines now recycle and reuse water used in the mining process.

The following Activities (#2a - #2c) allow you to see some of the work that must be done to get a mine up and running. It covers the following topics:

- Abiotic and biotic conditions of an organism;
- Population sampling;
- Some math skills;
- Before and after profiles of a mine.

Reading

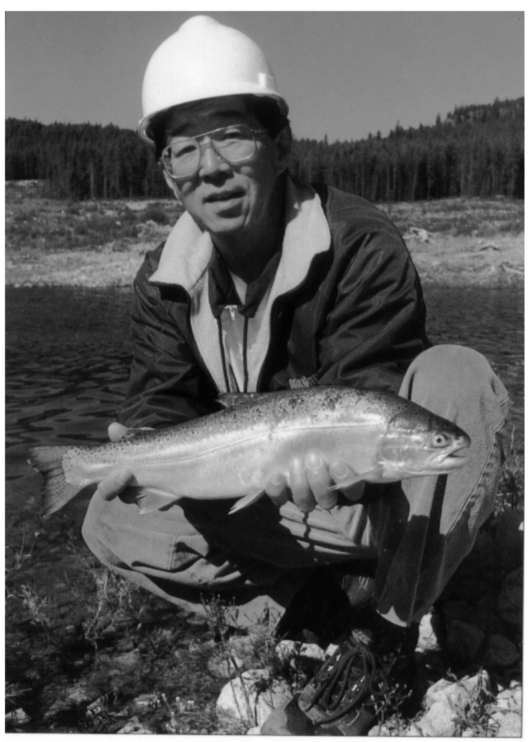
A Biological Survey: First Step in an Environmental Plan for the Mine

One of the first things you must do is go into the site where the mine is to be located and take an inventory of the plants and animals that are native to the area. Biologists are hired to tag deer, count fish and catalogue plants. You are going to do your own estimates of the deer and fish populations in the proposed mine site. But first, you need to know a few terms.

Definitions:

Population: a group of creatures of the same species living in the same area, (e.g. all of the Bighorn Sheep on a particular mountain make up a population).
Species: a plant or animal of the same type.

Abiotic Factors: any non living things in a creature's environment which affects it. (e.g. temperature, light, minerals in the soil, etc).
Biotic Factors: any living things in a creature's environment which affects it. (e.g. predators, parasites).
Ore Rock: rock that has enough ore minerals in it to be economically mined.



At Highland Valley Copper, Senior Environmental Engineer, Bob Hamaguchi holds a two-year old rainbow trout. The fish is part of a project in cooperation with the Ministry of Environment, Lands and Parks, where fish were stocked in a decommissioned tailings pond.

Name:____________________

Activity #2a: What do you need to live?

Abiotic and Biotic Factors affecting the Trout and Deer populations at the Mine Site.

Introduction:

You survive from day to day thanks to many things. Imagine how long you would survive without water or food or Vitamin C. All of these things are **abiotic** and **biotic** factors that affect how you live. In this assignment, you will look at some of the factors that affect deer and trout. You must know all of the things deer and trout need to survive and grow. Some of these factors are obvious. For example, trout need water. Others are not so obvious.

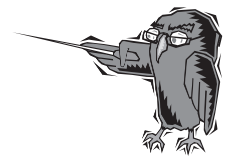
In the space below, list <u>three</u> factors, **abiotic** and **biotic**, which affect a trout's and a deer's ability to survive.

Trout:

Abiotic	Biotic
________________________	________________________
________________________	________________________
________________________	________________________

Deer:

Abiotic	Biotic
________________________	________________________
________________________	________________________
________________________	________________________



Activity #2a: What do you need to live?

Abiotic and Biotic Factors affecting the Trout and Deer populations at the Mine Site.

In the space below list three factors **abiotic** and **biotic** which affect a trout's and deer's ability to survive.

Trout:

Abiotic	Biotic
water,	insects,
oxygen,	other food,
sunlight,	predators,
dissolved minerals,	algae.
temperature	

Deer:

Abiotic	Biotic
water,	grass,
oxygen,	predators,
sunlight,	parasites,
temperature,	shrubs,
snow.	forests.

Activity #2b: Population Survey of Your Mine Site

Introduction:

In order to find out how many deer and trout are living in the area to be mined, you must count them. Counting all the deer and trout, however, would be time consuming and tedious. Instead, you will count some of the deer and trout and then use that information to estimate how many are in the whole area. This process is called **sampling**. Sampling is how scientists estimate fish stocks, grain harvests, and human populations.

How it works:

1. Take a map of the entire area you are interested in and break it up into small squares of equal size. In this case, make a grid of 1 cm x 1 cm squares.
2. Randomly pick 4 of those blocks and carefully count how many animals (in our case deer and trout) live in each block.
3. Average your totals for the 4 blocks and multiply that number by the total number of blocks.

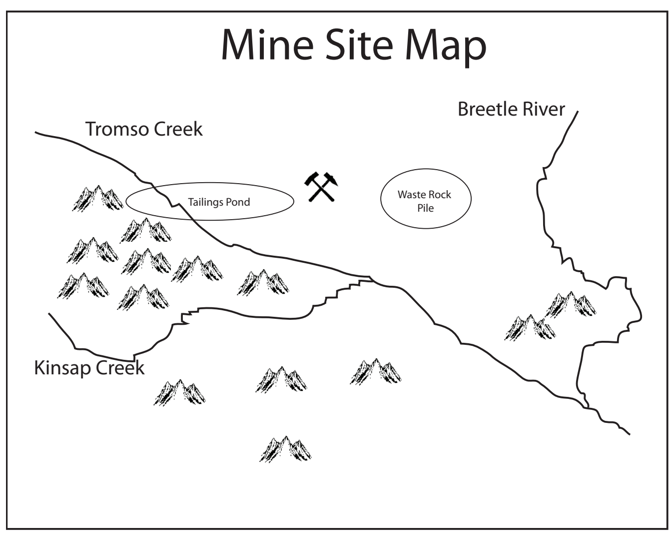
Now you have an estimate of the total number of animals living on the whole map.

Step 1:

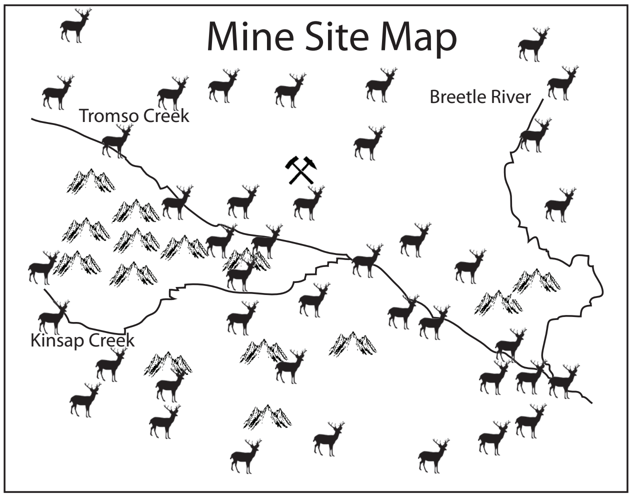
A map of the whole proposed mine site is shown opposite. On the next page are maps of the mine site but this time with the deer shown in one and the fish in the other. Each icon represents two deer and four trout. Divide each map into a grid of 1 cm x 1 cm pictures.

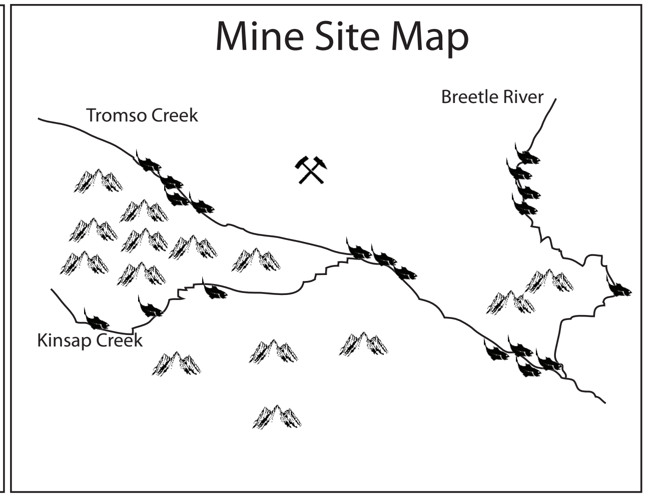
Step 2:

Pick four squares at random from the deer picture and four at random from the fish picture. For the trout picture the grid squares that can be picked should be only those squares that contain a stream. Count the number of deer and fish in these four squares only. Remember: each deer icon represents 2 deer and each fish icon represents 4 fish.



Note: Do not grid this map!





Deer
Number of deer
counted ______

Trout
Number of trout
counted ______

Step 3:
Average the numbers of deer and trout by dividing by four.
Write your average in below. eg. 44 deer in 4 blocks ÷ 4 = 11 deer per block.

Average Number of Deer______ Average Number of Trout_____

Step 4:
Count the total number of squares on your map. Then multiply that number by the average number of fish and deer per block.

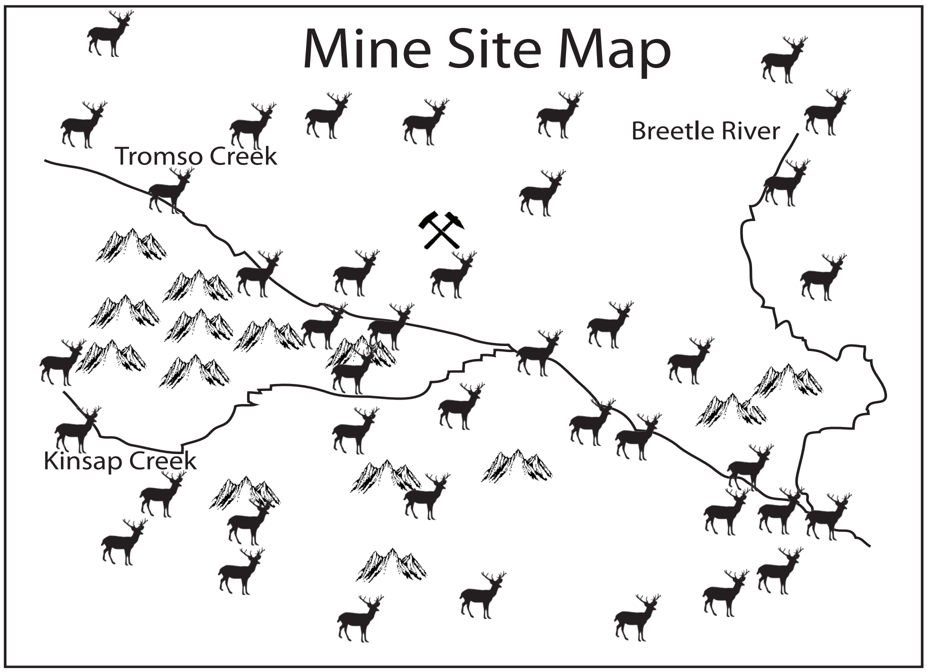
Total Deer = avg deer x # of blocks
Total Deer = ______ x______ =
avg. #blocks

Total Fish = avg fish x #blocks
Total Fish = ______ x______ =
avg. #blocks

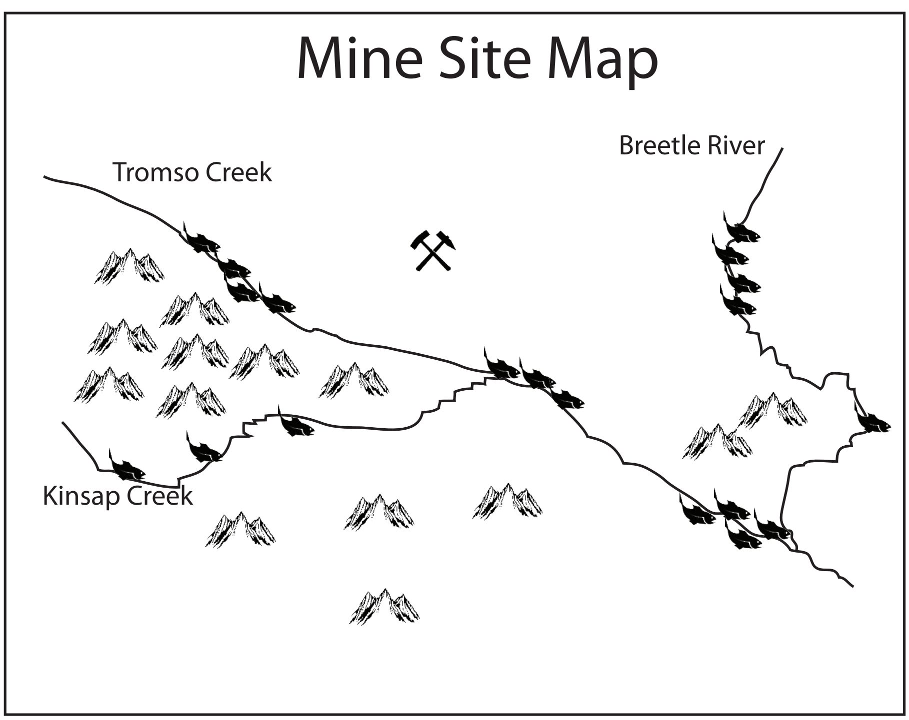
Now you have calculated an **estimated total** for all the deer and trout on the property. Write this data on Activity sheet #2c, "Environmental Mine Plan". Comparing the first map of the mine with those on this page you can see that the proposed mine site will impact some of the deer grazing areas and some trout streams. In the space provided on Activity sheet #2c, come up with some strategies for reducing the damage to the deer and trout populations. Suggest some ways you can offset the loss of some of these streams and grazing areas.

Large Size Map for copying if desired.

Deer



Trout



Activity #2c: Environmental Mine Plan:

Instructions: This worksheet will allow you or your group to outline the current environmental state of the mine site and the changes that will occur. In Part 1, fill in the data you collected from the earlier part of the project. In Part 2, make up your Environmental Mine Plan for the site.

Part 1: The Current Environmental State of the Mine Site

Questions:

1) What are some of the plants and animals a mine should consider before it starts digging (e.g. what life-forms are important to keep track of as the mine grows: worms?, grass?, bears?).

____

____

____

____

Data from Environmental Survey (Activity #2b):

Number of deer estimated to live in the Mine area ______

Number of trout estimated to live in the Mine area ______

2) In the space below, outline the 2 main concerns you have about mining and the effect on **trout** populations.

____

____

____

3) In the space below, outline the 2 main concerns you have about mining and the effect on **deer** populations.

____

____

____

Part 2: Solutions

Take a good look at the Mine Site Map. The tailings pond, the pit and other parts of the mine operations have a negative effect on the fish and deer in the area. Mines are required to change things to minimize damage (e.g. put up water treatment plants so polluted water doesn't get into streams). Sometimes, minimizing damage is difficult. In these situations a Mine is required to **offset** the damage to one area by improving animal habitats in other areas (e.g. a huge gopher den is threatened by the mine so the mine traps and moves them to another area ideal for a new den). Below you are required to think about these concepts of minimizing and offsetting effects to the deer and trout populations.

4) What are the three main things your company will do to prevent or offset impact on the **trout** populations?

____

____

____

____

5) What are three things your company will do to prevent or offset impact on the **deer** populations?

____

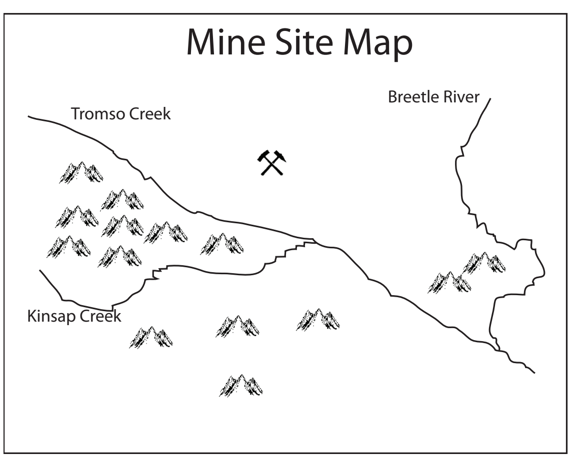
____

____

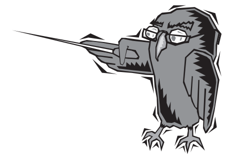
____

____

____



6) On the mine map left, redraw the locations of the waste rock pile and the tailings pond so that they have the least amount of impact possible on the animals.



Activity #2c: Environmental Mine Plan

Part 1: The Current Environmental State of the Mine Site

1) What are some of the plants and animals a mine should consider before it starts digging. (eg. what life forms are important to keep track of as the mine grows: worms?, grass?, bears?)
Answers will vary. Most people are concerned with sport animals and large animals. Examples could be deer, bear, elk, eagles, trout, salmon, owls.

Data from Environmental Survey (Activity #2b):
Number of Deer estimated to live in the Mine area: *approx. 300*
Number of Fish estimated to live in the Mine area: *approx 610*

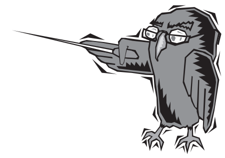
2) In the space below, outline the 2 main concerns you have about mining and the **trout** populations.
1)Mining may harm the fish as they dump massive piles of rock in the streams.
2)Contaminated water may pollute the streams and rivers.

3) In the space below, outline the 2 main concerns you have about mining and the **deer** populations.
1) The deer may be harmed by the drop in forage land.
2)The deer may not like to cross the property with all the activity.

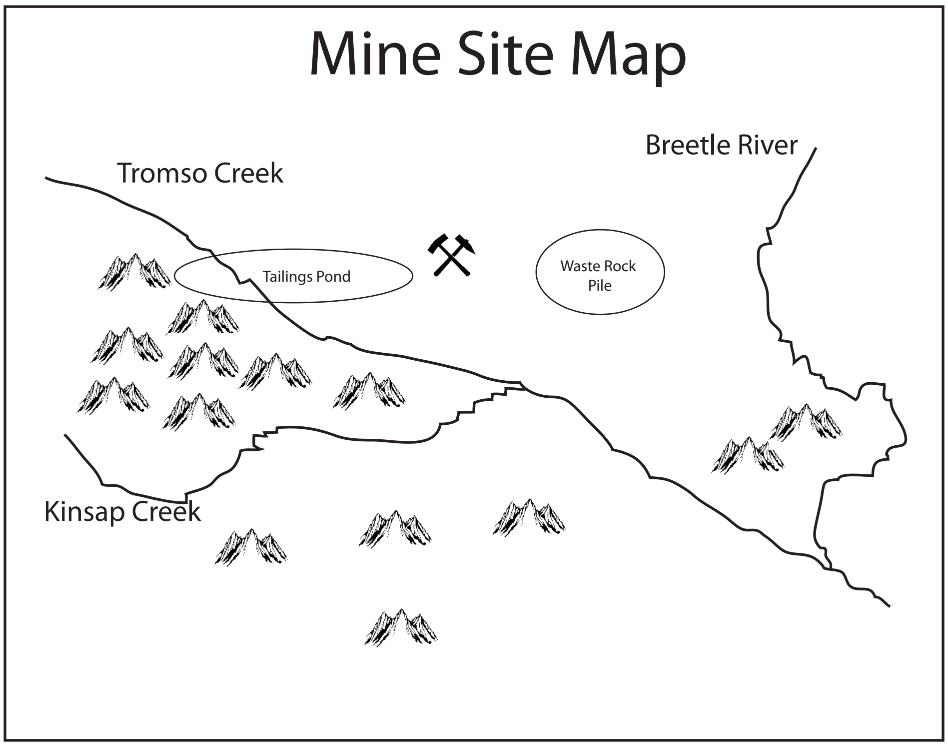
Part 2: Solutions

4) What are the 3 main things your company will do to prevent or offset impact on the **trout** populations?
1) Contain the waste water so it doesn't pollute the stream.
2) Put the tailings pond far from the stream.
3) Divert stream.

5) What are the three main things your company will do to prevent or offset impact on the **deer** populations?
1) Ban hunting on the property to conserve population numbers.
2) Provide food in difficult winters.
3) Monitor deer movements to see whether mining activities affect their travels.
4) Replant or reclaim land as soon as possible.

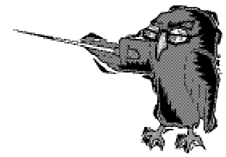


6) On the mine map, below, redraw the locations of the waste rock piles and the tailings pond so that they have the least amount of possible impact on the animals.



Move tailings pond to north of the mine site.
Leave the waste rock pile where it is.

Teacher Information



Environment 3: Environmental Problems

Teacher Plan:

- 5 minutes: Review previous activity on Environmental Planning. Make sure their "Environmental Mine Plan" (Activity #2c) is finished;
- 5 minutes: Brainstorm with the class the two concepts of "Resources and Waste" (Activity #3a);
- 15 minutes: Hand out worksheet on "Resources and Waste of the Past and Present" (Activity #3b). Have them work in groups and fill out the worksheet. Groups can call out their answers to the teacher who can make up a master list;
- Read page 5: "Resources, Waste and a Minesite" in preparation for Activity #3c;
- 60 minutes: "Environment and Mining" (Activity #3c, long option); OR
- 25 minutes: Activity #3d (short option) for students to develop their solutions to the four environmental concerns found in their workbook;
- Discuss students' suggestions on how to deal with environmental concerns with mining and explain what mines are currently doing to meet with those same concerns.

Notes:

The importance of the relationship between **Resources** and **Waste** is often lost on students. The introductory brainstorming session is important to illustrate the demands industrial societies place on our environment.

Man's effect on the environment can be expanded to as large a topic as the teacher desires. This is intended as a starting point for the wide range of issues that can be addressed.

"Environment and Mining" (Activity #3c or #3d) looks at how our planned mine will affect the local area. It takes a brief look at past practices and a closer look at modern ones. It also looks at some of the ways of dealing with modern mine problems.

Many people have either a neutral or negative outlook on the relationship between mining and the environment. These view points are understandable given some of the environmental impacts caused by past mining activities.

The main change in mining practices over the past four decades has been the dedication to and development of good environmental practices. Mining companies are required to meet some of the most stringent regulations in any industry. Additionally, mining companies are actively involved in researching how to lessen the impact of mining on the environment. The BC Technical and Research Committee on Reclamation (est. 1975) has led the way in this regard. Meeting strict guidelines and researching new techniques are costly in both time and money but are universally regarded as ethical business practice.

Teacher Information

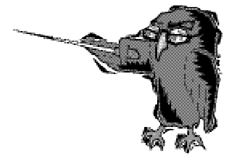
This environmental lesson challenges students to come up with solutions to some environmental concerns in mining. We do need the products from mining, but how do we get them with the least impact on the environment? After brainstorming solutions, students should compare what they have proposed with what is being done at mines. This can be done through a teacher-led discussion, or the teacher may have the students use some of the reference materials provided.

Upon completion of these activities the student will be able to:
1) Recall the main concerns facing mining today.
2) Prepare a demonstration for presentation.
3) Devise potential remedies for environmental problems in mining and mineral processing.

Photocopy:

- Pages: 4, 5;
- If you are going to use 3c (long option) photocopy pages 7, 8, 9, 10, 11;
  or
- If you are going to use 3d (short option) photocopy pages 13, 14.

Teacher Information



Activity #3a: Resources and Waste - Brainstorming Activity

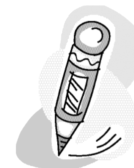
The purpose of this activity is to lead the students in a discussion of what is meant by **Resources** and **Waste**. Resources will be easy as they have already covered this concept in previous lessons, but waste might be a little more challenging. Try to get them to think of some of the other things that we don't normally think of as waste.

Resources
metals
lumber
food
oil and gas
stone and sand (for construction)
water
oxygen

Waste
paper
bones
CO_2 exhaust gases
used oil
plastic
metals
heat
urine

Although some of these things are natural, they are still waste products. Accumulating many of these waste products would be harmful to our environment. We have always needed resources and in the process produced waste. The difference in what we need and what we get rid of as resultant waste has not always been the same.

Activity #3b: Resources and Waste of the Past and Present



Past:

Imagine: You are a farmer living in the year 1102 A.D. in Italy. You have a small stone house and a small barn. Living with you is a spouse and 3 children. Below, list the things (resources) that are needed by you to survive, and those things (waste) that you don't need and would throw away.

Remember: In the past, resources were harder to come by. Harvesting resources like wood and metals took tremendous amounts of labour. Modern machines and industry make many resources cheap for us. Today we will throw away a small piece of metal or wood. Back then it would be used for something else (reusing). So think carefully when writing down an item in the waste category. The first ones are done for you.

Resources	**Waste**
food	animal bones

Present:

Now make up a similar list for you yourself today in the modern machine age. What do you need to live comfortably here today? Question: Do you think landfills were needed a thousand years ago? If not, why not?

Resources	**Waste**
food	leftover food

Reading

Resources, Waste and a Minesite

The Past:

Mining is one of the oldest human activities. It is even older than farming. It is also one that has driven industrialization. Just think of the following situations:

1) Rome was originally a mining site for salt from the salt marshes nearby. It slowly developed into the city of Rome.

2) Copper mined from the Great Lakes region of North America was traded across the continent. High quality obsidian from northwestern BC, used for arrowheads and tools, was also mined and traded around the continent.

3) Many of the precious items, past and present, have been mined, including gold, silver, diamonds and other gemstones.

4) Cheap iron, which was extracted using improved mining methods, helped drive the industrial revolution.

Historically, mining and smelting have also been very difficult, dangerous, and very polluting activities.

1) In olden days, many miners died from terrible lung diseases as a result of working in mines.

2) Mines used to leave a barren landscape in the countryside.

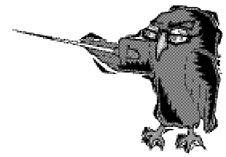
3) Smelters used to release large amounts of sulphur dioxide gas, causing widespread destruction of plants and wildlife due to acid rain.

4) Underground miners were commonly at a higher risk from a cave-in or an explosion in coal mines.

5) Mines were once allowed, often unknowingly, to release water bearing dissolved metals into local waterways.

In the following activity, you will be looking at some of these problems, associated with mines and their waste products. In addition, you will learn how mines are currently tackling some of these problems.

Teacher Information



Activity #3c (long option): Environment and Mining

Teach this activity depending on time. If you wish a shorter activity, do 3d (short) on page 12, which is a reasonably short class exercise, while 3c (long) is a slightly longer presentation exercise. You decide.

Introduction:

In this exercise the students, in groups of 2-3, make a presentation to the class on one of the following main environmental problems associated with mining:

- Acid Rock Drainage;
- Mine Site Reclamation;
- Water Quality;
- Air Quality.

Materials:

Each group will need the following materials to make their presentation:

- Poster paper;
- Felt-tip pens or pencil crayons;
- "Resource Information" sheets on one of the four main environmental problems;

Criteria:

The presentation should consist of :

1) A poster showing what the environmental problem is and how mines try to deal with it.
2) A brief oral presentation explaining what the poster shows.
3) A short slide presentation showing the environmental problem with a running commentary as to what the slides are showing.

Remember: Activity 3c (long) requires that the student groups are given the "Resource Information" sheets on the chosen environmental problem.

Resource Information

Acid Rock Drainage (ARD)

The Problem:

When mines break up rock that has previously been buried, they expose that rock to the elements. If the rock has certain minerals in it (particularly iron-bearing minerals such as pyrite) these can be oxidized by the oxygen in the air. An example of one of the reactions that may occur is:

Eqn: $\underbrace{4FeS_2}_{\text{(pyrite)}} + \underbrace{15O_2}_{\text{(oxygen)}} + \underbrace{2H_2O}_{\text{(water)}} = \underbrace{2Fe_2(SO_4)_3}_{\text{(ferric sulphate)}} + \underbrace{2H_2SO_4}_{\text{(sulphuric acid)}}$

Water coming in contact with the sulphuric acid becomes more acidic. Hence the name. This is a natural process, seen in rusty dirt found almost anywhere, which is enhanced by the activity of man, as you have likely seen on highway cuts. Wherever you see a red rusty stain on a rock, you are witnessing **Acid Rock Drainage (ARD)**. The opposite, Basic Rock Drainage, can also occur.

Mining Companies are:

- Capturing all related water and treating it;
- Placing waste at lake bottoms, or under a cover-material, to avoid contact with oxygen;
- Layering waste rock with buffer rocks to neutralize the acid;
- Diverting creeks to avoid waste dumps;
- Levelling waste dumps and sealing them to avoid oxidation;
- Not mining in areas where this problem would be too great to solve.

Acid Rock Drainage (ARD) is a challenging problem for the mining industry, but like most problems, it can be addressed. It is important to remember that the acidification of water by the rocks at some mine sites is a naturally occurring process involving oxygen. What mining does is to *accelerate* the process by increasing the surface area of exposed rock - through blasting. This accelerated production of acidic runoff could have harmful effects on the environment especially in increasing the levels of free heavy metals in the local water. Intense research continues to find more effective ways to reduce ARD at mine sites. For example, research continues on the action of bacteria in the generation of acid in rocks. By determining how bacteria are involved in ARD generation, new methods of treatment may be developed. Some of the current methods to combat ARD are:

Resource Information

1. **Capturing all runoff from old waste dumps that present ARD problems and treating the water:** At the now closed Sullivan mine, in Kimberley, some large waste dumps were positioned near a creek before ARD problems were understood. It was discovered that these waste dumps were generating acid and that some of it was finding its way into the creek. The mine cleaned up this problem in two ways: Firstly, a culvert was built to allow the creek water to flow past the waste dump, and keeping the creek water separate from the waste dump runoff. Secondly, all the water in and around the waste dump is collected in a drainage basin and pumped several kilometres away, to a water treatment facility that neutralizes the runoff. Once treated, the water is safely released back into the environment. This method of capturing ARD water and treating it is used at mine sites where ARD is a potential problem.

2. **Placing waste rock at lake bottoms, under the sea, or under an impervious cover-material to avoid contact with oxygen:** In this way the chemical reactions necessary to produce ARD can not occur. Since mining increases the exposure of rock to the atmosphere, which enhances ARD, it makes sense that reducing the exposure would reduce ARD. The best method of preventing ARD is by dumping waste rock under water. Waste rock can also be dumped into an old pit, covered with till, and capped and sealed.

3. **Layering waste rock with buffer rocks to neutralize the acid:** Calciferous rocks neutralize the acid leaching from the waste rock. The neutralizing potential of surrounding rocks is always considered before reporting a significant ARD concern. At the Samatosum mine near Barriere, which is now closed, the waste rock is layered with naturally occurring calciferous rocks (i.e. limestone). The layering pattern is carefully calculated and constantly monitored to ensure that the final water is no different from the natural water of the surrounding area.

Resource Information

Mine Site Reclamation

The Problem:

When mines operate, particularly open pit mines, they leave behind large piles of coarse waste rock which won't sustain any plant growth because it is coarse and contains no organic material. Tailings ponds present a similar problem: wide flat areas of sand, ground-up rock that lacks organics, are unsuitable for growing anything. Finally, there is the pit itself which can be huge and again is incapable of sustaining vegetation regrowth.

Mining Companies are:

- Developing reclamation plans in place prior to opening;
- Putting up large bonds ($) to cover the cost of reclamation;
- Working with the surrounding communities to plan for reclamation;
- Actively re-vegetating disturbed areas and waste rock at the mine site;
- Grazing cattle on reclaimed lands and/or wildlife foraging.

In historical times, mine site reclamation was not of great concern to mining companies, however, times have changed. Legislation and regulations are in place today to address the affects of land disturbance associated with mining. Before mining can begin, reclamation plans must be developed and approved by government. That is akin to having the finished landscape plans for a home before starting on the foundations. Not only must the reclamation plans be in place, but the millions of dollars necessary to reclaim the land must be posted with the government in bonds. These bonds ensure that the money needed to reclaim the site is available, even if the mine closes for unforeseen reasons.

One of the important career areas in the mining industry is in the environmental area. Scientists of all stripes and environmental engineers assess the biotic and abiotic factors of the original environment and develop plans to return the mine sites to as close to the natural conditions as possible once mining is finished. Once mining begins, Mining or Environmental Engineers direct the placement of waste rock, till and soil to optimise the regrowth of natural vegetation. Some mine sites have greenhouses where indigenous species of plants are propagated to generate seeds. These seeds are spread over test plots which are studied continually to determine the most successful methods for regenerating the natural habitat. The environmental team monitors populations of native animals and migratory species, to ensure that mining does not adversely effect them.

Reclamation is not carried out only after a mine has closed down. It is a well planned process, put in place even before a mine opens. Active reclamation begins when mining begins, and continues for many years after mining has ceased.

Resource Information

Water Quality

The Problem:

Mines use water in mill operations and rainwater percolates through broken waste rock. The water picks up metals in the process, which may render it unsuitable for release back into the natural environment.

Mining Operations are:

- Required to meet very high water quality standards;
- Continuously monitoring water quality;
- Treating water to remove toxins where that is an issue;
- Constantly having water samples checked by the government;
- Recycling and reusing water on site to greatly reduce their need for new supplies;
- Now designed to contain all water used on the site.

The process of mining must not adversely affect the quality of surface and ground water around the mine site. Mining companies have strict regulations and standards to follow related to water quality. Water sampling and analysis is a daily occurrence at any mine site. Water samples from the mine and from surrounding creeks and lakes are sent to assay labs on site, as well as to independent labs off-site as checks, to ensure compliance with regulations. Periodic inspections by government agencies monitor this process.

To ensure water sheds are unaffected, most modern mines are designed to isolate and contain all on-site water from the surrounding environment. Water is recycled by the mill from the tailings pond and back again. By isolating the water, the mine can collect it in tailings ponds or settling ponds and treat it. The treated water can then be reused or safely released into the surrounding environment if necessary.

For more insight into water quality standards, try the activity called "The Water Quality Challenge" Environmental Lesson 4 (page E4-3 Activity #4b).

Resource Information

Air Quality

The Problem:

In the process of smelting metals, smelters release sulphurous gases into the atmosphere. These gases combine with moisture in the atmosphere and cause acid rain.

Mining and Smelting Companies are:

- Developing new smelters to reduce emissions to less than 1%;
- Constantly monitoring air quality;
- Capturing emissions and making acids and fertilizers;
- Constantly having air quality checked by the government;
- Prepared to shut down smelting if emissions exceed limits.

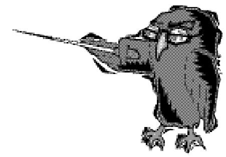
Air quality concerns related to mining are mostly associated with smelters. In early times, smelter emissions were not controlled. Today, air quality standards and regulations are in place and smelting sites are constantly monitoring air quality in and around the smelter site.

At Trail, the Teck smelting process includes the capturing of sulphurous emissions. These emissions are then transformed into readily usable sulphuric acid and fertilizers. What was once a waste emission is now a saleable product. Even with this emission treatment system in place, Teck continues carefully monitoring the atmosphere.

At the Alcan smelter in Kitimat, wet emission scrubbers have been replaced with a new dry scrubbing process. This has considerably improved emissions of fluoride compounds, which are the main contributors to emission problems in aluminum smelting. Kitimat regularly collects and examines the bones these fur-bearing animals in the region to determine fluoride concentrations. Monitoring the bone fluorides aids Kitimat in determining the success of their emission control program. Of course, Kitimat also regularly monitors surrounding air quality. Filtering, scrubbing, incinerating and recovery all contribute to reduced levels of harmful emissions at smelting sites.

Also of concern to employees and nearby citizens of mining operations is dust. This is a bigger problem in dry areas than wet ones, and can be controlled by applying water or calcite to mine roads to keep dust down. Air quality stations are standard equipment at all modern mines in BC.

Teacher Information



Activity #3d (short option): Environment and Mining

Plan:

The students need:

- Pages 13 and 14;
- A piece of paper and pen.

You need:

- To read pages 7-11 so that you are comfortable with what you are talking about.

Students will:

- Read pages 13 and 14 and write down some possible solutions to each problem. They can work individually or in groups. You can collect their work, or go over the answers in class. Remember the currently used solutions are on pages 7-11.

Note: For Activity 3d (short), the "Resource Information" sheets (pages 7 - 11) are for teacher use.

Reading for Activity #3d

Activity #3d: Environment and Mining

Acid Rock Drainage

Waste rock at metal mine sites often contain metal sulphide minerals which oxidize (rust) when left exposed to air and water. The oxidation process releases sulphuric acid which then makes the surface water acidic. Acidic water frees metal atoms, like copper, lead or cadmium, which can be harmful to aquatic life and decrease the quality of water for people in the area. What do you think can be done to deal with this problem?

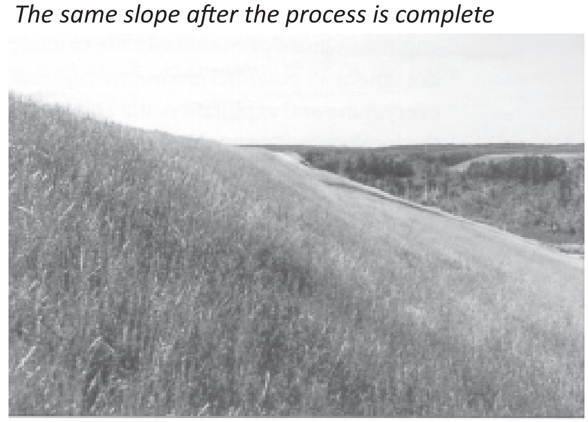
Collection ditches prevent acid runoff from entering natural waterways.

Mine Site Reclamation

Open pit and strip mines cause great change to the natural landscape of an area. Large open pits and waste rock dumps can remain without vegetation regrowth long after mines have closed. These remnants of mining operations reduce the beauty of an area and are often unsuitable for maintaining wildlife. What do you think should be done in order to deal with this environmental concern?

Reclamation in action:
The beginning of the reclamation process.

The same slope after the process is complete



Reading for Activity #3d

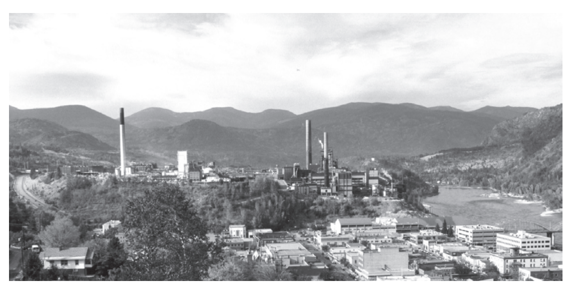
Water Quality

Tailings Pond at Highland Valley Copper Mine near Logan Lake, BC

Chemicals that are used during the milling process, can alter the pH of the water, freeing metal ions that are harmful to the environment. These chemicals are generally still present in the mill waste water which is stored in tailings ponds. What do you think should be done to ensure these chemicals do not damage our environment?

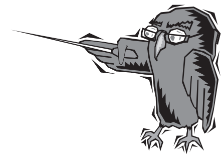
Air Quality

While there are minimal air quality problems at mines and mill sites, some smelting processes involve the genetaion of sulphurous gases as the ore concentrate is roasted. When these gases are discharged into the atmosphere they can form acidic compounds that impact on the environment. Today the "smokestacks" of smelters in North America contain "scrubbers" that capture and remove sulphurous gasses, greatly reducing those releasd to the atmosphere.



Zinc smelter at Trail, BC

Teacher Information



Environment 4: Environmental Standards

Teacher Plan:

In this sub-unit, the students are going to examine various water quality standards and choose the one they would like to see for the drinking water in their community. They will then rate different liquids that are commonly found at a mine site for their drinkability, by examining water quality analysis data. Only after rating the samples will they find out where they came from!

- 10 minutes: Introduce the concept of parts per million (ppm) and parts per billion (ppb). Talk about where numbers like these are commonly used;
- 30 minutes: "Water Quality Standards" (Activity #4a) and "Water Quality Challenge" (Activity #4b).

Notes and Background Information:

Before examining the liquid quality tables the students need to understand the concepts of **pH** and **parts per million** (ppm) or **parts per billion** (ppb)[1]. **pH** refers to the log of the concentration of hydrogen ions in solution. This concentration is expressed in terms of a number from 1 - 14. Solutions ranging from 1 - 7 are considered *acidic* (they have lots of $H+$ ions), with 1 being a strong acid and 6 being a weak acid. Solutions with pH 7 are considered *neutral*. Solutions with pH greater than 7 are called alkaline (or *basic*).

Parts per million is a difficult concept to relate to because a million is such a large number. One analogy that can be used is 1 ppm is equal to one chalk dot on a board compared to a 1 km chalk line. 1 ppb would then be that same chalk dot compared to a 1000 km chalk line. Although numbers like 2 ppm or 2000 ppb seem rather small, some chemicals can be harmful even at these minute levels.

Upon Completing these activities the student will be able to:

1) Explain what is meant by standards.
2) Compare and contrast parts per million and parts per billion.

Photocopy

- Pages 2-3

1 ppm is the same as mg/L (milligrams per litre); ppb is the same as µg/L (micrograms per litre)

Name:______________________

Activity #4a: Water Quality Standards

Introduction:

We know there are laws and regulations that tell us what is considered safe water and what is dangerous. What you might not have known is that the laws are different depending on different situations. Cattle can drink water considered unfit for humans and yet we can still eat their meat. For more on the wacky situation do the activity listed below.

Part 1 - Drinking Standards*

Question:

1) Below you will find three different water quality standards. Examine the tables and rank the standards from the most desirable for your drinking water to the least desirable for your drinking water. After ranking the standards, clearly justify in a paragraph both your most desirable and your least desirable standards.

*Please note these standards are based on a combination of Canadian and BC water quality guidelines.

Water Quality Standards

Standard	W	X	Y	Z	Rank
pH	6.5-9	6.5-8.5	6.5-8.5	6.5-8.5	
Copper (ppb)	<2-3	300	<1000	30	
Iron (ppb)	1000	none	<300	300	
Zinc (ppb)	7.5-240	2000	<5000	200	
Lead (ppb)	3-4.6	100	10	<1	

Justification:

More desirable:

____

____

____

Less desirable:

____

____

____

Part 2 - What's Good to Drink

Below is a list of several different liquids found at a minesite. These liquids are generally water with dissolved metals. Also in the list are a few surprise liquids. Answer the questions that follow and then ask your teacher to tell the identities of the standards and liquids.

Mine Site Liquids

Liquid	A	B	C	D	E
pH	7.1	8.1	8.5	5.8	3.8
Copper (ppb)	18.7	32.9	13.7	not detected	300
Iron (ppb)	6	161	266	not detected	3990
Zinc (ppb)	3.8	63.3	0.18	not detected	420
Lead (ppb)	<0.5	0.9	2.4	not detected	varies

Questions:

1. Above, you will find analyses of four liquids commonly found at a minesite. You are to rate these liquids from most desirable to drink to least desirable to drink. In a paragraph clearly justify your order of ranking.

2. Clearly indicate which of the liquids in Part 2 meet the standard you selected in Part 1.

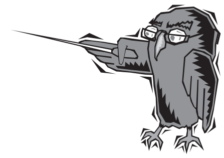
3. Ask your teacher for the identity of the following:

Standards	Liquids
W	**A**
X	**B**
Y	**C**
Z	**D**
	E

4. What did you find most interesting about the rankings you have made for water quality standards, now that you know where each one came from?

5. What do you find most interesting about your ranking of the drinkability of the liquids you chose, now that you know their identities?

6. What other information might you want included in a water analysis before deciding whether the water is suitable for drinking?



Activity #4b: Water Quality Challenge

Teacher Information

This activity gives students insight into water quality standards and measurements. It is very good practice in learning to interpret data and for making decisions based on data. This activity also fits nicely into the Science 10 chemistry unit dealing with ions and acid/base compounds.

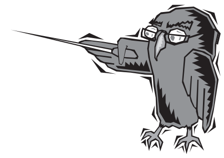
The activity is straight forward. However, you are the keeper of the most valuable information .... the identity of the quality standards and the liquids analyzed. Here is that information:

Standards
W Freshwater Aquatic Guidelines
X Livestock Guidelines
Y Drinking Water Guidelines
Z BC Example of Permitted Mine Discharge

Liquids
A A typical BC community supply
B Another typical BC community supply
C BC Example of Tailings Impoundment water
D Bottled water (e.g. Perrier)
E Natural Orange Juice

The students will find the results quite interesting!

Teacher Information



Environment 5: Environmental Video

Teacher Plan:

- 5 minutes: Introduce how mining activities can affect the environment (may vary depending on what they have learned before);
- 5 minutes: Discuss what mines could do in order to alleviate some of this damage; Hand out worksheet to be done during and after video (Activity #5a);
- 35 minutes: Show video, "Digging for Answers", pause at the end of each section to give the students a chance to fill in some of the answers.

Notes:

Give students a chance to digest what is said in each section. The video moves fairly quickly so it may be useful to have a discussion before moving on.

Upon completing these activities the student will be able to:
1) List some to the responses of mining companies to environmental problems.
2) Identify different viewpoints that people have about mining.
3) Compare and contrast opinion and fact.

Photocopy

- "Digging for Answers" worksheet pages 2, 3.

Activity #5a: "Digging for Answers" Video

What are mines doing to the environment?!? Watch the video and find out!
Instructions: Watch the video and fill out the answers in the spaces provided.

Part 1: Opinion

1. You hear a lot of different viewpoints in this first section. What is an opinion?

   ____

   ____

2. What is a fact?

   ____

   ____

Part 2: Executive

3. What is the job of an executive?

   ____

   ____

Part 3: Reclaim

4. How is dust from the railcars controlled at Fording Coal mine?

   ____

   ____

5. List 2 jobs of the environmental team at the coal mine.

   ____

   ____

Part 4: Innovation

6. What is the function of the settling pond?

   ____

   ____

7. What do they mean when they say: "The land was reclaimed with the mountain sheep in mind."?

   ____

   ____

Part 5: Research

8. What is Acid Rock Drainage?

9. Is this problem solved?

10. What is needed to solve it?

Part 6: Renew

11. What are "biosolids"?

12. Why are they used?

Part 7: Habitat

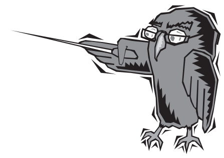
13. What does the man mean when he says they're "creating habitats"?

Part 8: Regulation

14. Why do mines have to set aside Environmental Bonds?

Part 9: Conclusion

15. Why do you think the opinions that the students held of mining were different at the end of the investigation than at the beginning?



"Digging for Answers Video" - Key

What are mines doing to the environment? Watch the video and find out!
Instructions: Watch the video and fill out the answers in the spaces provided.

Part 1: Opinion

1. You hear a lot of different viewpoints in this first section. What is an opinion?
   Answer: A belief is not based on certainty but on what seems to be true or probable.

2. What is a fact?
   Answer: Something stated as being true.

Part 2: Executive

3. What is the job of an executive?
   Answer: One who administers or manages affairs.

Part 3: Reclaim

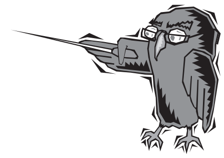
4. How is dust from the railcars controlled at Fording Coal mine?
   Answer: The coal is covered with latex to prevent spilling.

5. List 2 jobs of the environmental team at the coal mine.
   Answer: Monitor air quality, monitor water quality, monitor soil quality, replant vegetation.

Part 4: Innovation

6. What is the job of the settling pond?
   Answer: To settle particles out of the water.

7. What do they mean when they say: "The land was reclaimed with the mountain sheep in mind."?
   Answer: The vegetation that was replanted is ideal mountain sheep food, rock out crops were left as lookout points for the sheep



Part 5: Research

8. What is Acid Rock Drainage?
   Answer: Acidic waste water that occurs when water and air come in contact with certain minerals.

9. Is this problem solved?
   Answer: No.

10. What is needed to solve it?
    Answer: Research.

Part 6: Renew

11. What are "biosolids"?
    Answer: Human sewage waste.

12. Why are they used?
    Answer: To hold in moisture and fertilize the plants.

Part 7: Habitat

13. What does the man mean when he says they're "creating habitats"?
    Answer: They don't just replant everything, they try to create habitats for different creatures.

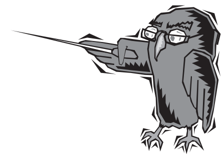
Part 8: Regulation

14. Why do mines have to set aside Environmental Bonds?
    Answer: To ensure that there is money to pay for the reclamation even if the mine goes bankrupt.

Part 9: Conclusion

15. Why do you think the opinions that the students held of mining were different at the end of the investigation than at the beginning?
    Answer: Students had more facts from which to form informed opinions.

Teacher Information



Environment 6: Acid Rock Drainage

By Keith Richert, Westview Secondary, Maple Ridge, BC

Teacher Plan:

- 5-10 minutes: Introduce ARD and review acids, bases and the pH scale;
- 50 minutes: set up experiments;
- Complete "Acid Rock Drainage" experiment (Activity #6);
- Assign questions at the end for homework.

Notes:

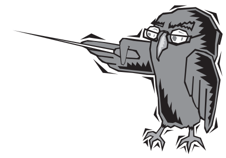
Earth Science 11 students should be familiar with pH and the pH scale. This background may have to be introduced for younger students or at least reviewed prior to conducting the experiment. The experiment demonstrates how acidic solutions are generated when sulphide minerals simply react with water and introduces the variables which enhance or inhibit the reaction. Pumping air into the mixture, adding oxygen, enhances the generating reaction. Sealing the beaker prevents the addition of atmospheric oxygen thus limiting the reaction; the solution will show a smaller drop in pH. Adding hydrogen peroxide will cause oxidation to occur quickly. *Thiobacillus ferroxidans* bacteria occur in nature, and significant numbers are necessary to accelerate the oxidation reaction and create problematic levels of acid. They are costly to purchase for lab use, but it may be possible to obtain a culture from the Mining Engineering Department at U.B.C.

Part 2 of the experiment simulates prevention and remediation methods. Treating the acidic solutions with lime demonstrates to students how ARD at mine sites can be neutralized. Sealing the immersed pyrite in a water-filled beaker simulates underwater storage of sulphide tailings, another acceptable method to prevent ARD at mine operations. When the Island Copper open pit mine at Port Hardy, B.C. closed in 1994, the pit wall was breached, allowing the pit to fill with seawater. The seawater *sealed* all exposed rock walls and prevented the exposure of sulphide minerals to air, thereby avoiding ARD generation at the closed mine site.

Students should work in small groups.

Powdered lime and pyrite can be obtained from a science supply store. Use 2-3 walnut size pieces of pyrite (or equivalent volume) per beaker.

Teacher Information



Part 2 demonstrates how to neutralize an acid using a base, but is not done herein by precise calculation. Carefully pour the lime solution from a graduated cylinder into the beakers a few ml at a time and observe changes in the appearance of the liquid while checking the pH with litmus paper.

Photocopy:

- Pages: 3 - 5.

Answers to Questions:

Part 1:
1. pH should drop most rapidly in the beaker with pyrite, air and bacteria.
2. The colour will be red due to iron in suspension.
3. We will be attempting to oxidize pyrite in these experiments.

Part 2:
1. $CaCO_3$ is a basic.
2. The solution is neutralized and metals are precipitated out of solution. Using lime to neutralize ARD at mine sites prevents acidic water containing dissolved metals from being released into the environment.

Acid Rock Drainage Background Information:

Acid Rock Drainage (ARD) is low pH ground and surface waters generated by the oxidation of the sulfide minerals to produce *sulphuric acid*. The process occurs naturally, but it can be caused or made worse by mining that exposes sulphide-bearing rocks to air. Poor environmental practices at active or closed mines can cause ARD. The major problem with ARD is that acidic waters dissolve metals, which in certain quantities are harmful to aquatic life and humans.

If waste rock at a mine site contains sulfide minerals such as pyrite (FeS_2), then it could generate ARD when exposed to oxygen and water. The sulphur will react with oxygen with the help of bacteria (*Thiobacillus ferroxidans*) to form *sulfuric acid*. When *waste rock* or *tailings* oxidize, they change colour to rusty brown, and the waters associated with them will show a drop in pH. This problem can be minimized by mixing waste rock with limestone which neutralizes the drainage. Waste rock *tailings* containing pyrite will be directed to a tailings pond. In this subaqueous environment the tailings will not oxidize and therefore pond water will not become acidic.

Acid Rock Drainage (ARD) is an environmental impact that must be addressed at many operating mines. ARD also remains an environmental problem at many abandoned mines that were closed at a time when ARD was not well understood and environmental standards and practices were less rigorous than they are today. One example of an historical ARD problem is at Britannia Beach, the Howe Sound community that once housed the mill workers for the prosperous Britannia Mines. When Britannia Mines closed in 1974 there was no closure procedure to prevent ARD generation from abandoned workings. Rain water and runoff filled the abandoned open pit at the top of the mountain and ran down through the tunnel complex reacting with exposed sulfide minerals in the rock to form sulfuric acid. This acidic solution dissolved copper and zinc and carried these metals into Howe Sound where they negatively impacted aquatic life.

Remedial action to address this environmental began in 2002. A "plug" designed and constructed by a PhD student in the Mining Engineering Department at U.B.C., was placed in the open adit at the 2200 foot level, thereby sealing off one problematic source of ARD to Britannia Creek. A surface water collection and water treatment system was built in 2006. The treatment plant adds lime to the acidic drainage. Fine, metal bearing sediment precipitating from the mix is collected and removed. Metal-free water is released to Britannia Creek, and flows into Howe Sound. Salmon returned in 2011.

Activity #6: Acid Rock Drainage Experiment

Purpose: To experiment with factors that influence the generation of Acid Rock Drainage.

Apparatus:

- 1 plastic coffee can lid
- 6-9 walnut-size pieces of pyrite
- 1 plastic bag
- 1 hammer
- 1 bottle of hydrogen peroxide
- 3 or 4 500 ml beakers per group
- pH meter or pH paper (litmus)
- 1 bicycle pump
- Calcium Carbonate (You can buy powdered limestone ($CaCO_3$) from a science supply store)
  Note: powdered lime is CaO; it is also used to neutralize acidic solutions.
- Bacteria (*Thiobacillus ferroxidans*)

Procedure Part 1: Create Acidic Solutions

1. Place 2 or 3 walnut size pieces of pyrite in a 500ml beaker (Beaker 1) containing approximately 125 ml of water.
2. Place a similar volume of crushed pyrite in a 500 ml beaker (Beaker 2). (Crush the pyrite by placing it in a folded, plastic coffee can lid, placing the lid in a plastic bag, and hitting it with a hammer.) Fill the beaker with water to the top and seal it with plastic wrap.
3. Put an equal amount of crushed pyrite in a beaker that is half filled with water (Beaker 3). Using a bicycle tire pump, pump air into the water and pyrite mixture. Add 100ml of hydrogen peroxide to the mixture.
4. Measure and record the pH of these solutions **every day** for 3 weeks, using either a pH meter or litmus paper.
5. (Optional) Add bacteria (*Thiobacillus ferroxidans*) to another beaker (Beaker 4) of pyrite and water (if the bacteria are available). Compare the pH and colour change with Beaker 3.

Questions:

1. In which beaker did the pH drop the fastest? Explain your answer.

2. Did you observe any other change in this solution? If so, what element may have caused it?

3. What chemical reaction were you trying to cause with the pump? With the hydrogen peroxide? With the bacteria?

Procedure-Part 2: Neutralize Acidic Solutions

Neutralize these acidic solutions by incrementally adding calcium carbonate. Calcium carbonate reacts with the weak acid forming water, carbon dioxide and calcium salts. Approximately 0.4 g/L will be sufficient. However, to be more exact, use the following equations:

H_2SO_4 ß> H^+ + HSO_4

The proton concentration can be can be calculated using the following equation.

$$pH = -\log_{10}([H^+])$$

Rearranged:

$$[H^+] = 10^{(-pH)}$$

For every mole of H_2SO_4 you need 1 mole of $CaCO_3$. The following equation can be used to calculate exactly how much limestone is needed.

$$\mathbf{CaCO_3\ (gCaCO_3 / 1) = [CaCO_3]\ (mole\ CaCO_3 / 1) \cdot 100.1\ (gCaCO_3 / mole\ CaCO_3)}$$

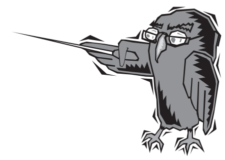
Add a little and check the pH. Check and record the pH of the lime solution using litmus paper. Do the same the following day until the pH is 7 (neutral).

Questions:

1. What is calcium carbonate? An acid? A base? Or is it neutral? (circle one)

2. How does calcium carbonate react with an acidic solution? Summarize in one or two sentences how and why this reaction is important in dealing with acid rock drainage at mine sites.

Teacher Information



Environment 7: Flocculation Experiment

By Keith Richert
Westview Secondary, Maple Ridge, BC

Teacher Plan:

- 5-10 minutes: Review Environment 6 Acid Rock Drainage;
- Complete "Flocculation Experiment" (Activity #7);
- Assign questions at the end for homework;
- Plan on monitoring plant growth for one month or longer.

Notes:

Students should work in small groups. The students should have previous knowledge of the pH scale from Science 10.

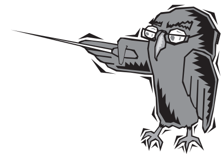
It is recommended that your students use the ARD experiment solutions (**Environment-6**) as slurry. (This experiment can also work using the waste slurry from the Flotation experiment (**Mining-3.**))

Flocculent can be obtained from a wholesale food-manufacturing firm. Tailings may be obtained upon request from an operating mine. Contact them and ask specifically for tailings and explain the purpose. You must calculate the approximate volume of tailings you will require depending on your class size and number of experiment pots. (A mixture of pottery clay and organic soil can be substituted for tailings (1 part clay /5 parts soil.))

The amount of flocculant to be used with 1 litre of solution is very small. Add only a few grains to get the desired result. The flocculant will cause the solid particles to clump together and settle to the bottom of the beaker.

This experiment can be used in the Geological Science (Resources and Environment) unit for Earth Science 11 to cover the PLO: identify environmental problems related to the development of a natural resource.

Teacher Information



Photocopy:

- Pages 2-5

Answers to Questions:

1. An Environmental Engineer needs to have a strong background in both chemistry and biology.

2. Flocculation refers to the successful collisions that occur when the hydraulic shear forces in the rapid mixing of flocculation basins drive the destabilized particles toward each other. Agglomerates of a few colloids then quickly bridge together to form microflocs, which in turn gather into visible floc masses. These floc masses then precipitate out of solution. Ultimately, the flocculent helps separate the sludge from the water.

3. Filtered water could be used to irrigate reclaimed land to promote the growth of vegetation at a mine. This would be in accordance with the 3 R's (Reduce, Reuse, Recycle).

4. So long as the bacteria concentrations in the water are not significant, the answer should be "yes." ***Do not have the students drink the water, but discuss how clean the water is.***

5. The plants in the sludge should have sprouted first, because the sludge is mineral rich. (This may not be the case when you do the experiment.)

6. The plants growing in the sludge should do just as well as those growing in the soil. Over a long period of time, however, the plants in potting soil should do better because of the more slow release fertilizers in the soil.

7. Answers will vary, but there should be reference to clarifying water and recycling it, and the ability to establish vegetation on mine waste, reclaiming land for wildlife habitat or agriculture.

Activity #7: Flocculation Experiment

Introduction:

Mining operations use **flocculation** to settle out sludge from mine drainage and from tailings pond effluent. The sludge comes from metals and other fine, clay-sized, particles in solutions that come from the mine and the concentrator. In the flotation process, after the desired metals such as copper are skimmed off, the remaining slurry is sent to the tailings pond. After initial settling, the solids in the slurry are sent to a Floc tank where chemical reagents are added which cause the remaining solid material to settle out. The clarified water is then either recycled back to the concentrator or undergoes further treatment and is released into a natural waterway.

For much of its operating life, the Sullivan Mine at Kimberly, B.C., released untreated mine waters into the local drainage system causing extensive pollution. In 1979 the mine constructed a mine water treatment system that uses flocculation to clarify and treat water which can be discharged directly into the St. Mary River. Sludge is sent directly to a designated waste site area. Now the previously polluted areas have rebounded back to a healthier ecosystem due to the water treatment facility at the mine.

Purpose: To simulate a method used by the mining industry to
1) treat mine discharge and effluent and
2) to reclaim solid mine waste.

Apparatus:

Beaker (500 ml)
Flocculant (powder)
Tailings (or a simulated mixture made from clay and organic soil)
Litmus paper or a pH meter
Funnel
Filter paper or coffee filter
Potting soil
Peat moss
Marigold seeds
Small plastic pots for growing plants
Garden hand shovel

Procedure:

1. Mix slurry tailings with tap water to form a **slurry**. Test the pH of the slurry with litmus paper or a pH meter. If the slurry is acidic, add lime to achieve a neutral pH (7) or slightly basic solution (>7).

2. Add a few grains of flocculant to the slurry; agitate or gently shake the beaker to stimulate clarification.

3. Place the flocculated slurry into the filter paper-lined funnel in the second beaker. The sludge should have settled by this time to the bottom of the beaker. The filtered water should be clear of any solid material and look as clear, if not more clear than tap water.

4. Remove the sludge using a spoon or garden hand tool, and put it into a planting pot.

5. Carefully mix peat moss into the sludge to help hold moisture and loosen the soil. Use approximately 1 part moss for every 3 parts sludge.

6. Plant 4-6 marigold seeds, or others, according to package instructions.

7. Fill a second pot with potting soil and plant 4-6 marigold seeds in the soil.

8. Place the pots either on a windowsill or in a greenhouse, if one is available at the school.

9. Check the pots daily and record in your journal when the seeds germinate and sprout, and record their growth (i.e. height). Note the difference between the plants growing in the tailings and the potting soil. Use the filtered water to water the plants.

Questions:

1. What prior knowledge would an Environmental Engineer need before starting this process at a mine?

2. What is flocculation and what does the flocculant do to the slurry?

3. How can a mine reuse filtered water?

4. Do you think the filtered water would be safe to drink?

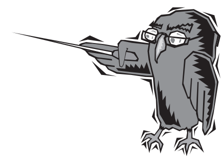
5. Which plants sprouted first, the ones in the mine sludge or the potting soil?

6. After the first month, which plants showed the best results?

7. What has this experiment taught you about mining and the environment?

Conclusion: (Should be 2 or 3 sentences related to the purpose of the experiment).

Teacher Information



Mining 1: Metals from Stone

Teacher Plan:

- 10 minutes: "Mining and Me" teacher led brainstorm (Activity #1a);
- 5 minutes: Oral reading: "Types of Mines" (page 6);
- 15 minutes: Ore examination (Activity #1b);
- 10 minutes: "Mental Mining!" (Activity #1c);
- 5 minutes: "Review" of Mining Process (page 26);
- Crossword puzzle for remainder of class (pages 27), Key below.

Notes:

This is also Lesson 1 of the "Rocks and Minerals" Sub-Unit"

Most students (and teachers for that matter) do not fully appreciate the importance of mining to their everyday lives. These short introductory lessons help students understand what products come from mines. They show students the many mine sites in BC and begin to link finished mining products to the "rocks" they came from.

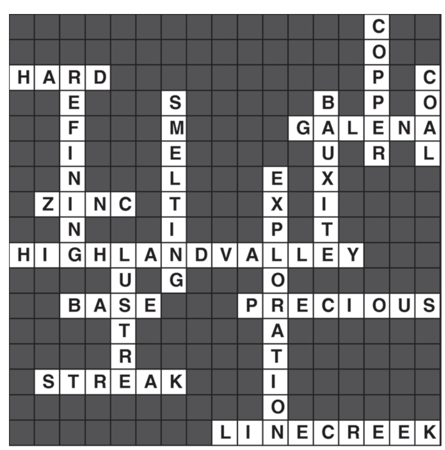
* Please note in Activity #1b ("Common Metals and their Ores"), bauxite is listed as an ore. Although a class set of bauxite samples is not available, a single refined powdered sample is available in the Alcan kit, which accompanies your unit, and may be shared with students.

Upon completing these activities the students will be able to:

1) Identify some of the different ore minerals that are mined.
2) Identify where mineral products are used in everyday life.
3) Infer where mineral products are used indirectly in their lives.

Photocopy:

- Pages 2 - 7, 22, 23, 26, 27 for student use.



Review Crossword Puzzle Key

Activity #1a: Mining and Me

Look around the classroom. How many objects can be directly or indirectly linked to mining and mineral processing? Work with a partner and list the ideas you come up with.

You have probably identified objects like metal door knobs, copper pipes and chromium plated sink taps. I wonder, however, whether you have also included wooden tables? Wooden tables you say! How are they related to mining? Well, tables are cut by metal saws, put together with metal nails and screws and are transported by metal trucks burning fossil fuels! Hmm, maybe you should re-examine your list. What else could you add?

I hope you now appreciate that mining is very important to all of us and that it touches all aspects of our lives. Not only does it provide material things for us but mining is also British Columbia's second largest resource industry. Mining employs a great number of people, builds cities and benefits the economy of our province. Looking at Fig. A, you can see the tremendous number of mines in BC.

Teacher Information

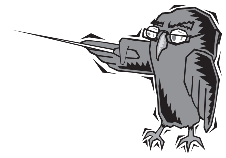
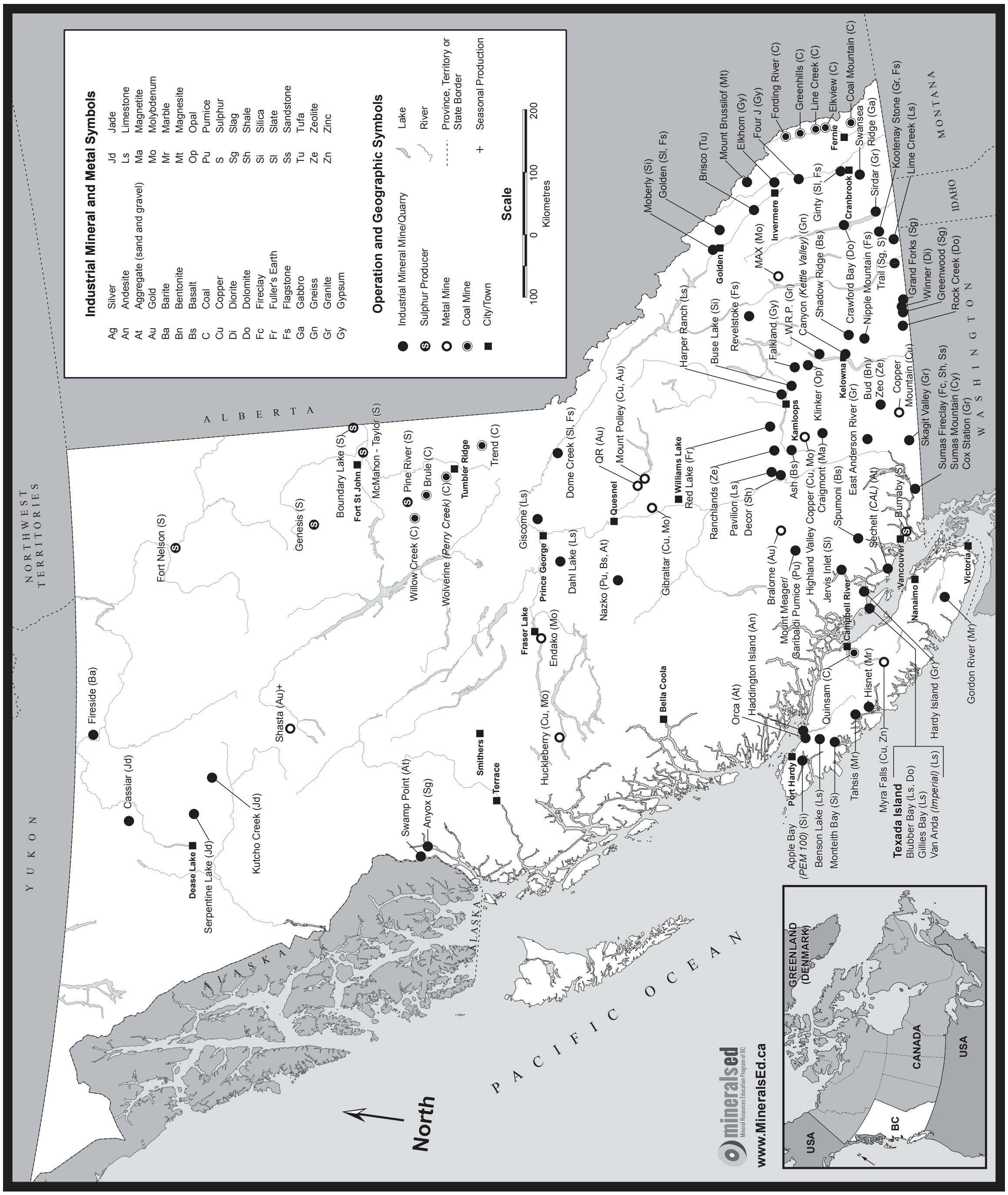


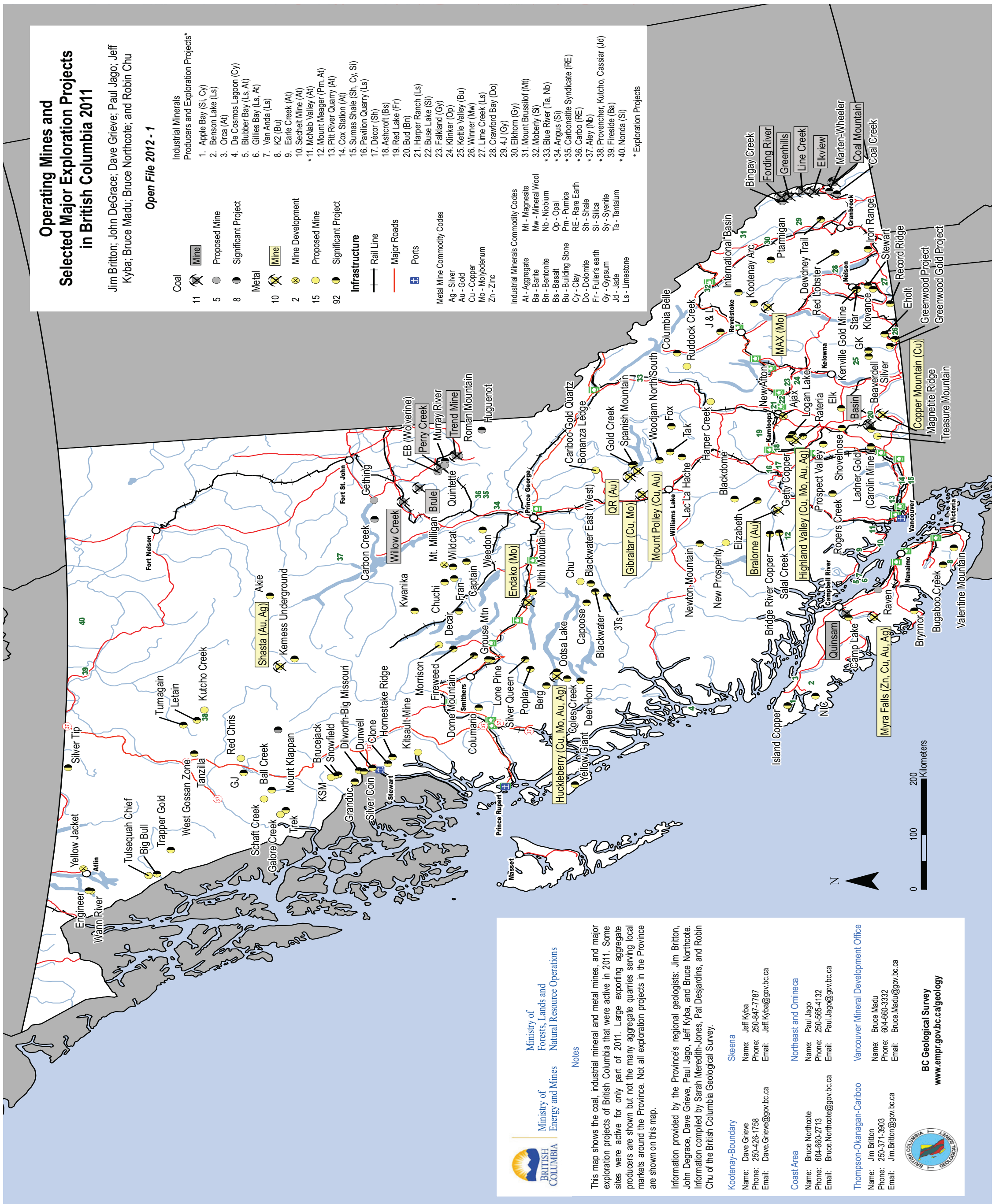
Figure A:
Major Coal, Metal, and Industrial Minerals Operations in BC



Teacher Information

Figure B:

Major Mines and Advanced Exploration Projects in BC



Reading

Minerals are very important to us

Many of the things we need to live, and most of those that make life more comfortable, depend directly or indirectly on minerals taken from the earth. Food and water supply, shelter, clothing, health aids, transportation and communication, a wide variety of products used at home, at play and at work, all depend on the minerals industry.

Our stove and most kitchenware is made from mineral resources!

To grow most of our food we need fertilizers made from minerals. Fertilizers also help the growth of plants such as cotton and linen which are used to make much of our clothing. In the North, where many of us hunt for food, we need guns and bullets made from metals. To transport food to our tables we need trains, airplanes, trucks, boats, and snowmobiles - all made from such metals as aluminum, steel, copper, and zinc. To cook our food, we need metal pots and pans, knives and forks.

We watch television: sets are made from cables, wires, and electric components, all made from metals or minerals. The rockets, and the satellites they carry into space for telephone and television services, are made from metals.

Water is pumped through copper pipes, by brass pumps, and drains through copper pipes into steel sewage tanks. The wiring in our homes and office buildings is copper or aluminum; the walls contain gypsum. Steel beams are made from iron, carbon, and chromium, and the lumber may have been treated with chemicals made from minerals. Our homes sit on gravel or concrete foundations, that are built from materials taken from the ground.

We need metal rigs, drill pipes and assorted equipment to drill the oil wells to get gas for our metal snowmobiles, boats, cars, and trucks, and coal, oil or uranium to provide us with electricity. Metals make the moulds needed to produce the plastics which are so common today. Glass in our windows, and the ceramics in our bathroom sinks, toilets and bathtubs are all produced from minerals. Lead and zinc are used in batteries that are so necessary to power our vehicles, radios, and portable stereos.

We need mining!
Each year, every North American requires 40,000 pounds of new minerals. At this level of consumption, the average newborn infant will need a lifetime supply of:
361 kg of lead, primarily for automotive batteries, solder and electronic components;
344 kg of zinc, as an alloy with copper to make brass, as protective coatings on steel and as chemical compounds in rubber and paints;
682 kg of copper for use in electrical motors, generators, communications equipment and wiring;
1,633 kg of aluminum for various uses, from beverage cans to folding lawn chairs to aircraft;
14,863 kg of pig iron for kitchen utensils, automobiles, ships and large buildings;
12,068 kg of clay, for making bricks, paper, paint, glass, and pottery;
12,824 kg of salt for cooking, plastics, highway de-icing and detergents;
562,773 kg of stone, sand, gravel and cement, for roads, homes, schools, offices and factories.

Reading

Types of Mines:

Mining involves extracting all kinds of minerals from the ground. The table below divides the types of mines into four groups, based on the product being mined. Precious metals are those products that command a very high market price. Base metals are less expensive and have many uses. Fossil fuels were originally living plants and animals that have formed high energy chemicals that fuel our machines and are used to make many synthetic products. The non–metal group contains a wide variety of materials that have unique qualities that make them useful i.e.: clay for dinner plates; and granite for building stone.

Precious Metals	Base Metals	Fossil Fuels	Non-Metals
Gold	Copper	Coal	Limestone
Silver	Lead	Crude Oil	Gypsum
Platinum	Zinc	Natural Gas	Graphite
	Aluminum		Asbestos
	Molybdenum		Fuller's Earth

While all of these materials are mined or produced in BC, we will concentrate on metal mining, which includes both the precious metals and the base metals listed above. Most of these metals are not found in their pure state, they are mined in the form of chemical compounds, called ore minerals. While most rocks contain metals, only rocks containing a high enough metal content to make their removal worthwhile are called **Ores**. Those not containing enough metal are referred to as **Waste Rock** or **Gangue.**

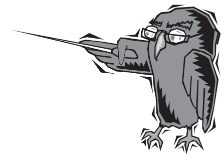
Activity #1b: Common Metals and their Ores

You will be given a sample set of ores and a worksheet. Complete the table on the worksheet by carefully observing the ore samples. Look at each sample and note its colour, lustre and streak. Everyone knows what colour is. Luster is how shiny a sample is. Pure metal is usually very shiny while dirt is not. Streak is when you take an ore sample and drag it across a rough porcelain surface. The colour of the streak can be very different from the ore sample. On your worksheet write down the colour and the luster of the mineral and its streak colour.

Activity #1b: Common Metals and Their Ores

Fill in the blank columns.

Ore Mineral Composition	Colours	Luster	Streak	Metal	Uses
Chalcopyrite ($CuFeS_2$)				Copper	
Malachite ($Cu_2CO_3(OH)_2$)				Copper	
Azurite ($Cu_3(CO_3)_2(OH)_2$)				Copper	
Bornite (Cu_5FeS_4)				Copper	
Galena (PbS)				Lead	
Magnetite (Fe_3O_4)				Iron	
Sphalerite (Zn,FeS)				Zinc	
Bauxite ($A1_2O_3.2H_2O$)				Aluminum	
Molybdenite (MoS_2)				Molybdenum	

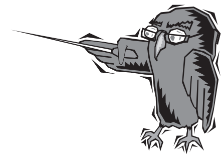


Activity #1b:
Common Metals and Their Ores

Ore Mineral (Composition)	Colours	Luster	Streak	Metal	Uses
Chalcopyrite ($CuFeS_2$)	Golden yellow to copper	Greenish black	Metallic dull metallic	Copper	Electrical conductor, brass making.
Malachite ($Cu_2CO_3(OH)_2$)	Greenish	Silky to earthy	Pale green	Copper	Electrical conductor, brass making.
Azurite ($Cu_3(CO_3)_2(OH)_2$)	Blue	Shiny to earthy	Light blue	Copper	Electrical conductor, brass making.
Bornite (Cu_5FeS_4)	Iridescent blue	Metallic	Pale greenish black	Copper	Electrical conductor, brass making.
Galena (PbS)	Grey to silver	Metallic or dull	Grey	Lead	Storage batteries, solder
Magnetite (Fe_3O_4)	Black	Metallic or dull metallic	Black	Iron	Steel for vehicles, bridges and buildings, etc.
Sphalerite (Zn,FeS)	Yellowish brown or red	Resinous	White to reddish brown	Zinc	Alloyed with copper in brass; galvanizing iron.
Bauxite ($A1_2O_3.2H_2O$)	Reddish brown (Ref. sample kit)	Earthy	**	Aluminum	Electrical conductor, cook-ware, lights, light weight structural materials.
Molybdenite (MoS_2)	Silver grey	Metallic	Greenish grey	Molybdenum	Plastics, synthetic fabrics, paints, vitamins, hardening steel, a catalyst in breaking down nitrogen in soil.

** Bauxite is actually a mixture of minerals, and therefore does not have a diagnostic streak.

Teacher Information



Mineral Fact Sheet

1. ALUMINUM

General
Aluminum is the most abundant metal found in the Earth's crust. The crust is made up of 8% aluminum but, unlike gold or silver, it is never found in a native state. Most minerals rocks and soils contain aluminum compounds, but aluminum can be made inexpensively only from bauxite ore that consists of a combination of the three minerals: boehmite, diaspore and gibbsite.

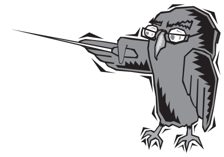
Aluminum is usually produced in an alloy form, with copper, magnesium, manganese, silicon, tin and zinc. It has many valuable properties such as its light weight, strength, corrosion resistance, electrical conductivity and heat conduction, as well as light and heat reflection.

Uses
Manufactured products include: doors, windows, house sidings, beverage cans, foil, cooking utensils, automobile, truck and airplanes parts, bottom of irons, tubing in air–conditioning units, bolts and screws.

As supplies of iron ore for steel making are becoming exhausted, aluminum is increasingly being substituted for steel in many products.

Mines
Aluminum is produced at a smelter in Kitimat, BC, which imports its bauxite mainly from Australia, because there are no bauxite deposits in Canada.

Teacher Information



Mineral Fact Sheet

2. ASBESTOS

General

Asbestos is the name for several minerals that form long, thin, threads or fibres. The names of some of the asbestos minerals are chrysotile, crocidolite, tremolite and actinolite. Historical names for asbestos include **earth flax** and **mountain flax.**

Asbestos fibres are found in veins in bedrock. The veins formed when the rock cracked and the cracks filled with fluid of the right composition to form asbestos minerals. The asbestos minerals crystallized on the walls of the cracks and grew out into the cracks as long fibres.

Uses

Although asbestos fibres look like cloth threads, they are threads of rock that don't burn. Because of their fibrous nature, they can be woven, just like cloth. Therefore, gloves and other clothes can be made of asbestos to protect people from fire. Asbestos fibres have been used in walls and ceilings for the same reason.

Another useful property of asbestos fibres is that they are very strong. If you tested an asbestos fibre and a steel wire of the same thickness, you would find that the asbestos is stronger in certain ways. This strength is useful in making building materials, like cement. When asbestos fibres are added to cement, it makes the cement much harder to break.

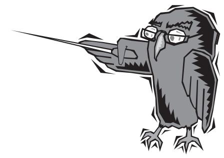
A concern with asbestos is that it can cause lung disease in people who breathe in the short fibres from asbestos dust over a long period of time. Though asbestos is not poisonous when swallowed, it irritates people's lungs and they can develop asbestosis, a disease that often becomes terminal. Smokers are most prone to get this lung disease if they inhale asbestos dust.

Some people who have worked with asbestos in their jobs have only developed lung disease many years later. Years ago, people did not know that the dust could be harmful. Workers now wear special protective dust masks to prevent the fibres from entering their lungs.

Mines

Asbestos was mined at the Cassiar Mine, in Northern BC, from 1952 to 1990.

Teacher Information



Mineral Fact Sheet

3. COAL

Types

There are different types (ranks) of coal: lignite, sub–bituminous, bituminous, and anthracite. They burn at varying intensities: when lignite burns, it does not give off as much heat as sub–bituminous coal; sub–bituminous coal does not give off as much heat as bituminous; and anthracite gives off the most heat of all.

Formation

Millions of years ago, there were many more swamps than there are today. These swamps were full of trees and other plants, just like the swamps in Florida today. The swamps were eventually covered with sediment. As the plants were buried deeper and deeper under the sediment, pressure and heat slowly converted the plant-matter into coal.

As vegetation is buried over time, it first becomes lignite. Lignite is brown and often still has chunks of wood in it. As it is buried deeper and experiences higher pressure over a longer period of time, it becomes sub–bituminous coal, and then bituminous coal. If more pressure and heat is added, it finally becomes anthracite, which is black and shiny.

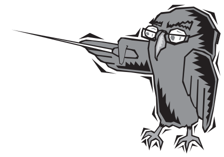
Many people do not call coal a mineral because their definition of a mineral does not include anything that is formed from plants or animals. Whether you call coal a mineral or not, it is like other minerals in many ways: it is often found deep in the earth; and must be mined in the same way as other minerals.

Uses

The simplest use of coal is to burn it in a stove for heat. Most houses in North America were heated with coal furnaces until the 1940's and 1950's. Coal burns hotter and longer than wood. Usually anthracite is used for heating houses. In some parts of the world anthracite is still used to heat homes. Very little coal is used for domestic heating in BC. It has been replaced by oil, natural gas and electricity, which cause less pollution.

One of the main uses of coal today is to generate electricity. In Alberta, Saskatchewan and Ontario, locally available coal is often used. The coal is burned in furnaces that heat water into steam. Furnaces that make steam are called boilers. The steam from the boilers is then used to spin turbines to generate electricity.

Teacher Information



Another use of coal is for making steel. To make steel, iron ore must be melted. The molten iron can then be combined with other molten metals to form alloys. Very hot temperatures are needed to melt iron ore. A special blend of coal, which has been changed to coke by heating, known as **coking coal** is used. Coke is usually made from bituminous type coal. Coal that can form coke for melting metals is often called by a special trade name: **metallurgical coal**.

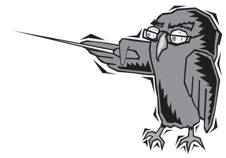
Of coal produced in BC 90% is metallurgical or coking coal; the remaining 10% is thermal coal.

Mines

Coal Producing mines in BC:

- Willow Creek, near Chetwynd;
- Perry Creek Mine, near Tumbler Ridge;
- Brule, near Tumbler Ridge;
- Trend, near Tumbler Ridge;
- Elkview, near Sparwood;
- Line Creek, near Sparwood;
- Fording River, near Elkford;
- Greenhills, near Elkford;
- Coal Mountain Operations, near Sparwood;
- Quinsam Coal near Campbell River on Vancouver Island.

Teacher Information



Mineral Fact Sheet

4. COPPER

General
Copper is found in many minerals. The important copper minerals are chalcopyrite, bornite, chalcocite, tetrahedrite, and to a lesser extent, malachite. Sometimes copper is found in its native state like gold. Copper is the most important metal mined in BC.

Copper is found in all types of rocks. It is found in and mined from igneous rocks as well as metamorphic rocks. It is also found in quartz veins, associated with other valuable minerals like gold. Copper is alloyed with tin to form bronze, and with zinc to form brass.

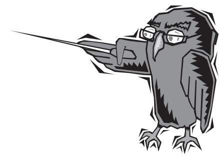
Uses
After iron and aluminum, copper is the third most widely used metal. In your house, the pipes that carry water and the wires that carry electricity are probably made of copper. "Pennies" are copper – or zinc coated with copper.

Early man learned to use copper because it was soft enough to be shaped by hand, but hard enough to be useful for knives and other tools.

Mines
Past copper mines in BC:
- Britannia Copper Mine on Howe Sound operated from 1904 to 1974;
- Island Copper, near Port Hardy, closed permanently in 1996;
- Afton Mine, near Kamloops, closed in 1997; renewed exploration underground 2006-2008;
- Kemess Mine, in north central BC

Current copper-producing mines in BC:
- Highland Valley Copper, near Kamloops;
- Myra Falls Mine, near Campbell River;
- Gibraltar Mine, Mount Polley Mine and QR Mine near Williams Lake
- Huckleberry Mine, south of Smithers
- Copper Mountain Mine, near Princeton
- New Afton Mine, near Kamloops - underground extension of previous Afton open pit

Teacher Information



Mineral Fact Sheet

5. GOLD

General

Gold, usually found in its native state, often occurs in quartz veins where it may be seen with the naked eye. A quartz vein is formed when a large crack or fracture in bedrock is filled with fluids of the composition of quartz. The fracturing happens deep within the Earth, where there is much heat and pressure. Fractures can be caused by extreme folding or faulting, earthquakes or volcanic action. The fluids entering the cracks or fractures solidify as cooling occurs. Gold found in this form is called **Lode Gold**, hence the term: "Motherlode".

Gold is also found in other kinds of mineral deposits: it can sometimes be found in volcanic rocks in concentrations so small that it cannot be seen with the naked eye, and is often a valuable by-product of copper mines!

Uses

Since ancient times gold has been used for money and jewellery. Gold is attractive because it has a bright yellow colour, and is soft and easily workable. It also does not easily tarnish or react with chemicals like other metals. Gold is very valuable but it is rare and hard to find.

You can see how much more valuable gold is than other metals by comparing the price of gold with the price of other minerals and metals. For example:

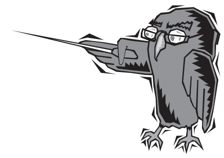
- 1 kg. of zinc is worth about $2.23
- 1 troy ounce of gold is worth over $1,500, 1 kg is approximately $48,226
- 1 kg. of copper is worth about $9.04
- 1 tonne of metallurgical coal is worth about $277

Prices (July 2012) are in US dollars (prices fluctuate)

Mines

The bulk of known gold reserves occur not in gold only deposits, but in copper–gold deposits. BC "lode" gold mines, include the following past-producers: Golden Bear Mine, Snip Mine, and Eskay Creek Mine. A different kind of hard-rock gold deposit was mined at Nickel Plate Mine (closed in 1996). Kemess Mine in north-central BC is a Cu-Au operation.

Teacher Information



Mineral Fact Sheet

6. IRON ORE

General

Iron, found in combination with other elements, is a common metal, making up about 4% of the earth's crust. Two common iron minerals are hematite and magnetite.

Iron is the main component in steel, which is a widely used metal in our industrial society.

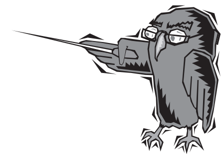
Uses

Steel is the most widely used but also the least valuable metal today. It is used for the construction of bridges and buildings; and the manufacture of automobiles, machines, appliances and many other products.

Mines

Most iron ore is mined in Newfoundland, Quebec and Ontario, with British Columbia mining only a small amount.

Teacher Information



Mineral Fact Sheet

7. LEAD

General

Lead is most commonly found combined with sulphur, as the mineral galena. Galena is a shiny grey colour and is very heavy. Silver is often associated with the mineral galena and, as a result, lead is often a by-product from some of the richest silver mines. As well, galena is often found in veins with sphalerite, a zinc mineral. Some of the largest deposits of lead being mined today were formed when heavy, lead-zinc-rich fluids gushed from underwater vents.

Uses

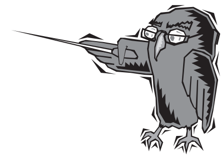
The primary use of lead today is in electric batteries. That is why batteries are so heavy. Lead was once used to make pipes and paints. Because lead is harmful when inhaled or swallowed its use has been reduced.

Another modern use for lead is in gasoline. Addition of lead makes older cars run better but also puts lead into the air we breathe. In Canada lead is no longer used as a gasoline additive so new cars are designed to run on gasoline that does not contain lead.

Mines

The are currently no lead producing mines in BC. The Sullivan Mine near Kimberley, BC was an underground lead mine which operated from 1900-2000.

Teacher Information



Mineral Fact Sheet

8. MOLYBDENUM

General

Molybdenum is found in the mineral molybdenite which consists of sulphur and molybdenum. Most molybdenum in BC occurs in large low grade mineral deposits where molybdenite occurs in networks of veinlets and as disseminated "specks" in igneous rocks.

Uses

Molybdenite is very slippery and is therefore used as a lubricant. One of the old wagon trails that crossed America passed a spot where molybdenite was found in the mud. The pioneers used this mud to grease their wagon wheels. Today molybdenite is used to oil machinery that gets so hot that regular oils cannot be used.

The largest use of molybdenum is in making special steels. Like manganese, molybdenum is added to steel to make the steel harder and tougher. These steels are used in cars, trains, airplanes, buildings, and even in your bicycle. It also gives the steel a higher heat resistance. This heat resistance is important: jet airplanes depend upon molybdenum and tungsten combined with other metals, to make the jet engines.

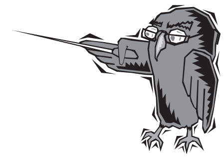
Molybdenum is also a necessary element in soils for plant growth. Most soils contain very small amounts of molybdenum, which acts as a catalyst allowing plants to break down the nitrogen in the soils so that photosynthesis can occur. But there are some areas with no plants at all... because there is no molybdenum in the soil. When farmers need to add molybdenum to their crops, they make a sodium–molybdate solution which they dip the seeds into. To fertilize an acre of ground, only takes one and one–half ounces of molybdenum!

Molybdenum is also used to make plastics: synthetic fabrics, paints, vitamin pills. It is also what puts the red in your colour television picture.

Mines

Molybdenum is mined at Endako Mine near Endako, BC, while copper mines such as Highland Valley Copper and Gibraltar Mine produce molybdenum as a by-product.

Teacher Information



Mineral Fact Sheet

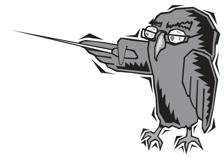
9. PLATINUM

General
Platinum, a beautiful silvery white metal, is usually found in its native state. Because it does not weather or break down, platinum is often found in placer deposits like gold. Platinum is as valuable as gold and there have even been times in history when the price of platinum has been much higher than that of gold.

Uses
Platinum is used in jewellery just like gold. People in some Asian countries like Japan prefer platinum jewellery to gold jewellery. Platinum is also used to make special wires and parts for electronic instruments. The nose cones of missiles are coated with platinum because it will not melt at high temperatures. Platinum is used in catalytic converters in cars to clean the exhaust gases and keep the cars from polluting the air.

Mines
In the late 1800's, placer platinum was recovered from stream sediments in the Tulameen area.

Teacher Information



Mineral Fact Sheet

10. SILVER

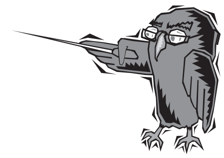
General
Silver is sometimes found in its native state like gold. But most often it is found combined with other metals. Gold nuggets usually contain silver. When gold has silver in it, it is a lighter yellow colour than pure gold. Silver is also found in small amounts with deposits of lead, zinc and copper.

Some of the richest silver deposits are veins of galena that contain much silver. Usually, crystals of galena form in cubes. When galena is rich in silver, the silver prevents the galena from crystallizing as cubes. The crystal form of galena can, therefore, be used as an indication whether it is rich in silver.

Uses
Silver is used in coins, jewellery and in silverware utensils. The biggest use of silver, however, is in photography. Crystals of silver halide are used in photographic film. When you take a picture, light is let into the camera. The light shines on a layer of silver halide crystals on the film. The crystals change depending on how much light hits them. When the film is developed, changes in the crystals show up as light and dark areas which make up the picture. Silver is also easily recycled.

Mines
In BC, silver was mined with lead and zinc, at the now closed Sullivan Mine. It is a by-product at Highland Valley Copper, Myra Falls, Gibraltar, and Eskay Creek Mines (Eskay is now closed).

Teacher Information



Mineral Fact Sheet

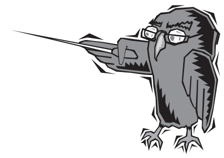
11. TIN

General
The most important ore mineral of tin is cassiterite. Cassiterite is mined from veins and also from some granites. Cassiterite does not weather or break up easily when exposed to rain and air. It appears loose in gravel and sand and can be mined using placer methods.

Uses
Tin is used, like zinc, to coat other metals to prevent rusting. "Tin cans" are actually steel cans coated with tin. Tin is also mixed with other metals to form pewter, bronze and solder. One interesting use of tin is in making window glass. Molten glass is poured onto a bed of molten tin. The molten tin, like any other liquid, forms a very flat and smooth surface. When the molten glass floating on top of it cools, it is also very flat and smooth.

Mines
Tin is not produced in BC. The largest tin mines are in Malaysia and Thailand where enormous dredges mine placer cassiterite from rivers and bays.

Teacher Information



Mineral Fact Sheet

12. ZINC

General
The most common and important zinc mineral is sphalerite. Sphalerite consists of zinc and sulphur. Sphalerite can be different colours and doesn't shine like a metal, as does galena or chalcopyrite.

Zinc is most often mined from deposits containing lead, zinc and silver which were formed from discharge of lead-zinc-rich liquids from submarine vents.

Uses
Zinc is the fourth most used metal in the world. The largest use of zinc is in galvanizing (steel products dipped in hot liquid zinc). The zinc coats the steel and prevents it from rusting. You have probably seen many galvanized steel products: metal buckets, garbage cans, and steel pipes used for drinking water are all usually galvanized. The wire fencing around your school is also galvanized.

Zinc is used for many other things. "Pennies" are now being made from zinc and then are only coated with copper. Zinc is mixed with copper to make brass. In small amounts, zinc is necessary in our diet. You can buy zinc supplements and zinc lozenges for sore throats at the drug store.

Mines
Zinc is one of the principal products at the Myra Falls Mine on Vancouver Island. The Sullivan Mine was a world class example of this type of deposit. Zinc is also found in quartz vein deposits, together with gold.

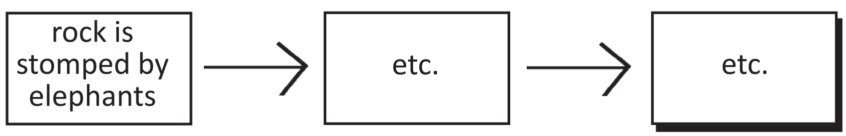
Activity # 1c: Mental Mining!

You are now familiar with some of the ores mined in B.C., yet it is not easy to see how a piece of chalcopyrite or bornite could become a copper pipe. So, how does it happen?

Instructions:

Make a flow-chart indicating the steps you think the ore samples you have studied need to go through in order to get the metals out of the ore. Use your imagination!

Example of flow-chart:



When you have completed this activity, your teacher will show you Figure C which will show you the actual steps that occur in a mining operation to turn ore to metal. Take a look!

Reading

Figure C:
Steps of Mining and Mineral Processing

Mine Site

EXPLORATION
locating, mapping and sampling the ore body

MINING
extracting the ore by drilling and blasting, removal of waste and hauling

MILLING
crushing and grinding the ore

CONCENTRATING
removing ore from waste rock
freeing target mineral from surroundings

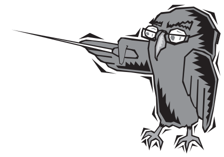
Transportation to the refinery by rail, ship or truck. The refinery may be close by, or half way around the world.

Refinery

SMELTING
chemically separating the target metal usually through heating

REFINING
using electrolysis to purify the target metal to +99.9%

Teacher Information



Supplementary Information:

The following are some notes to support the overhead on the previous page.
Reference pages provided are found in the Placer Dome booklet: *The Mine Development Process*, which is part of this resource unit. It is strongly recommended that you read this booklet as well as the other booklets provided.

Exploration

(ref. pages 3–7 and 18–25): Much time and money is spent in search for ore deposits. Exploration scientists examine geological information to determine where more detailed exploration should take place. Closer site examinations, including assaying of soil samples, are followed by exploratory drilling. Drill core samples are analyzed to determine the quality of the mineral deposit. Next, present and future economic appraisals are compared to the potential ore reserves to determine whether the mine can be economically developed.

Mining

(ref. page 7 and pages 37–42): After constructing the mine site, buildings and equipment, and mapping the ore body, the physical work of removing the ore begins. Some mines are **open pit** while other are **underground** operations. Either requires careful surveying and constant ore quality control by analysis. Blasting reduces the size of rock so that it can be transported. To get to the ore much of the material initially transported is waste rock, which is rock containing too little ore for it to be processed. The waste rock is hauled to dump sites, which are reclaimed. The ore is moved by haul truck and/or conveyer to the milling site.

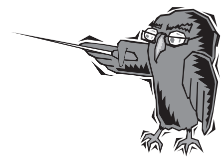
Milling

(ref. pages 7–8, 44): Milling the ore involves a combination of grinding and crushing it into tiny fragments. Huge jaw crushers and cone crushers break the ore to a gravel-like consistency. Water is added to the ore as it enters huge ball or rod mills. These mills tumble the rocks at high speed and ultimately crush it to a fine watery slurry.

Concentrating

(ref. pages 8, 44): The ore slurry is then separated by a wet flotation process. Flotation reagents and frothers are added to the slurry which cause the mineral-laden compounds to attach themselves to air bubbles that are introduced by a compressor. The minerals then float to the top of the slurry where they are skimmed off. Coking machines and dryers remove most of the water, leaving the mineral concentrate dry and ready for shipping.

Teacher Information



Smelting:

(ref. pages 46–48): The mineral concentrate may contain some "pure" metal, but more commonly it consists of metal that is bound in metal sulphide compounds. There are several processes, designed to remove the metal trapped in these compounds. Perhaps the most well known method is roasting the ore in a smelter, which replaces the sulphur with oxygen. This process is technically called **pyrometallurgy**. The sulphur gas is then trapped and treated to prevent sulphur emissions into the atmosphere.

Other methods of treating the concentrate include: biological leaching, where bacteria are used to eat the sulphur, thus freeing the metal; and wet leaching, where a chemical replacement reaction frees the metal from the sulphide compound. Technically, biological leaching is known as **biometallurgy** and wet chemical leaching is called **hydrometallurgy**. All three processes are used in BC.

Refining:

The refinery is usually located at the same site as the smelter. Generally, the refining of metals involves a process miners call **electrorefining**. The impure metal from the smelter is placed in an electrolytic solution and hooked up to a voltage source. The electrical current causes the impure metal bar to release pure metal ions, which travel to a pure electrode, where they "plate" into their pure metal form. The impurities are left behind. The pure metal is then melted, poured into molds and readied for shipping to the manufacturer, where it is made into the finished products consumers can use.

Questions

Review Questions:

1. Provide support for this statement: "Mining is very important to people of BC."

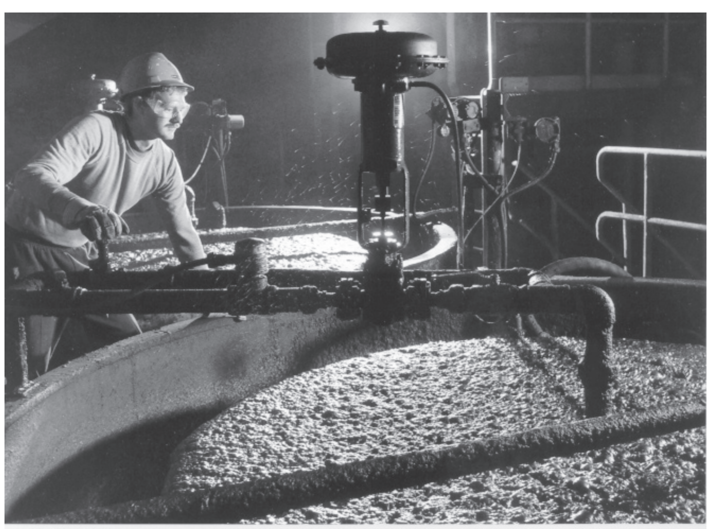
2. Most rock contains some metal. What then makes some rocks "ores" and some rocks "waste"?

3. List several products that people use that come from the minerals listed:

   A) Chalcopyrite B) Galena C) Bauxite

4. Explain the difference between base metals and precious metals.

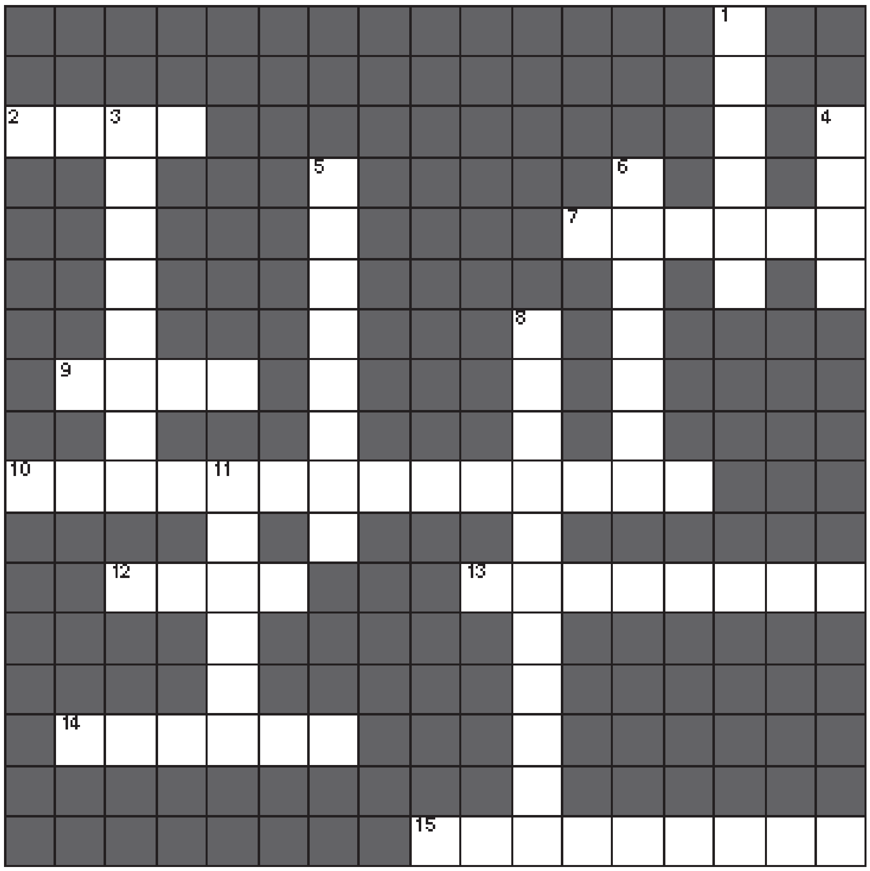
5. Are most metals found in the pure state? If not, in what form are they found?



A mill operator inspects the slurry in one of the three flotation cells in the mill at Highland Valley Copper Mine.

Review Activity

Mining 1: Review Puzzle



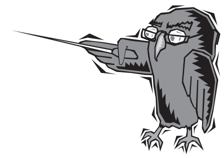
ACROSS

2) Diamond is a very ______ mineral
7) The chemical symbol is PbS
9) Used to galvanize steel
10) Biggest open pit mine in Canada
12) Metal used in industry
13) Metal worth lots of money
14) Color left when rock is scratched on unglazed ceramic tile
15) A BC coal mine

DOWN

1) Used in electrical wiring
3) Process used to purify minerals
4) Burned to generate electricity
5) Separating mineral from mineral compounds
6) A common aluminum ore
8) Looking for the ore
11) How a mineral shines

Teacher Information



Mining 2: Only Ore

Teacher Plan:

- 5 minutes: Teacher review of "Mining 1 – Metals from Stone" (pages 26-27);
- 10 minutes: Oral reading "Locating the Ore" about locating, mapping and blasting ore bodies (pages 2-5);
- Complete "Density Separations" (Activity #2a);
- Assign questions at the end for homework (page 8).

Notes:

Activity #2a demonstrates the principle of density separation. This activity could be used in the Science 8 Unit on "Matter", in the section dealing with separating substances from mixtures.

Density separation is used to remove waste rock from the heavy ore before the milling process at the Sullivan Mine in Kimberley, B.C. Density separation is also key to the separation of coal from waste rock. In this case it is the low density coal that floats while the waste rock sinks. Please see the supplementary activity on coal in the last section of this binder.

Upon completing these activities the student will be able to:

1) Describe the different types of methods used to find ore.
2) Quantify the differences in density between two rock samples.
3) Describe where density would be useful in separating ore rock from waste rock.

Photocopy:

- Pages: 2-8.

Reading

Locating the Ore

Prospecting for ore conjures up images of the rugged prospector with a pack-sack and a pick trekking through the remote wilderness. While this image of prospecting has remained unchanged for decades, mining itself has quietly transformed into a highly sophisticated technological industry. Searching for minerals, today, involves trained exploration crews and skilled scientists utilizing satellites, helicopters, airplanes and sophisticated ground equipment.

Few mines are discovered in convenient places. The exploration geologist must cope with frontier conditions, but in exchange, lives and works in places that few others are likely to visit.

A helicopter arrives at a remote exploration drill site.

Reading

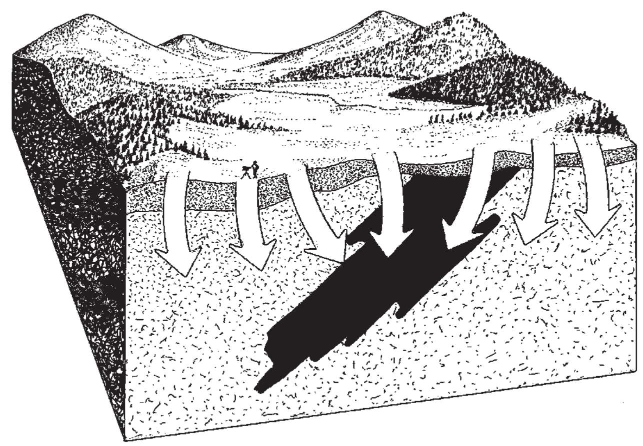
Methods for Finding Ore

Clues that orebodies occur in an area can come to geologists in the form of changes in the gravitational, electrical, and magnetic forces within the earth. Radioactivity is another clue that can indicate what lies beneath the earth. Soil sampling and the analysis of plants are also used to support the findings of geologists. Finally, a great number of drill holes are sunk to retrieve drill core samples that ultimately determine whether an economic orebody exists.

A great deal of time, patience and effort, as well as large amounts of money go into finding ore-bodies. But when a mineral strike is made, it can be more than worth the effort!

Gravimetric

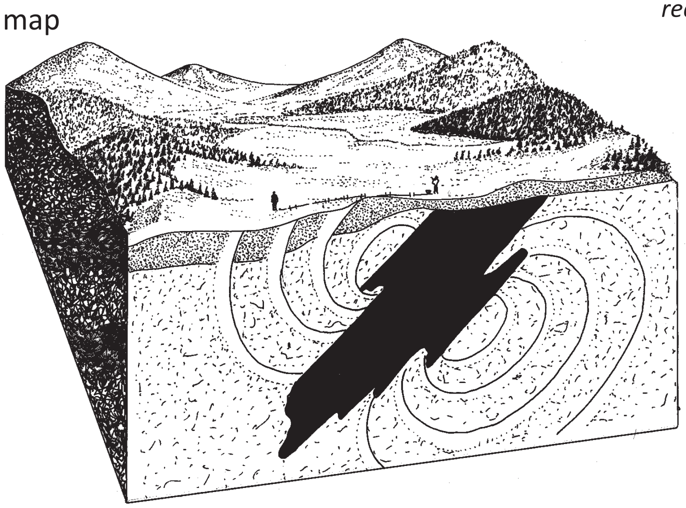
The gravity that holds you to your chair is often thought to be the same anywhere on the earth. This is not true. Gravity changes depending on the density of the rock beneath you. You could not detect this difference yourself but sensitive machines can. Often, rock with a higher specific gravity can contain valuable ores, so geologists will map out the gravimetric numbers and use that to try to predict where ore may be found.



The darker orebody causes a higher gravity reading due to its higher density compared to the surrounding rock.

Self-Potential

Ground water can act on the metals in a deposit to produce a weak electric charge (just like a weak but huge battery). Measuring the voltages at the surface may show a significant change when mineralization is present beneath the surface.

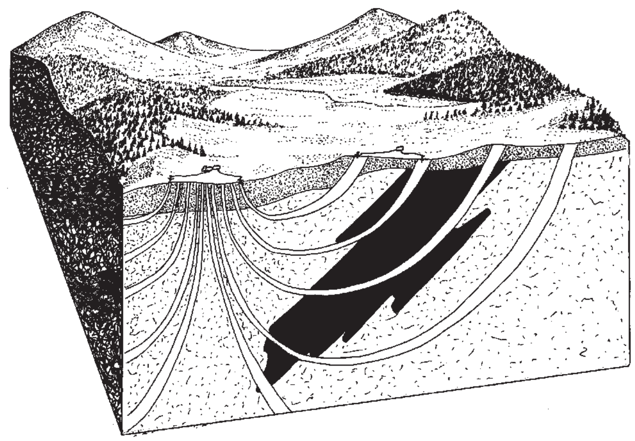


The orebody generates a current through the surrounding rocks. This current can be detected at the surface.

Reading

Induced Polarization:

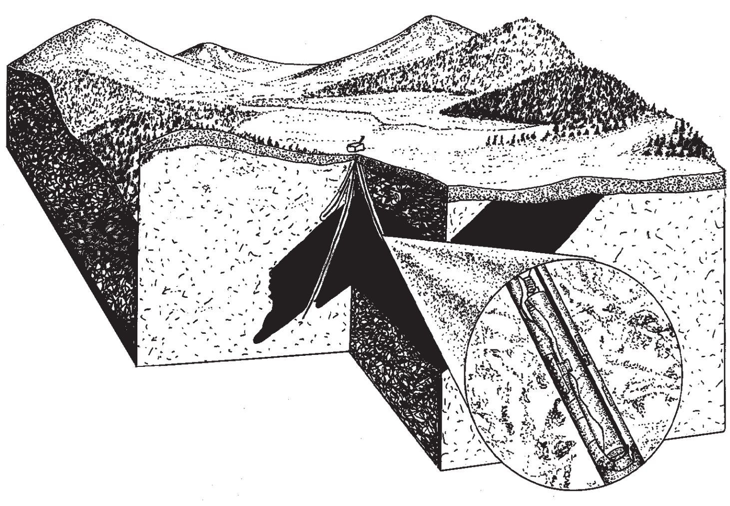
A field of electricity can be created in the ground by passing a measured amount of electric current through it, using two electrodes and a generator. By measuring the voltage caused by this field with a second pair of electrodes, a given distance away, the geophysicist can calculate the electrical property of the ground, which is known as the **resistivity**. If even small amounts of metallic minerals are present, the ground can also become charged by the electric field, producing **induced polarization** (ref. *The Mine Development Process* – Placer Dome Inc. page 21).



The ground is electrified by two electrodes placed a distance apart. The current flows through the ore body, which holds the charge for a brief time.

Exploratory Drilling:

The final proof of mineralization – short of actual mining – is drilling. This illustration shows a diamond drill which, from a single surface location, can penetrate geological formations in a pyramid pattern. Cylinders of rock, called **drill cores**, are sampled from depths which would otherwise be inaccessible. A series of such cores, taken at set intervals over a known anomaly, are then analyzed for mineral content. The all-important grade (ratio of recoverable metal to waste rock) is established primarily through this exercise (ref. *The Mine Development Process* – Placer Dome Inc. page 20).



From a single drill site core is drilled in several different directions, to see whether minerals are present. The drills bring up core which are cylinders of rock that can be analyzed.

Note: A core sample is provided in the Science of Mining experiment materials package.

Reading

What to do now that you know there is ore in the ground.

Note: Ore is rock that can be profitably mined while "Waste" rock cannot be.
If you know where an economic ore body is located in the ground, the next stage is to remove it. In some situations the only way to get the ore out is to dig tunnels underground and follow the rich ore veins in the earth. Most mines in BC today, though, are open pit. This means that a big pit will be dug and the ore rock will be transported to the mill for processing. The waste rock will go into big piles called waste dumps. The first step in this process is:

Blasting

Honk! Honk! Honk! The horn sends out the warning sound. Soon after, the ground trembles as the thunderous roar of the blast signifies the crumbling of the rock face.

Production blast in an open pit. Blasters complete certificate courses in underground and surface blasting, which stress electrical circuits, rock mechanics and explosive chemistry. Do you have what it takes?

Now the loose chunks of ore can be removed, transported and crushed. Despite careful surveying, each load of ore will contain some waste rock. For the sake of money, time and energy, it is preferable to remove as much of the waste rock as possible before milling. In the next activity you will discover one method that miners use to avoid processing waste rock.

Activity # 2a: Density Separation (Floating Rocks)

Problem: How to separate waste rock from ore before the milling process begins.

As you may already know, to separate substances from one another you need to look for a difference in their properties. In some mines there is a distinct difference in the density between waste rock and ore minerals. Let's see how differences in density can be utilized to separate materials.

Apparatus:

50 ml mixed rock sample provided
600 ml beaker (or larger)
30 cm x 15 cm cardboard
Centigram balance
25 ml graduated cylinder
Hand lens
Saturated sodium chloride solution

Procedure:

1. **Observe the mixed rock sample provided. You should identify two distinctly different** types of rock. Carefully pour some of your rock sample onto the cardboard provided. Observe each type of rock with the hand lens. Quickly sketch each type and record their properties. Your teacher may want you to calculate the density of each. To do so, calculate the mass of a rock sample with a centigram balance and divide it by the volume of that sample. To determine the volume, place the sample in a graduated cylinder that already has water in it and find out how much the water rises (the rise in the water equals the volume of the rock).

   *** Note: One of the rock samples crushes easily. Be sure not to break it up.**

2. Fill a 600 ml beaker to the 400 ml level with saturated sodium chloride (NaCl) solution. Carefully lift the cardboard to the edge of the beaker and slowly pour some of the rock into the beaker. While pouring, be sure to observe what each rock type is doing as it enters the liquid. Record your observations.

3. Pour the rest of your sample into the beaker this way until the separation is complete. Then skim off the floating rock. Rinse it with water then set it on a paper towel to dry.

4. Decant (carefully pour) the liquid off the rock that sank. Remove the rock from the beaker, rinse it and allow it to dry on a paper towel.

5. Once again, use your hand lens to observe the separated samples of rock. Record your observations as to the success of the rock separation.

6. Gently pat the rocks dry with paper towelling and re–mix the rocks back into their original container. Clean up the rest of your apparatus.

Questions:

1. What property was used to separate the rocks from one another?

2. How would the density of the rock that floated compare to the density of the saturated sodium chloride solution? How would the density of the rock that sank compare to the density of the saturated sodium chloride (NaCl) solution?

3. As an engineer at a mine you are responsible to separate waste rock from ore before the milling process. The waste rock has a density of 4 g/ml and the ore has a density of 3 g/ml.
Suggest how you could separate the two and sketch the procedure.

The Sullivan Mine

At the Sullivan Mine in Kimberley, BC, density separation was used to remove waste rock from ore before the milling process. The density of the ore mineral (which is mainly galena, a lead ore) is approximately 7.6 g/ml. The waste rock had a density of about 2.4 g/ml. Upon entering the mill, the crushed mixed rock was passed through a watery galena slurry (soup) that has a density of 3.0 g/ml. As a result, the waste rock floated while the desired ore minerals sank. The waste rock was removed by skimmers, then cleaned and returned to the environment by spreading it out over the tailings pond and covering it with soil. Meanwhile, the ore continued through the milling process. At Sullivan Mine about 30% of the original mixed rock was waste. Eliminating the waste from the milling process results in great savings in time, money and effort.

Questions

Review Questions

1. **Locating orebodies is a major expense in mining. Why is this so?**

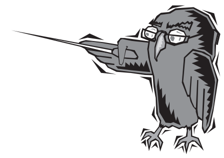
2. **List several clues that could assist a geologist in locating an orebody.**

3. **How do you think mining exploration has changed over the past 100 years?**

4. **What role does density separation play in the Sullivan mine?**

5. **Why is the separation of waste rock before milling so important?**

Teacher Information



Mining 3: Let's Concentrate

Teacher Plan:

- 5 minutes: Review questions on "Only Ore" (page 8 of Mining 2);
- 10 minutes: Students to read about milling "From Rock to Concentrate. The Job of the Mill" (pages 2-4) and prepare for Activity #3a;
- Complete "Mineral Bubble Bath"(Activity # 3a).

Notes:

Flotation is the key process in separating target metal minerals from other minerals. Activity #3a is a messy but extremely fun and interesting activity for the students. This lesson could be used in the Science Grade 8 Unit on "Matter", in the section dealing with separating substances in a mixture.

Remember during Activity #3a to be sure that:

- students blowing into the tubing are wearing eye goggles;
- students do not blow too hard;
- tubing is sterilized, or snipped off, before storage;
- air stones are blown clear before storage;
- molybdenum powder is mixed with an equal amount of sand.

Upon completing these activities the student will be able to:

1) Understand how molybdenum powder and sand can be separated, and why.
2) Describe the process of separating mineral from waste rock in a mine.

Photocopy:

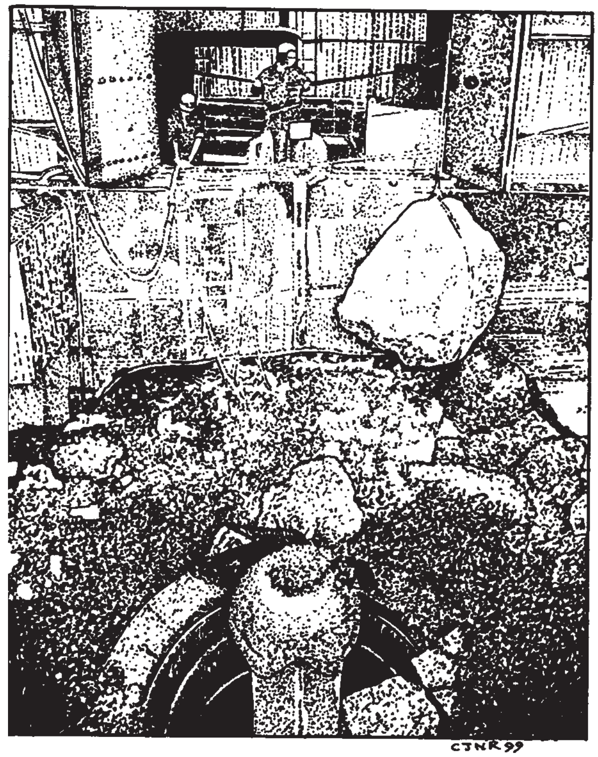
- Pages: 2-6.

Reading

From Rock to Concentrate: The Job of the Mill

A person visiting a concentrator at a minesite is immediately impressed by the baffling array of tanks, pipes, pumps, solutions, conveyors and noises. Rotating mills grinding ore; frothy bubbling slurries of liquids; and huge drying machines add to the mysteriousness of the milling process. This seeming confusion is actually a carefully designed system with one unifying purpose — the recovery of valuable mineral concentrate from the ore supply.

Most base metal mines in B.C. currently use a wet flotation system to concentrate the valuable metal minerals desired. However, before flotation can occur, the ore must be ground up. Huge jaw crushers shatter the ore and spinning ball mills tumble it into a fine powder. The powdered ore is then combined with water to form a pulpy slurry .



Crusher and mill

Rod and ball mills within the concentrator facility of Gibraltar Mine, where fine ore is ground further before being passes on the flotation unit.

The Rod and Ball Mill

Rocks coming from the mine into the mill are large and may contain only a small amount of the desired minerals. The minerals must somehow be extracted from the rock. The only way to do this is to smash the rocks into a fine powder. This is the job of the **Ball Mill**. Huge drums made of metal turn around and around like the inside of a clothes dryer. But imagine that in your dryer, along with your clothes, some 10 kg steel balls are spinning. It wouldn't be long before your clothes became a ragged mess! Well, in the drums at the mill, this is exactly what they

Reading

do to the ore. Cannonball sized steel balls are added to large turning drums that contain ore rock. The steel balls drop on the ore-bearing rock as the big drum turns. The balls break up the rock to a fine powder. That is the job of the Ball Mills.

Flotation Tanks

Once the ore-bearing rock has been crushed in the ball mill and mixed with water, it is in a form that looks like thick muddy water. This "slurry" contains about 50% solids. The rock and ore are now a fine powder. The next task is to separate the grains of **Ore Minerals** from the grains of **Waste**. This is done by a process of **Flotation Separation**. You will be doing an activity that will show you how this process works.

Flotation tank in action

In this process, bubbles pass through the slurry of crushed rock and minerals.

The bubbles attach to the minerals but not to the waste rock, because of the difference in chemistry between the minerals and the waste rock. So, bubbles of air rise to the surface of the water with shiny minerals attached to them. The waste rock on the other hand sinks to the bottom of the tank where it can be removed and pumped to tailings ponds.

Ship at Vancouver Wharves in North Vancouver takes on copper concentrate destined for Japan.

Questions

Drying

The base metal minerals removed by flotation are dried by machines into a lumpy powder called a **concentrate**. The concentrate is then ready for the next phase of the mining process, referred to as **smelting**. Although two smelting operations exist in BC, some concentrates (such as copper) are shipped to Japan.

Review Questions:

1. What is the main objective of milling ore rock?

2. What must be done to the ore before it is ready for the flotation process?

3. Why do you think mill sites are usually located right at the mine instead of nearer to the smelter?

Activity #3a: Mineral Bubble Bath

Introduction:

Now that a solids slurry has been created, it is necessary to concentrate the metal bearing minerals by removing them, while leaving waste materials behind. The activity below will help demonstrate how flotation separates valuable minerals from waste in the ore slurry.

Problem: To remove valuable base metal compound from a pulpy ore slurry.

Apparatus:

Molybdenite ore and sand mix
2 eye droppers
100 ml graduated cylinder
Frothing agent (dish soap)
Scoopula
Filter paper
Hand lens
50 cm tygon tubing
Air stone (aquarium)
Spill pan or trough
Goggles

Procedure:

1. Observe the sample of molybdenite mix provided through a hand lens. Record your observations.

2. Use a scoopula to measure 15 ml of the mix into the 100 ml graduated cylinder.

3. Add enough water to the cylinder to fill it to the 40 ml mark. Gently shake the contents to mix them. Record the appearance of the contents.

4. Put on eye goggles. Place the graduated cylinder into the spill pan. Insert the air stone into the tygon tubing provided. Then lower the airstone into the bottom of the graduated cylinder. Blow through the tygon tubing to create a steady stream of small bubbles. Do not blow too hard! Record the results of your actions.

5. Carefully add 1 drop of frothing reagent. Try blowing again. If bubbling occurs let it rise to the top of the graduated cylinder and spill over into the

spill pan. Record what effect the frothing reagent had on the mixture. Carefully describe the appearance of any of the mixture that made it into the spill pan.

6. Carefully filter out some of the materials left in the graduated cylinder. Then filter out the contents of the spill pan. Blot each sample dry and observe them with a hand lens. Make notes on the similarities and differences between the two samples.

7. Follow teacher instructions for cleaning up the equipment.

Questions:

1. What is the role of the frothing agent in flotation separation?

2. What was the material that seemed to be stuck to the surface of the bubbles? Where did it come from?

3. What do you think happens to the molybdenum material after it has been floated in the mill?

4. What do you think happens to the material that stays in the bottom of the flotation tanks?

Additional Information:

This process is similar to the one used in mills to purify and separate the ore material. In a copper mill, two flotation tank systems are used if the ore contains copper minerals and molybdenum: one for concentrating the copper; and one for the molybdenum. The process in the lab works because molybdenum is attracted to the air bubbles. The sand in the mixture is not attracted to the bubbles. Thus the molybdenum is lifted to the top and the sand stays on the bottom. The frothing agent makes the bubbles last so that the mineral can be skimmed off. The result is a metal bubble bath! This flotation process is not unlike the work of soap detergent on dirt particles on clothes in the washing machine.

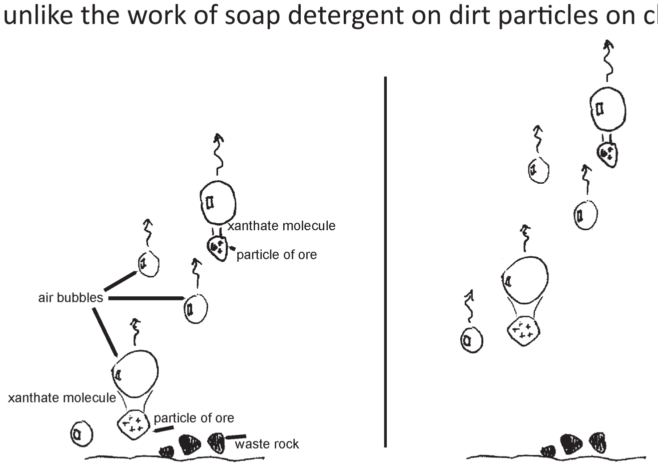
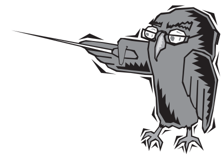


Figure A
Air bubbles attach to the mineral (ore) particles through two mechanisms:

- *Physically, like peanut butter to your hand - "physical adsorption";*
- *Chemically, like a balloon rubbed on your head attaching to a wall - "chemical adsorption".*

The waste stays down.
Xanthate is a frothing agent used in industry with copper concentrates, but not with molybdenum.

Teacher Information



Mining 4: Purification

Teacher Plan:

- 5 minute: "Review Questions" on milling (page 4 of Mining 3);
- 10 minutes: Orally read through "Smelting" (page 2);
- Remainder of lab: "Electrifying Metal" (Activity # 4a);
- Post-lab reading and questions for homework (pages 7-9).

Notes:

This topic is above the level of Grade 8's. It can still be used in the Grade 10 section on "Electrochemistry" on it's own.

Upon completing these activities the student will be able to:

1) Explain the processes of mineral purification.
2) Compare and contrast smelting and electrorefining.
3) Electroplate copper onto an aluminum sheet.

Photocopy:

- Pages: 5-9.

Reading

Smelting

The ore concentrate that comes from most mine sites is primarily a metal sulphide compound that is made up of 30 –70% metal, in combination with sulphur.

Eqn: galena (PbS) = Pb + S
(metal sulphide) (metal) (sulphur)

$$\underset{\text{(metal sulphide)}}{\text{galena (PbS)}} = \underset{\text{(metal)}}{Pb} + \underset{\text{(sulphur)}}{S}$$

The next step in the mining process is to get rid of the sulphur so as to be left with pure metal. This process is usually done by heating the concentrate and is referred to as smelting. Each type of metal sulphide is different. Thus, the smelting processes must be custom designed for each situation. In general terms, smelting involves combining the metal sulphides with oxygen in huge, hot, furnaces. The sulphur reacts with the oxygen to create sulphur dioxide gas while the relatively pure metal remains behind as a solid.

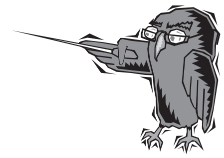
Eqn:

$$\underset{\text{(metal sulphide)}}{PbS} + \underset{\text{(oxygen)}}{O_2} \longrightarrow \underset{\text{(metal)}}{Pb} + \underset{\text{(sulphur dioxide)}}{SO_2}$$

Two huge smelting operations exist in BC. At Trail, the Cominco smelter processes mostly lead and zinc concentrates, which it receives from BC mines, as well as from mines in other parts of the world. The Cominco smelter also recovers other valuable metals in lower quantities. Alcan in Kitimat smelts and refines aluminum concentrate imported from other countries. Aluminum concentrate is an oxide, not a sulphide, and aluminum is recovered by means of an electrolytic process. The smelting of BC copper concentrate is generally done in Japan.

In earlier years, smelters belched the waste sulphur dioxide gas into the atmosphere where it combined with water to produce acid rain. As a result, many smelter sites became environmental waste lands. Today, sulphur dioxide emissions are tightly controlled and monitored by both the mine and the provincial government. At Trail, 95% of the sulphur is being captured for use in chemical fertilizers and for the production of sulphuric acid. The environment around smelters has improved dramatically and now support a wide abundance of life!

Teacher Information



Electrolysis

Electrolysis in mining is usually referred to as electrorefining. In Activity #4a the students or you, the teacher, will be plating an aluminum sheet with copper. The following notes will help to improve the quality of the plating process.

It is possible to obtain a visibly pure electrolytic deposition of copper using a "C" or "D" size dry cell if the cathode surface is quite large. Thus, we have chosen to use a 100 sq. cm. piece of aluminum. You have been provided with aluminum sheeting. Copper pieces are packaged with the materials for the poster activity in Mining Lesson 6 ("Review of Mining Science"). Each sheet can be cut into two electrodes by using the diagram on (page 4). If you want to use a smaller size cathode, such as an aluminum strip, you need to include a variable resistor in your circuit so that the current flow is about 2 milliamperes per sq. cm. of cathode.

The nitric acid in the acid solution helps to reduce bubbling at the cathode. The reaction is

$$NO_3^- + 10H^- \text{ —— } NH_4^+ + 3H_2O$$

Stirring is beneficial, especially at higher currents.

Cathodes have to be grease free. Wash with a solvent if needed.

The anode may darken due to oxidation.

A weighable amount of copper may be deposited in about 30 minutes using the large electrode. The small sized cathodes would require several hours. If left overnight, it is possible that the batteries would discharge and the electroplate could be dissolved by the acid.

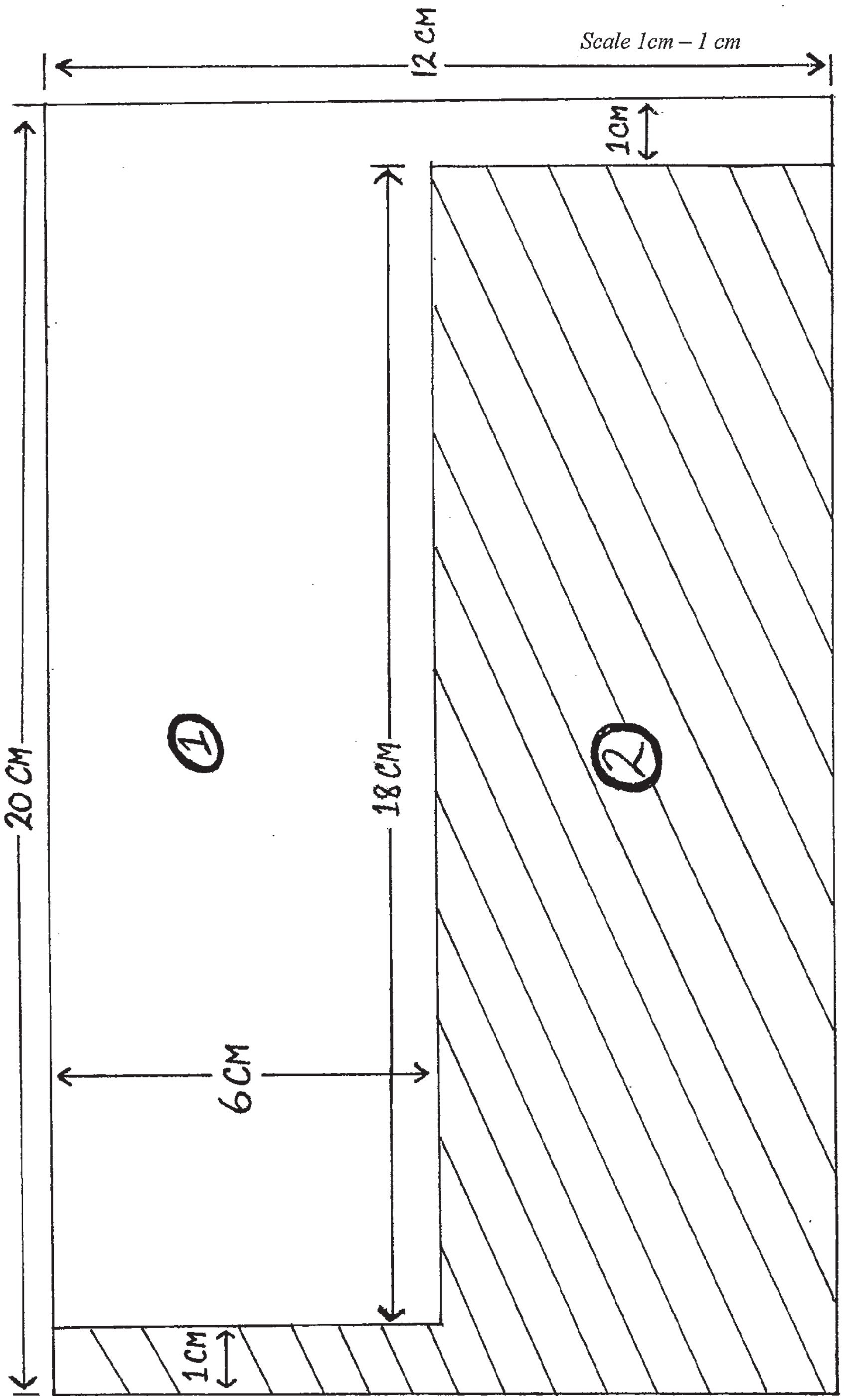
A calculation using Faraday's law could be incorporated into the unit. A summary of Faraday's Law is: One gram equivalent weight (31.77 gm/mole(e–) for copper) will be deposited by 96,500 coulombs. A coulomb is one amp of electricity per second. A student could be asked how much copper would be deposited in 30 minutes at a current flow of 500 milliamperes. The result is:

$$\frac{30 \text{ min} \times 60 \text{ sec/min} \times 31.77 \text{ gm/mole(e–)} \times 0.5 \text{ coulombs/sec}}{96{,}500 \text{ coulombs/mole(e–)}} = 0.30 \text{ gm}$$

Teacher Information

Making Aluminum Electrodes for Activity #4a

Scale 1cm – 1 cm



Activity #4a: Electrifying Metal!

Introduction:

The smelting process often results in base metals that are well over 99% pure. That is not good enough! The manufacturers that require metal for their operations need a purity of 99.9% or higher. To achieve such pure products, the smelted metal (often called blister metal) requires further purification in the refinery. The activity below will allow you to see how electricity is used to purify (refine) blister metals. This process is called **Refining.**

Problem: To use electrolysis to remove the impurities from smelted copper metal to obtain a higher level of purity.

Apparatus:

Fine steel wool
Two wires
1.25 volt battery
Methanol
Acid solution (1.0M H_2SO_4 & 0.05M HNO_3)
Copper electrode (small)
Aluminum electrode (large)
Stirring rod
400ml beaker

Procedure:

1. Use the fine steel wool to thoroughly clean the metal electrodes. Be sure to touch only the edges of the electrodes after they have been cleaned. Observe and record the properties of the materials.

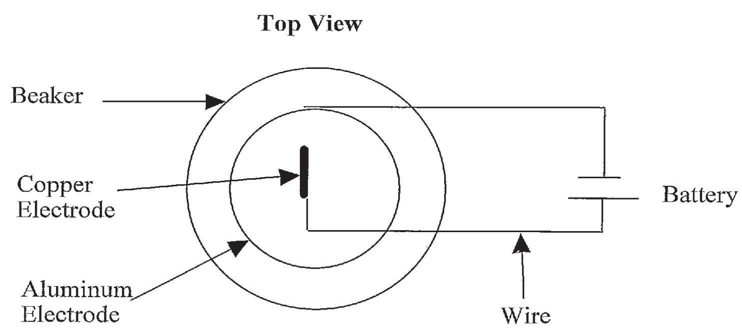
2. Take the cylindrically shaped aluminum electrode and ensure that it easily fits into the beaker. Then remove the electrode.

3. Put on safety goggles. Add enough acid solution to the electrolysis beaker to measure to the 250ml mark (always be careful when using acids!).

4. Carefully place the aluminum electrode into the beaker. Use a wire to attach the negative end of the battery to the protrusion on the aluminum electrode.

5. Use a wire to attach the positive end of the battery to the copper electrode. Carefully suspend the copper electrode into the middle of the acid solution as shown in Figure A. Be sure to keep the electrodes from touching one another.

FIGURE A



6. Allow the electrolysis to take place for 15 minutes. Record all the observations you can during this time.

7. Carefully remove the electrodes from the electrolysis beaker. Dip the electrode one at a time into the methanol beaker your teacher has set up for you. Allow your electrodes to dry while you clean up the electrolysis apparatus following your teacher's instructions.

8. Carefully examine each electrode and record its appearance. Follow your teachers directions for the proper cleanup of the materials.

Questions:

1. Where did the copper that plated onto the aluminum electrode come from?

2. How would you expect the mass of the copper electrode to change as the electrolysis continued?

3. How would you expect the mass of the aluminum electrode to change as the electrolysis continued?

4. Explain what you think is happening during the electrolysis that allows for the purification of copper.

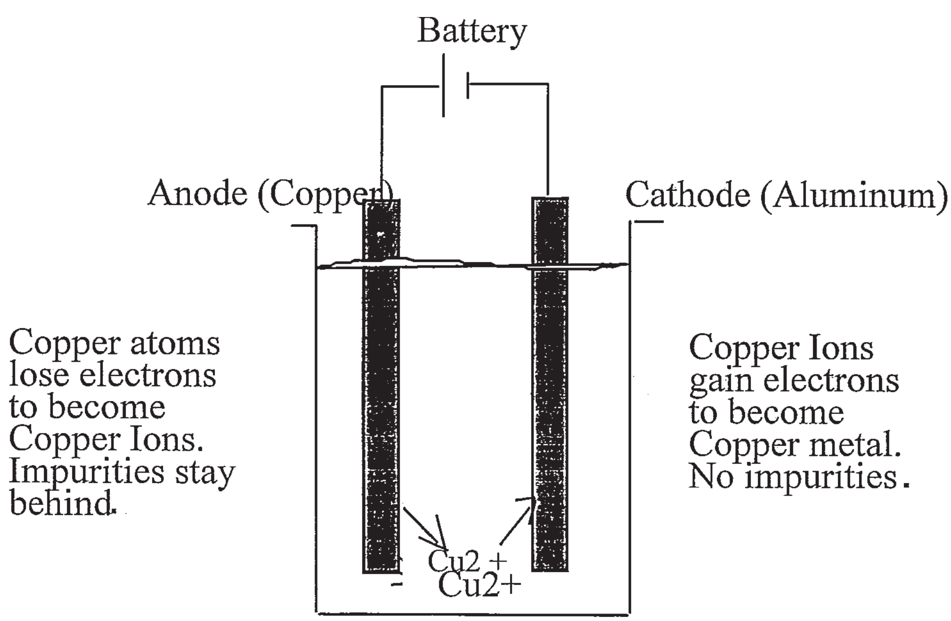
Reading

Anodization Explained

The secret to purification by electrolysis (in this case anodization) lies in the attraction of copper ions in solution to the electrons made available by the negative terminal of the battery. At the negative terminal (also called the cathode) there is an excess of electrons which carry a negative charge. The dissolved copper ions in the solution carry a positive charge. Thus, they are attracted to the negative terminal where they receive electrons, to form pure copper metal.

At the same time, the positive terminal of the battery is releasing electrons from the copper contained in the copper electrode at the positive terminal (also called the anode). This process causes the copper to form positive copper ions in the solution which take the place of the ions being removed at the negative terminal. The net result is the removal of copper from the copper electrode, and the depositing of that copper at the negative terminal (fig. B).

FIGURE B



In our lab example we used an aluminum electrode so that you could see the plating results easily. In the normal refining of copper the impure blister copper would be the anode and a pure copper sheet would be the cathode. Through electrolysis, only the pure copper would be removed from the blister sample and plated onto the cathode. Meanwhile, the impurities would fall away into the solution. It should be noted that often the so called "impurities" can be gold

Reading

or silver. If this is the case, a great deal of extra profit can be made from the impurities. These impurities fall to the bottom of the tank below the piece of blister copper, and can be reclaimed.

At Gibraltar Mine near Williams Lake, BC copper in oxide minerals is leached in an acidic solution and plated onto aluminum sheets in the on-site SX-EW plant (not inoperation in 2009). .

Observe carefully the picture and diagram of the electrolysis of lead in the Cominco refinery. You may be able to see the thin layers of pure lead cathodes and the thicker layers of blister lead anodes. Electrorefining proceeds 24 hours a day, 365 day a year at Cominco in order to meet world demands.

Cominco's zinc operation is somewhat different. Instead of being smelted into blister form, zinc goes through a wet chemical leaching process that helps to avoid the production of environmentally harmful sulphurous gases. The end result of this process is a zinc sulphate solution which is then refined using an electric anode and a thin aluminum cathode. The zinc ions are attracted to the aluminum cathode during electrolysis where they form a pure zinc coating. Periodically, these cathodes are removed and the pure zinc is stripped off. The pure zinc is then melted into bars for transport to the manufacturers of zinc products. Zinc has a variety of uses from the protection of metal parts, to the formation of beautiful cosmetic products (see zinc pamphlet).

Extractive metallurgy is the science of producing pure metal from ores or concentrates. The split between mineral processing, which deals with the production of concentrates, and extractive metallurgy is commonly accepted as the point at which the original mineral undergoes a chemical change.

The two general categories which encompass extractive metallurgy are hydrometallurgy and pyrometallurgy. **Hydrometallurgy** involves leaching: the mineral is dissolved in a solvent to allow separation of the components. **Pyrometallurgy** is a high temperature process in which all materials are converted to the molten form prior to separation.

Extractive metallurgists use their knowledge of chemistry and physics in the design and operation of metallurgical facilities. They may be involved in plant operations, research aimed at developing advanced technology, education or consulting.

Reading and Questions

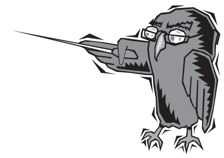
Questions:

1. What is the main material removed from metal concentrates in the smelting process and what is done with that material?

2. Use a diagram to show how the electrolysis of silver might occur.

3. Why is it sometimes important to keep the impurities left behind from the electrorefining of copper?

Teacher Information



Mining 5: Careers

Teacher Plan:

- See Lesson Outline on page 4.

Notes:

Photocopied materials are not necessary for this lesson;

The video *"Careers in the Minerals Industry"* is very good and you may want to show it twice in order to allow the students to see all the careers in it;

Material presented here is not intended to be prescriptive and may be adapted to suit the circumstances.

Thanks:

This lesson is adapted from the *"Careers in the Minerals Industry"* Unit. This unit was developed for CAPP 10. If additional activities are desired, the complete unit may be downloaded from the MineralsEd Web site: www.MineralsEd.ca/s/CareerEducators.asp.

Video and *"Careers in the Minerals Industry"* Unit written by:
Dave Meronuk and
Phil Wright

Introduction

*"**Careers in the Minerals Industry**"* is formatted to approximately follow the four stages of the life of a mine: Exploration, Extraction, Processing and Reclamation. The video also provides information relating to corporate head office activities, as well as information on the supply and services sector.

Exploration:

Through the use of satellites and computer technology, searching for minerals has become a very sophisticated process. But, as you will see, field geologists, drillers, assayers and the like still play major roles in the discovery of viable mineral deposits.

Extraction:

Once the very complicated permitting process has been completed (which includes the submission of a complete reclamation plan) and government approval is received, mining can begin. The big machines move in, the ore is dug up and sent to the mill for processing and reclamation procedures are initiated. Mines have to be efficient to be economical, and the large variety of employees in this field have to be highly-skilled and well-trained. Today's market is global and extremely competitive.

Processing:

Once again, efficiency is the key. As the ore reaches the mill, it must be ground, mixed with chemicals and water, and then processed into concentrate. The concentrate is sent to smelters for further refining. As before, well-trained employees are required. Mines are involved in on-going research to develop faster, more cost-effective, methods of processing.

Reclamation:

At all stages of mining a reclamation plan must be in place and observed. Bonds are posted with government agencies to insure that reclamation and monitoring of the environment will continue long after the mine has closed.

Suppliers, contractors and consultants are involved in providing a variety of material, equipment, services and expertise vital to a mining operation. It is estimated that for every job on the mine site, there are three required in the support industries.

This video only scratches the surface of the career opportunities in the minerals industry. Please feel free to use the enclosed information, materials and activities to further your exploration.

Teacher Information

Order of Activities as seen in the Video: "Careers in the Minerals Industry".

Mining - Exploration, Extraction, Processing, Reclamation

- Certified Blaster
- Mining Engineer
- Exploration Geologist
- Mine Geologist
- Helicopter Pilot
- Assayer
- Technologists
- Haul Truck Drivers
- Surveyor
- Computer Programmer and Operator
- Computer Analysts
- Mine Workers:
  - Equipment Operators
  - Surveyors
  - Drillers
  - Mine Engineers
  - Mechanics
  - Welders
  - Electricians
- Environmental Engineers
- Construction Workers:
  - Carpenters
  - Electricians
  - Steel Workers
  - Plumbers
- Safety Supervisors
- Purchasing Agents and Warehouse Personnel
- Managers, Superintendents, Foremen
- Mineral Processing Engineers
- Human Resources/Personnel Superintendents
- Marketing Specialists
- Communications Specialists
- Clerical Staff

Mining - Suppliers, Contractors and Consultants

- Caterers
- Cooks
- Contractors
- Accountants
- Consultants
- Financial Analysts
- Stock Brokers
- Clerical Staff
- Transportation Workers:
  - Truck Drivers
  - Boat Captains
  - Train Engineers
  - Pilots

Teacher Information

Possibilities for activities related to the video will depend upon the individual teacher's assessment of student needs, as well as the availability of career information and resources within the school.

Lesson Outline

The following activity may be done with students in groups, or in the format of an open class discussion. It is written as a group activity.

1. Within the groups, have students brainstorm with the purpose of generating a list of career opportunities that they think exist in **Minerals and Related Industries**. You may wish to reward the group that compiles the longest list.

2. Show the video *"**Careers in the Minerals Industry**"*. While the film is underway, have the students checking off those activities that they have on their lists as well as adding new careers that they did not have listed originally (it may be necessary to run the film twice. It is 13.30 min. in length.)

3. At the end of the video, allow each group time to update their individual lists. A designate from each group could read their list aloud, to be recorded on the board or overhead.

4. From the total class list, individuals within the groups would choose three to five careers that might be of interest to them. They would then divide a page in three, listing: the career in one column; long and short term benefits in another; and drawbacks of the job in the third. This would be an unresearched activity and would require discussion and sharing within the groups.

5. Within the teacher's own time frame and objectives, the completed assignment may be handed in the following day and may be marked.

Teacher Information

Detailed List of Careers in the Mining Industry

Exploration

- Geologist
- Mining Engineer
- Mining Technologist
- Geophysical Consultant
- Metallurgical Engineer
- Surveyors & Assistant
- Prospector
- Accountant
- Mechanic
- Expediter
- Heavy Equipment Operator
- Drill Machine Operator
- Blaster
- Diamond Driller
- Cook
- Camp Manager
- Legal Advisor

Development of the Ore Body

- Engineers:
  - Mining
  - Mineral Process
  - Metallurgical
  - Mechanical
  - Civil
  - Electrical
  - Geological
- Economist
- Environmental Specialist
- Environment Technologist
- Mining Consultant
- Government Regulator

Milling & Mineral Processes

- Lab Chemist
- Mineral Processing Engineer
- Industrial Engineer
- **Crushing, Grinding, Flotation Operators**
- **Instrument Specialist**

Reclamation/ Environment

- Physical Science Technologist
- Forester
- Agricultural Technologist
- Labourer
- Biologist
- Fish & Wildlife Specialist
- Environmental Consultant

Mine Workers

- Financial Officer
- Purchasing Agent
- Miner
- Truck Driver
- Instrument Technician
- Geologist
- Heavy Equipment Operator
- Personnel Officer
- Mining Engineer
- Computer Programmer
- Surveyor
- Office Support Staff
- Accountant
- Mine Inspector
- Safety Personnel
- Industrial Hygienist

Tradesmen

- Electrician
- Welder
- **Mechanic**
- **Machinist**
- **Carpenter**

Communicators

- Desktop Publisher
- Public Speaker
- Writer/Photographer
- Graphics Expert
- Media Consultant
- Commercial Artist/Printer

Commodity Sales & Transportation

- Sales & Marketing Representative
- Economist
- Administrator
- Clerical Staff
- Transportation Expert
- Commodity Expert
- Financial Expert

Teacher Information

Average Weekly Wages & Salaries in the Canadian Minerals Industry

	2010
Metal Mines	$1,537.00
Coal Mines	$1,428.00
Nonmetal Mines	$1,311.00
Smelting and Refining	$1,349.00
Average Wage	$1,406.00

The information in the table was obtained from *Mining in Canada - Facts & Figures,* 2010.

The average annual salary and benefits per minerals industry employee in BC for 2011 was $115,700. This figure is taken from the PriceWaterhouseCoopers *The Mining Industry in British Columbia 2011 Report* (*See* http://www.pwc.com/ca/en/mining) This publication is produced annually each May.

The mining industry in BC employed around 45,703 people; 21,112 directly and 16,590 indirectly and an estimated 8,000 induced jobs. The industry has become the safest heavy industry in the province. (From Mining Association of BC, 2010, www.mining.bc.ca)

FOR ADDITIONAL STATISTICAL INFORMATION RELATED TO EARNINGS CONTACT:

BC STATS
Province of British Columbia
Ministry of Finance and Corporate Relations
“Earnings and Employment Trends” Contact: Data Services (250) 387-0327

THE MINING ASSOCIATION OF CANADA
Suite 1105, 350 Sparks Street
Ottawa, Ontario K1R 7S8
“Mining In Canada - Facts & Figures” http://www.mining.ca/

APPLIED SCIENCE TECHNOLOGISTS & TECHNICIANS OF BC (ASTTBC)
10767 -148th Street
Surrey, BC V3R 0S4 http://www.asttbc.org/

THE ASSOCIATION OF PROFESSIONAL ENGINEERS & GEOSCIENTISTS
Suite 200-4010 Regent Street
Burnaby, BC V5C 6N2 http://www.apeg.bc.ca/index.html

Teacher Information

Mining 6: Review of Mining Science

Teacher Plan:

- "Summary Activity" (Activity #6);
- 15 minutes: "Summary Questions" (page 4);
- Highland Valley video (optional).

Notes:

This cooperative summary lesson gets students to demonstrate their understanding of mining. It is visual, therefore it can make a great display for the classroom. This activity could easily be used for evaluating the students' understanding of the unit.

Upon completing these activities the student will be able to:
1) Recall the main steps involved in the mining process.

Photocopy:

- Pages 3 and 4 for student use.

mineralsed
Mineral Resources Education Program of BC

Activity #6a: Summary Activity

Materials needed per group:

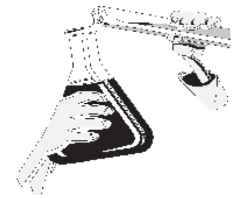
- Stiff poster paper
- Baggie of copper concentrate
- Baggie of chalcopyrite
- 4 colours of felt pen
- Baggie of blister copper
- Baggie of copper wire

Place students into homogeneous groups of 3 or 4. Give each group the materials provided. Ask the students to fix the baggies onto the poster paper in a sequence that shows the mining process and connect the baggies with arrows. In one colour of pen, the students should name the places where each step in the process is occurring. In another colour, the students should briefly explain what is occurring at each step along the way. In a third colour the students indicate environmental concerns related to each step along the way. You may also want the students to indicate how each concern is being dealt with.

Sample Poster (Student poster would have more detail!)

What Goes On at a Mine

	Removing the Ore	The Mill	The Smelter	The Refinery
Product	Chalcopyrite	Concentrate	Blister Copper	Pure Copper
	 →	 →	 →	
Process	Drilling, surveying Blasting, hauling	Crushing, flotation,	High heat sulphur concentrating	Electrolysis removal
Environmental Concerns	Reclamation, Acid Rock Drainage	Tailings, water quality	Sulphur gas slag removal	
Environmental Remedies	Reseeding waste rock	Water treatment, water recycling	Gas scrubbers to remove sulphur	



Activity #6a: Summary Activity

Materials needed per group:

Stiff poster paper
Baggie of copper concentrate
Baggie of chalcopyrite
4 colours of felt pen
Baggie of blister copper
Baggie of copper wire

You will be assigned to a group of 3 or 4 students. Each group will be given the materials listed above. Your task is to fix the baggies sample into the poster paper in the sequence in which they occur in the mining and mineral processing industry. Then use the felt pens to identify on the poster paper:

a) The name of each production site (i.e.: mine, smelter, mill, etc.)
b) The types of activities that occur at each site.
c) The environmental concerns related to each site.
d) The way these concerns are being dealt with by mining companies.

*Use a different colour felt for each of a, b, c, and d – be sure to include as much detail as you can.

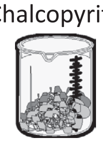
Sample Poster

What Goes On at a Mine

Removing the Ore **The Mill** **The Smelter** **The Refinery**

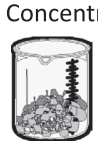
Product

Chalcopyrite



→

Copper Concentrate

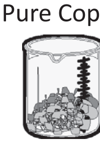


→

Blister Copper

→

Pure Copper



Process

comments

comments

comments
comments

comments
comments

Environmental Concerns

comments

comments

comments
comments

Environmental Remedies

comments

comments

comments

SUMMARY QUESTIONS

1. A new mine is being proposed for North West B.C. Do you have any concerns? If so, what are they? If not, why not?

____

____

____

2. Has your attitude about mining changed at all from two weeks ago? If so, how? If not, why not?

____

____

____

3. What did you find most interesting about the mining process? Why did you find this part interesting?

____

____

____

4. What careers are highlighted in this unit? Would they interest you? Which one and why? If not, why not?

____

____

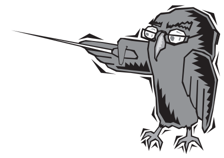
____

Teacher Information

Rocks and Minerals 1: Metals from Stone

Please Note: Use <u>Mining 1: Metals from Stone</u> for Rocks and Minerals 1

Teacher Information



Rocks and Minerals 2:

Erosion and Placer Deposits

Teacher Plan:

- 15 minutes: Oral reading of "Main methods of Weathering" (pages 2-3);
- 45 minutes: "Stream Erosion" (Activity #2a);
- 30 minutes: "Panning for Sediments" (Activity #2b).

Notes:

Students will have a chance to learn about the processes of erosion and weathering. The two activities take the students through erosion in a hands-on and creative way. The teacher information illuminates the process of placer deposits in more detail. This information can also be given to the students to enhance their understanding.

Upon completing these activities the student will be able to:
1) Describe the main ways that weathering occur.
2) Describe the process of erosion.
3) Predict where the best place on a river would be for gold panning.

Photocopy:

- Pages 2-8 for student use.

Reading

Weathering and Erosion:

What is Weathering?

Wind has eroded this desert rock

Rocks that are exposed on the earth's surface are constantly being eaten away (weathered) by many different environmental elements:

- Heat and cold cause rocks to flake;
- Running water wears bits of sand from rocks;
- Plant roots break up rock; and
- Wind eats away at rocks.

When rocks break up it is called **Weathering**. Small, broken, bits of rock are often carried away from their starting point. The movement of weathered bits of rock from one place to another is called **Erosion**. Water carries many small bits of rock which can make the water murky and muddy. The Fraser River is a good example of this process. Sometimes, the wind will carry the small rocks far away from their starting point. In desserts, the wind will carry the sand for thousands of kilometres and deposit them to form large dunes. Some of the eroded rock will not go far at all. Often the eroded rock will become mixed with dead leaves and other organic matter to form soil.

Where Does the Eroded Rock Go?

Sand Dunes

River Delta

Farmers Fields

Reading

Two Main Types of Weathering

Mechanical Weathering:

This is the physical break-up of rock. This can occur in many ways as, for example, when water gets into cracks in the rocks and freezes. The freezing water expands and causes the rock to split. Water also causes rocks to break apart when it moves them, as in a fast moving stream or on a beach with waves. The water jostles the rocks against each other and they slowly wear away. The wind also causes mechanical weathering by blowing sand around which, over time, wears down the rock much like sand paper on wood.

Chemical Weathering:

This is when rock is changed by a chemical reaction. For example, acid water can dissolve certain rocks. Limestone dissolves in this way and this is why caves are often found in areas of limestone rock. Acid rain dissolves some types of rock even faster and can result in damage to statues and buildings. Usually a rock is broken down by a combination of Chemical and Mechanical Weathering.

Sediments:

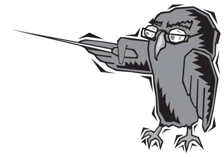
These are small bits of rock which flow down a river, or are carried by wind, and eventually settle out. Sediments can be particles of many different sizes: some grains are big, like sand grains; others are small, like fine powder. Whenever moving water slows down, it no longer has the energy to carry its load of sediment and particles begin to settle. Rivers that are very muddy, like the Fraser, carry millions of tons of sediment every year. All this sediment build up at the mouths of rivers and form large sandy deltas.

Try This!: Settling Demo
Take a large graduated cylinder and fill with a mixture of:

1) sand grains
2) smaller sand grains
3) fine dust

Shake it up and put it down. Watch what happens! Where do the grains settle? Where does the silt settle?

Teacher Information



Placer Gold Deposits

What is it?

Gold is sometimes found as small flakes and pebbles mixed in with the sand and gravel of a river bed. This type of deposit is called a **Placer Gold Deposit**. When you see the old prospector with a gold pan at the river's edge he was looking for gold mixed in with the grains of sand.

How does it get there?

Gold is formed in rock deep inside the earth. This rock may eventually be exposed to the surface of the earth through geological processes that take millions of years. When the gold bearing rock gets exposed it is subjected to erosion and weathering. Rain and meltwater will carry the small grains of eroded rock and gold off the mountain and this material will often end up in small streams and rivers.

Small, light, particles of rock, almost like flour, will often be carried, by the river, all the way to the sea. Dense materials like gold, however, will settle out of the river as soon as it looses the energy that is necessary to carry the load. This is similar to what you saw in the demo. Most of this settling occurs where the river is slow. Over a long period of time the sediment in these parts of the river can accumulate a large amount of gold. This is a called a placer gold deposit.

How do they mine a placer deposit?

A placer gold deposit can be mined through a process of lifting the sediments into sluice boxes and allowing the dense gold to settle out and the lighter minerals to flow away with the water. Placer deposits can have large amounts of gold in them and be very valuable.

Often, however, the old prospector with a gold pan is not looking for a placer deposit. He is usually looking for the source of the gold itself. He will follow the river upstream and check every tributary for gold. He will then follow the tributaries until he finds the one that was eroding the gold from the rock. This rock can then be mined with tunnels and shafts for the gold it contains.

Activity #2a: Stream Erosion

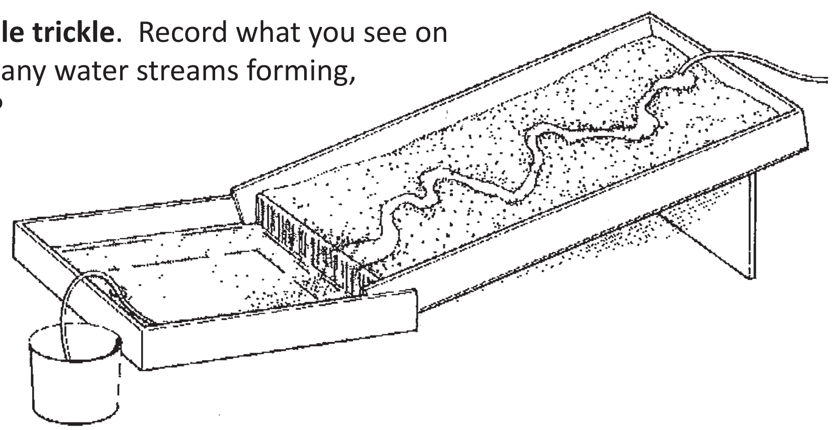
Introduction:

One of the best ways to learn about erosion is to experience it yourself. In this activity you will be making a stream table and watching the results of water on the landscape. You will create two situations: erosion of sand and gravel; and erosion of sand and gravel with trees. You will record what you see on a worksheet that your teacher gives to you.

Procedure:

1. Set up a stream table as shown in the illustration below. Most schools will have stream tables as part of their science materials. If yours does not, a simple stream table can be set up using a flat board and an orange tray, as shown. For the fill, use a mixture of sand and gravel about 3 cm deep.

2. Turn on the water to a **gentle trickle**. Record what you see on your worksheet. Are there any water streams forming, or does it sink into the dirt?



3. Next turn on the water to a faster rate. Look at the particles that flow down the table and into the water. Are they larger or smaller than before? Is a small stream beginning to form? Note your observations in the appropriate spots on your worksheet.

4. Leave the water on for a while and let a fair amount of erosion occur. Look into the water at the base of the stream table. This represents where a river enters an ocean. What is happening at this point? Record your answers on your worksheet.

5. Turn the water to flow at an even faster rate and note how much sediment the water washes off. Note how strong the water-flow is from the tap. You will be using this same strength for the next part.

Part B: Erosion with Trees Present

6. Set up one of your stream tables on a slope, with trees. You can do this in several ways:
   A) by using a styrofoam board and toothpicks to represent the trees; or
   B) using a regular board and pins (dissecting pins will do) for the trees.

7. Repeat steps 2 to 5 using the Stream board with the trees. Note the difference in erosion when there were trees present as compared to when there were not any. Answer the remaining questions on your worksheet.

Stream Table Worksheet

Questions:

1. In procedure 2, you have the water on at a trickle.

A. Does a little river of water form?

____

B. Are there small particles of dirt, called silt, in the sand? How can you tell?

____

2. In procedure 3, you turn the water on a little stronger. Does erosion of sand particles occur?

3. When a river or stream forms on your stream table, draw its shape as you see it in the space below.

4. After letting the water flow down the stream table for a while, a small pile of sediment forms in the bottom of the pan. This pile is the delta of your stream. Draw both the stream entering the pan and the delta here.

5. Describe what happened when you had the stream table with the trees on it. Did erosion occur as quickly? Why or why not?

Activity #2b: Panning for Sediments

Weathering and Gold

I'm sure you've seen the picture of the old prospector hunched over a pan at the side of the river. He was panning for gold in the sand and gravel that rest on the banks and bottom of the river. How did that gold get there??? Read on and find out!

Step 1: Gold is found in rock. It is formed deep in the earth and at high temperatures. Eventually, through erosion, over millions of years, the gold bearing rock is exposed and eroded from the hills. The little bits of rock and gold flow downstream with the swiftly flowing river.

Step 2: As the river gets larger and slower, sediments begin to drop out of the water and settle on the river bottom and at the edges.

Step 3: Because gold is more dense than sand, the gold settles out more quickly. When a river turns a corner it slows down. This is often a good place to look for gold flakes.

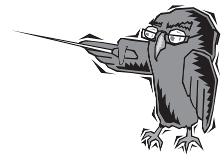
Step 4: The gold panner finds a slow part of the river and begins to pan for gold. He scoops up a bit of sand and water and swirls the mixture gently. Because gold is heavier than sand it sinks to the bottom of the pan. Repeating the process over and over again, the gold panner collects some gold in the bottom of his pan.

Assignment:

Make up a Cartoon about erosion and sedimentation. Take a white sheet of paper and make up a cartoon following the life of a small piece of gold. Here is a possible storyline.

1. The piece of gold in the rocks on a mountain.
2. How the rock bits get broken off the mountain.
3. What happens to it in the river.
4. Where it eventually settles in the sediment.
5. An old prospector finds it in his gold pan.

Teacher Information



Rocks and Minerals 3: Swell Time

Teacher Plan:

- 5 minutes: Reading and discussing "What About Coal???" (page 2);
- 5 minutes: Demonstrating the lab "A Swell Time" (page 3);
- 40 minutes: Students performing lab "A Swell Time" (Activity #1) and clean up.

Notes:

This lesson uses coal for the lab exercise. Unfortunately coal oxidizes in the open air. Coal that has been sitting around on a shelf for several years will be completely oxidized through and through. This will prevent the following lab from working. To achieve success with this lab reasonably fresh coal must be used. To obtain fresh coal contact the address below and they will be happy to send out coal samples.

For more information about coal mining and samples please contact:

Coal Association of Canada - www.coal.ca
Look for the "Coal Kit". This kit is a tremendous resource full of great activities and information. It could easily be an integral part of the Science Grade 9 Energy Unit on fossil fuels!

Upon completing these activities the student will be able to:
1) Describe the different types of coal and the steps of coal formation
2) Demonstrate the test of coal's Free Swelling Index.

Reading

What About Coal?

Introduction:

Although gold, copper, lead, zinc and other shiny metals often come to mind when you think of mining in BC, you should be aware of the other dominant force.. COAL! Mining this valuable jet black resource creates direct employment for thousands of British Columbians and helps to support a thriving economy. Coal provides us with fuel and perhaps most importantly it is a key ingredient in the production of steel products.

Where Coal Comes From:

Coal is remarkably different from other rocks in that it is organic in origin. Yes, the black rock really began as living organisms! Millions of years ago lush vegetation associated with peat bogs and swamps was covered by geologic activity. When the right conditions existed the vegetation slowly decayed and transformed into coal. Since each coal deposit came form different plant material and were subjected to different geological conditions, it follows that not all coal is created equal. Some coals called Bituminous, are soft, while others were compacted by great forces into harder coal, called Anthracite. Coals also vary in the amount of sulphur they contain. Coal is often classified by its end use. Coal that is used as fuel for electric generators and home heating is called Thermal Coal. Coal that is used strictly by the steel industry is Metallurgical Coal.

Coal in BC:

Most of British Columbia's Coal is Metallurgical. From the mines along the foothills of the Rocky Mountains, sedimentary coal seams are blasted loose in a mine. This coal is then separated from the surrounding waste rock through a density separation process similar to that in Activity #2a of the "Mining Science Sub-Unit". In this case, however, the valuable coal is less dense than the waste rock. Thus the less dense coal remains floating on a watery bed while the more dense waste rock sinks and is removed. The coal is then dried and shipped to Japan via rail and freighter where it is used as metallurgical coal for the steel industry.

You might be wondering how you can determine whether coal is Thermal or Metallurgical. Well, one simple experiment can provide you with some strong clues.

Activity #1: A Swell Time!

Introduction:

When coal is heated to a high temperature in the absence of air, a solid residue consisting of carbon will swell within the heating chamber. This residue is known as Coke (obviously not the kind you drink!). Coke is important to the steel making process. The greater the ability of coal to swell, the better coking agent it becomes. The ability of coal to swell is known as the Free Swelling Index. Metallurgical coals have a very high free swelling index. Follow the instructions below to see how you can have a swell time with coal.

Procedures:

1. Obtain a mortar and pestle from the lab and grind up one of the coal samples provided to a fine powder. Be sure to make note of the type of coal sample your teacher has given you.

2. Carefully calculate the mass of a crucible and lid. Then add approximately one gram of powdered coal. Be sure to record the overall mass in you observations as Mass Before Heating.

3. Put on your safety goggles and follow carefully your teacher's instructions for safe use of the Bunsen burner while strongly heating the covered crucible for three minutes.

4. Without opening, allow the crucible and contents to cool and then calculate the mass again. Record this mass as Mass After Heating.

5. Now lift the lid of the crucible and carefully observe what has happened to the powdered coal sample. Record your observations.

6. Repeat this lab using a different coal sample.

Data:

Copy a data table like this one on your lab sheet:

	Sample 1:	**Sample 2:**
Mass of crucible and lid		
Mass of crucible, lid and coal before heating		
Mass of crucible, lid and coal after heating		

Activity #1: A Swell Time!

Questions:

1. Compare the before and after masses you recorded for each coal sample and try to account for any differences.

2. Compare and contrast the crucible contents after heating, to the coal you started with.

3. Try to account for any differences in the results between the two different coal samples you have tested.

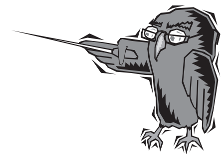
4. How is "free swelling index" used in determining the end use classification of coal?

5. Distinguish between these terms:
   a) Coke & Coal.

   b) Metallurgical coal and thermal coal.

   c) Bituminous coal and anthracite.

Teacher Information



Types of Coal

Coal consists of a complex range of materials, and coal from one deposit may differ greatly from that of another. These differences result from the varying types of vegetation from which the coal originated; the depths of burial; and the temperatures and pressures at those depths; as well as the length of time the coal has been forming in the deposit. The varying amount of mineral matter in a coal deposit may also have a significant effect on its properties and classification.

Coal is generally classified by what is known as **rank**. Although several classification systems exist, the one most often used in North America is based on the degree of transformation of the original plant material to carbon. The rank of coal, from those with the least carbon to those with the most carbon are: lignite; sub-bituminous; bituminous; and anthracite.

Moisture content also plays a part in ranking: coals which are low in moisture and high in carbon are ranked more highly. In addition to carbon, coals contain hydrogen, oxygen, nitrogen and varying amounts of sulphur. High-rank coals are high in carbon and therefore heat value, but low in hydrogen and oxygen. Low-rank coals are low in carbon but high in hydrogen and oxygen content.

The highest rank, and the hardest coal, is **anthracite**. It is found almost exclusively in remote regions of northern British Columbia and the Yukon. Anthracite is not being mined in Canada at present.

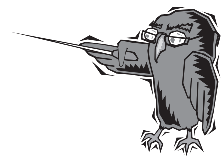
Bituminous coal, ranked second highest, is found in Alberta, British Columbia and the Maritimes. Bituminous coal can be either metallurgical (used to make coke for the steel industry) or thermal (used to generate electricity). In 2010 the operating coal mines in BC produced 26 million tonnes of bituminous coal.

Sub-bituminous coal is softer than bituminous coal and contains more moisture, making it less economic to transport over long distances. Alberta is the only province where sub-bituminous coal is currently mined. About 24 million tonnes of sub-bituminous coal were produced in 2010. This type of coal is mostly used to generate that province's electricity.

Lignite is a soft, brown or black coal found in southern Saskatchewan and southeastern Alberta. Only the Saskatchewan deposits are currently being mined. In 2010, Saskatchewan produced 10.3 million tonnes of lignite coal.

In total, Canada produced more than 68 million tonnes of coal in 2010. 40 million was in thermal coal and 28 million was steel-makiing coal.

Teacher Information



Rocks and Minerals 4: Igneous Rocks

Teacher Plan:

- 5 minutes: Reading and discussing "Igneous Rocks", page R4-2;
- 5 minutes: Demonstrating the Lab 14D "Igneous Inquiry" from *Science Probe 8*;
- 40 minutes: Do either:
  Activity 1 - Molten Plasticine, page R4-4, or
  Activity 2 - Crystal Growth, page R4-5.
- A walk around the grounds (final activity).
- Do Igneous Rocks Worksheet, page R4-6.

Notes:

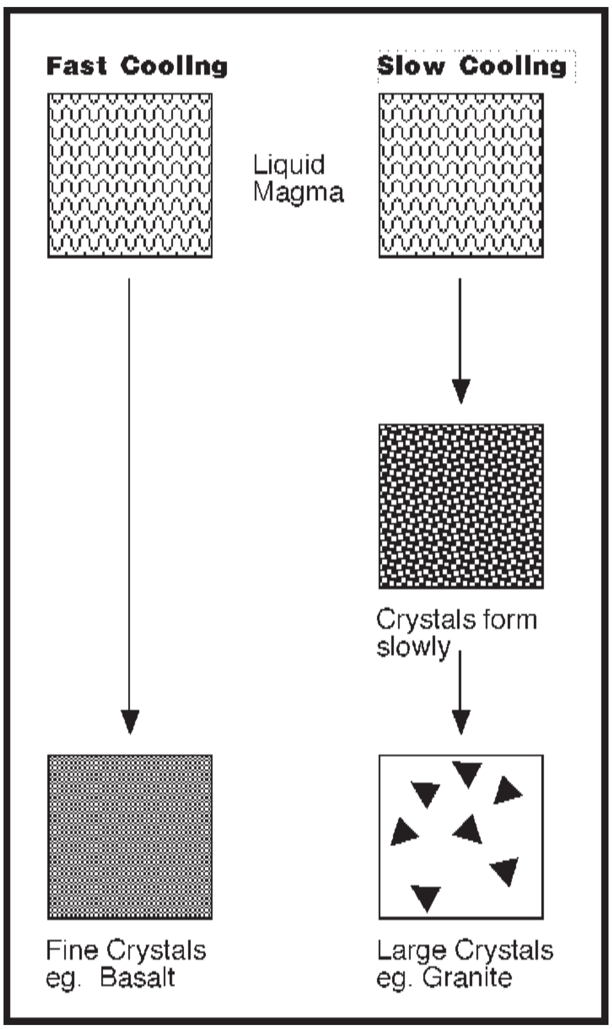
This lesson involves learning how igneous rocks form and how to identify them. Identification can be difficult as igneous rocks vary widely in appearance depending on where they formed. Please remember that identifying the name of a rock (e.g. granite, diorite, basalt) can be very difficult. Students will only be asked to recognize the category (igneous, metamorphic, or sedimentary) and to distinguish between volcanic and plutonic. To make things more straight forward for the students, use samples with distinct features and unambiguous origins. A list of appropriate rocks is given on page R4-3.

Upon completing these activities the student will be able to:
1) Describe how igneous rocks form.
2) Describe the different types of igneous rocks.
3) Recognize representative igneous rocks and distinguish between plutonic and volcanic rocks based on texture (mineral crystal size).

Igneous Rocks

Introduction:

Deep in the Earth's crust where the temperature and pressure are high, there are pockets of molten rock called **magma**. When this magma cools and hardens it becomes **igneous** rock. Sometimes the magma cools slowly underground. Other times the magma rises to the surface and erupts as **lava,** which cools quickly. Quick cooling or slow cooling, any rock forming from liquid rock becomes igneous rock. The diagram below shows what happens when magma cools at different rates.

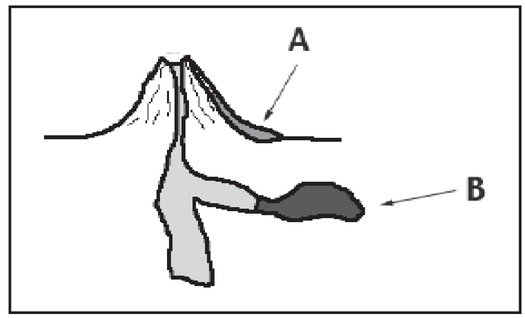


As magma cools, crystals of minerals start to form. At first they are sub-microscopic in size, but as cooling continues the crystals continue to grow. The longer it takes for the magma to cool, the longer the crystals grow and the bigger they are when the rock is completely solid.

Reading

Two Types of Igneous Rock

Igneous rocks made of coarse mineral crystals cooled slowly underground. Igneous rocks made of fine mineral crystals cooled quickly at (or very near) the Earth's surface.



Volcanic or Extrusive

Formation: Molten lava cooling quickly on the Earth's surface.
Characteristics: Fine-grained, crystalline, possibly with holes, or glassy.
Common Examples: pumice, basalt, obsidian
Good outcrop locations in B.C.: South Thompson (Kamloops region), North Thompson, Okanagan valley, Cariboo, North Central B.C., Garibaldi Provincial Park (Mt. Garibaldi, Black Tusk and Diamond Head), Wells-Gray Provincial Park, Vancouver Island (west of Campbell River)

Plutonic or Intrusive

Formation: Molten magma cooling slowly underground.
Characteristics: Coarse-grained, crystalline; commonly very hard and dense.
Common Examples of: granite, diorite, gabbro
Good outcrop locations in B.C.: Vancouver Island, Coast Range Mountains from Vancouver (North Shore mountains) to Alaska, along the Coquihalla Highway at the Coquihalla Summit.

Activity #1: Molten Plasticine

Introduction:

As you learned from the reading, magma cools to make igneous rock. When it cools slowly underground, large mineral crystals form. Examples of igneous plutonic rocks with large crystals are granite, diorite, and gabbro. In this activity you will make a model of a plutonic igneous rock using Plasticine. When you have finished the activity, keep your model for the final lab on meta-morphic rocks.

Materials:

- two different colours of Plasticine
- granite

Procedure:

1. Obtain a plum-size wad of two different colours of Plasticine. Place one of the colours aside.

2. Take the other colour of Plasticine and break it up into small, pea-size pieces. Make sure you have several of pieces.

3. Take the other colour of Plasticine and flatten it out into a sheet about 2 mm thick.

4. Next, take the small bits and push them gently into both sides of the flattened sheet.

5. Finally, roll the flattened sheet into a ball with a minimum of kneading.

6. There! You have a representation of an igneous rock. Take one from the class, and cut it in half and note the "crystals" all the way through. Keep your rock until the metamorphic lab.

Questions:

1. Rock is a mixture of two or more minerals. How did you represent the different minerals in your model?
2. Describe the conditions under which this type of igneous rock would have formed.
3. Compare your Plasticine model to the hand sample of granite. Are they both made of "mineral crystals" that are big enough to see with the naked eye? How is the model different from the real granite?
4. Why is it difficult to make a Plasticine model of a fast cooling volcanic rock like basalt, obsidian or pumice?
5. What edible food item most resembles pumice? What edible food item most resembles obsidian?

Activity #2: Crystal Growth

Introduction:

You have learned that in the formation of igneous rocks slowly cooled magma becomes a rock with large mineral crystals. In this lab you will observe crystallization of minerals through the process of evaporation. You will allow one solution containing dissolved minerals to evaporate *quickly,* while another will be allowed to evaporate *slowly*. While igneous rocks <u>do not</u> form by evaporation, this experiment allows you to observe how **evaporation rate** (as a model for **cooling rate**) influences mineral crystal size.

Materials:

- 2 microscope slides
- one drop of salt (NaCl) solution
- stirring rod
- a hot plate
- microscope
- one drop of copper sul phate ($CuSO_4$) solution

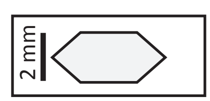
Procedure:

1. Get two microscope slides. Label one slide **1**, the other slide **2**.

2. Place one drop of salt (sodium chloride) solution on one end of each slide. Place one drop of copper sulphate solution on the other end of each slide.

3. Place slide **1** on the hot plate so the liquids evaporate quickly. Place slide **2** on your desk where the liquids will evaporate slowly.

4. As the liquids on the slides evaporate, mineral crystals will form on the glass. Examine all four crystalline spots with a microscope using a 10X ocular. Use a mm-scale ruler along with the two slides under the microscope to measure the sizes of the crystals. Sketch and label the four different crystals, including a bar scale to show how big they are.



Questions:

1. What is the difference between the crystals that formed quickly and those that formed slowly?
2. Which of the two slides simulates Igneous Plutonic rock formation; which simulates Igneous Volcanic rock formation?
3. How do you explain the difference in shape between the salt crystals and copper sulphate crystals?

Igneous Rock Worksheet

For each of the following statements write in the words **plutonic, volcanic,** or **other rock.**

1. A rock that cooled deep underground. ____________

2. A rock that is made up of small grains of sand. ____________

3. Rocks formed by an erupting volcano. ____________

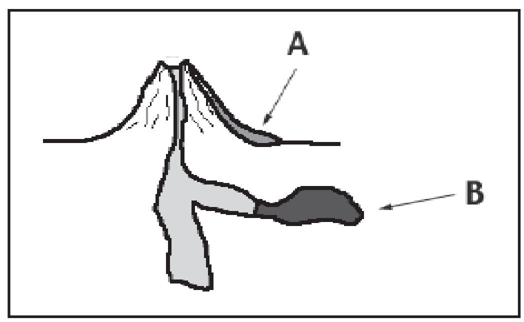
4. Rocks that are made up of large mineral crystals. ____________

Answer the following questions:

5. In the following diagram describe the appearance of the **rocks** you would find in location A and B.

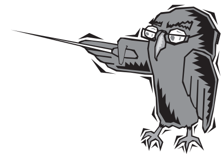
A:____________________________

B:____________________________



6. Design a driving trip that would allow you to see some igneous plutonic and volcanic rocks. Try to find the location of an extinct volcano and include it in your travel plans. Write a brief description of your trip here.

Teacher Information



Rocks and Minerals 5: Sedimentary Rocks

Teacher Plan:

- 5 minutes: Reading and discussing "Sedimentary Rocks", page R5-2;
- 30 minutes: Do either:
  Lab 14E "Sedimentary Inquiry" from *Science Probe 8*; or
  Activity 1 - Make Your Own Sandstone, page R5-6; or
  Activity 2 - Pretend It's A Fossil, page R5-7.
- 15 minutes: Do questions and finish up labs.
- A walk around the grounds (final activity).
- Do Sedimentary Rock Worksheet, page R5-8.

Notes:

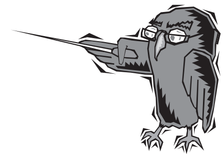
Sedimentary rocks are interesting to look at and its fairly easy to understand how they form. The activity in *Science Probe 8* and in here are both good at showing the processes involved. "Make Your Own Sandstone" is a good hands-on activity that shows the role of **cement** in making sedimentary rock. Good representative sedimentary rocks for students to examine include:

- shale - made from fine grained, clay-sized particles (mud)
- sandstone - made from sand-size mineral and rock particles
- conglomerate - made from coarse, granule to pebble-size and larger rock particles

Also, success in creating "mouldic" sugar cubes in Activity 2 depends largely on making sure that the water drips **very** slowly on to the paper towel covered sand.

Upon completing these activities the student will be able to:
1) Understand the process of sedimentation and cementation.
2) Describe the different types of sedimentary rocks and how they form.
3) Understand generally how fossil fuels form and where they occur in BC.

Teacher Information

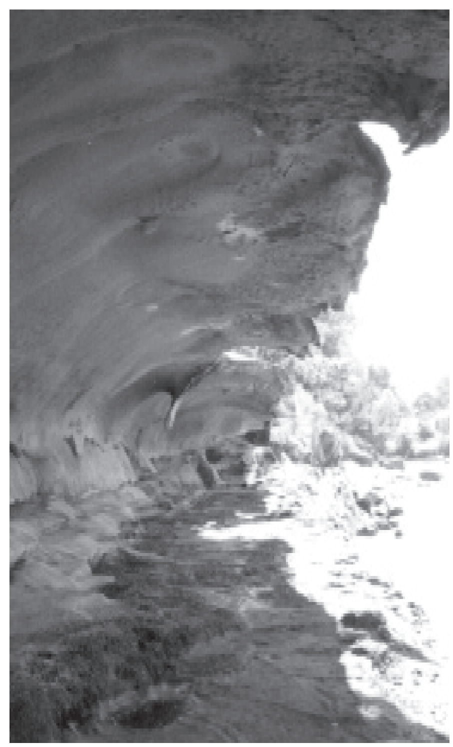


Fascinating Sedimentary Rocks in British Columbia

1) The **Gulf Islands** in the Strait of Georgia are made of sandstone and other sedimentary rocks. The sediments were deposited during the uplift of the Coast Range beginning about 70 million years ago. Correlative rocks on Vancouver Island include coal-bearing sequences which have been mined in a number of areas since the mid-1800s.
The distinctive rocks formations shown to the right are on **Gabriola Island**. They are made from soft sandstone and were carved by the ocean.

2) In the **Thompson-Okanagan** region of BC large, amounts of sediment were left by retreating glaciers. They include thick sands and gravels in the river valleys and thick, fine-grained lake deposits in the Okanagan Valley proper. These relatively young deposits are still soft and crumbly.

3) Another interesting outcrop of sedimentary rocks is at **Horne Lake Provincial Park** on Vancouver Island. There, limestone has been dissolved by fresh groundwater leaving behind caves. These caves are open to the public and are fascinating to explore.



Malaspina Galleries at Gabriola Island BC. Here soft sandstone has been worn away by the sea.

Reading

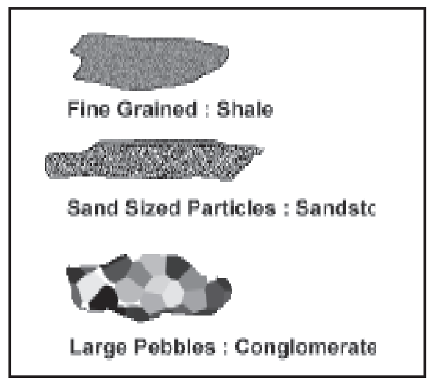
Sedimentary Rocks

Introduction:

Sedimentary rocks form from **sediment**. Sediment forms as large rocks are weathered and broken down into smaller particles. These particles, or **grains**, are commonly carried by water, wind or ice, and are **deposited** where the water or wind slows down, or the ice melts. One such place where sediment is deposited is a **delta**, where a river meets the ocean. In a delta, the water slows down and the sand and silt carried by the river settles out on the sea floor. As this sediment slowly builds up, its weight squeezes on the sediment below. Over thousands of years, with the pressure of the sediment pile and the addition of **cement**, a silty sandstone is formed.

Sedimentary rock needs:

- mineral and rock particles (mud, sand, pebbles)
- pressure - to compact the loose grains, and
- cement - to hold the grains together.



Examples of different types of sedimentary rocks.

The cement is like a glue that holds the grains together. Without cement the sediment would remain soft and fall apart in your hands. The cement commonly comes from minerals dissolved in **groundwater** moving slowly through the sediment. You may have already seen one type of cement forming in an old, leaky sink! That milky, crusty material on the sink wall or around the fixtures is the mineral **calcite**. Calcite ($CaCO_3$) and silica (SiO_2) are two common cements in sedimentary rocks.

Sedimentary rocks are named according to the size of the grains. For example:

- silt or mud sized grains make up **shale** or **mudstone,**
- sand sized grains make up **sandstone**, and
- pebbles or rocks make up **conglomerate**.

Sedimentary Rocks and Fossils

Sedimentary rocks commonly start as sediment on the sea floor or in river beds. When a plant or animal living in these places dies, its remains may be preserved in the sediment. Over time the soft tissues decay and the hard parts, such as bones, shells, scales, are replaced by minerals that preserve the original shape of organism. This preservation is called a **fossil**. Sedimentary rocks are the only ones that commonly contain fossils. High pressures and temperatures that

Reading

cause metamorphism destroy fossils. Extreme temperatures of magmas prevent preservation of fossils in igneous rocks.

There are many places in BC where sedimentary rocks with fossils occur (Figure 1, page R5-5). Good areas to look include eastern Vancouver Island and the Gulf Islands, and the entire Rocky Mountains and their foothills. Sedimentary rocks also underlie many areas in the BC central interior, but are commonly metamorphosed.

Sedimentary Rock and Fossil Fuels

Coal, oil and natural gas are examples of **fossil fuels** that occur in sedimentary rocks. They are called fossils fuels because they come from dead plant matter. When plants die, they may accumulate on the surface, and then become gradually buried as sediment. Over time the heat and pressure of burial change the energy stored in the plant tissues into a fossil fuel.

Coal

Coal forms from dead **land plant material** such as branches, leaves and roots, that accumulates in swamps or bogs. In these places of lush vegetation, the dead plant material accumulates so fast that it is not in contact with air for very long and does not decompose! The plant tissues are made of **carbon** and other lighter elements. As this material becomes buried, the higher temperatures and pressures cause the lighter elements to be removed, leaving behind matter that becomes richer in carbon over time. The change is:

peat □ □ **lignite** □ □ **bituminous coal** □ □ **anthracite**

Richer in Carbon →

Harder →

More Dense →

Coal energy comes from the carbon in the plant material. As the plant material is changed and the accumulations become more carbon-rich, the coal becomes harder and more dense. For example, **lignite** is around 40% carbon while **anthracite** can be 90% carbon.

Coal is used in many ways. In Alberta and other provinces it is the primary source of electrical energy. Coal is burned to produce heat to boil water to make steam that runs turbines. Coal mined in BC, in contrast, is sent to Japan where it is an ingredient used in the making of steel. Coal is also used in chemical manufacturing.

Coal deposits occur in sedimentary rocks in two main areas in BC. Early in the colony's history and continuing until the 1970's, coal was mined on the east coast of Vancouver Island, from

Reading

Campbell River to Nanaimo. Only Quinsam Mine near Campbell River is still operating. Today coal mining goes on mostly in eastern BC. As of 2012, there are five mines in the Kootenays and four in the eastern foothills of the Rocky Mountains near Chetwynd and Tumbler Ridge.

Oil and Natural Gas

Oil and natural gas also form from buried plant material, in this case the soft tissues of tiny sea creatures called **plankton**. Some of these plankton are little plants called algae, which like other plants use sunlight to grow and reproduce. When they die, they fall to the sea floor and become part of the bottom sediment. Over millions of years, as this plant material becomes buried, it is heated and squeezed until the carbon and hydrogen in the plant tissues change into liquid (oil) and/or gas (natural gas). These fluids fill the pore spaces between grains of sediment. Under the right conditions they remain trapped in the sediment at depth until they are drilled and pumped to the surface.

Oil and natural gas occur in ancient sedimentary rocks underlying many parts of BC (Figure 1). Today production occurs only in the northeast. Geologists, however, are actively exploring for these resources in the Fraser Valley, the Queen Charlotte basin, Vancouver Island, and the Bowser and Nechako basins.

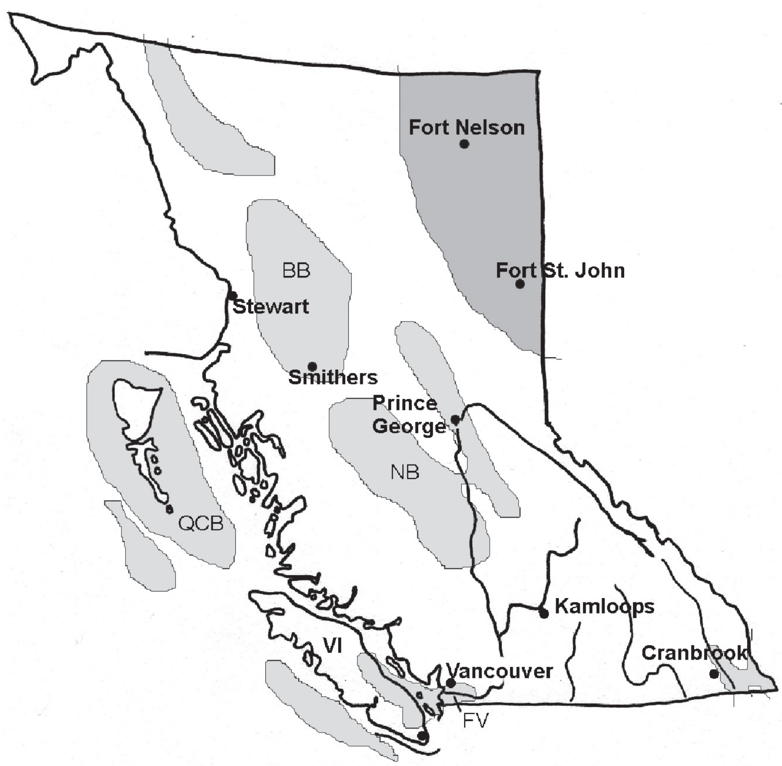


Figure 1: Map of BC showing the locations of sedimentary basins (grey areas) where oil and gas deposits are likely to occur.
Production now occurs in the NE region (dark grey). Several other areas have been drilled for exploration.

BB = Bowser Basin,
NB = Nechako Basin,
QSB = Queen Charlotte Basin,
FV = Fraser Valley,
VI = Vancouver Island.

Activity #1: Make Your Own Sandstone

Introduction:

So far you have learned that sedimentary rock is made up of mineral and rock particles plus a cement. In this lab you will make your own sandstone using sand and a cement, and then compare it to real sandstone.

Materials:

- 1 small paper cup
- enough sand to fill half the cup
- white glue thinned with water
- toothpick or similar device for stirring
- hand lens
- real sandstone samples

Procedures:

1. Get one paper cup and a stir stick.
2. Fill the paper cup half way with sand (or other small rock fragments, if desired).
3. Add some watery glue and stir the sand until all of it is mixed with the glue.
4. Place on a shelf and wait until the next day.
5. Peel the paper cup off your hardened *rock*.
6. There! You have made sandstone! Look at your sandstone with a hand lens and compare it to a real sandstone. Note any differences.

Questions:

1. Sandstone is a mixture of two materials, mineral and rock particles and cement. What two ingredients did you use to simulate these?

2. When you look at your sandstone and the real sandstone what differences do you see?

3. Which sandstone, the real or the fake one, would be able to be outdoors and last for a long time? Why? Try it!

Extension Idea!!

Sandstone and other sedimentary rocks are commonly layered. Simulate this by doing this activity with several different types of sand (different colours or textures) and layering the glue - sand mixtures one on top of the other.

Activity #2: Pretend It's a Fossil

Introduction:

When a paleontologist finds a fossil it is not the actual remains of the dead creature, but instead a special preservation of the tissue or an impression of the tissue. In this activity you simulate how fossil impressions of animals and plants form.

Materials:

- 1 clear plastic cup
- enough sand to fill 3/4 of the cup
- three sugar cubes
- paper towel
- water tap

Procedures:

1. Poke 4 holes in the bottom of the cup using a nail or similar device.
2. Pour the sand into the plastic cup and wet with water.
3. Push three sugar cubes into the sand so that they are next to the cup wall and can be seen through it.
4. Place a folded paper towel on top of the cup and place the cup underneath a very slowly dripping tap for several hours.
5. Look closely at the cup the next day. Write down your observations.
6. If it is hard to see anything through the cup you may have to carefully remove the wet sand without disturbing it. You should see hollow areas in the sand. They are the **moulds** of the sugar cubes! They are ***fossil sugar cubes***! Pretty exciting, hey? In nature, over time, hollow areas in sedimentary rock where there were once organic remains will fill in with minerals carried in percolating groundwater. Thus, a fossil forms!

Questions:

1. Which type of fossil formation is imitated in this activity - mould fossilization or replacement fossilization? Support your answer.
2. What did the dripping water do to the sugar?
3. Under what conditions might you actually find the real preserved remains of an ancient creature and not just an impression?

Sedimentary Rock Worksheet

For each of the following statements write in the words **shale, sandstone, conglomerate, coal** or **oil.**

1. A rock made of dead land plant material. ____________________

2. A rock made up of small grains of sand. ____________________

3. Buried remains of tiny sea creatures make this. ____________________

4. Rock with the appearance of concrete (lots of large pebbles). ____________________

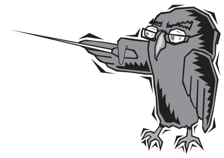
5. Mud turns into this. ____________________

Answer the following questions:

6. Almost all fossils are found in sedimentary rocks. Explain why this is so.

7. If you were to travel to the Grand Canyon in the U.S. you would see there layer upon layer of sedimentary rock exposed by the cutting action of the Colorado River. As a paleontologist looking for fossils draw a profile of the canyon showing the sedimentary layering and indicate where the youngest fossils would be found and where the oldest fossils would be.

Teacher Information



Rocks and Minerals 6: Metamorphic Rocks

Teacher Plan:

- 5 minutes: Reading and discussing "Metamorphic Rocks", page R6-3;
- 30 minutes: Do either:
  Lab 14F "The Big Squeeze" from *Science Probe 8*, or
  Activity 1 - "The Metamorphic Transformation", page R6-4.
- 15 minutes: Do questions and finish up labs.
- A walk around the grounds (final activity).

Notes:

Metamorphic rocks can be difficult for beginners to identify or categorize. Concentrate on rock samples that have distinct foliation (layering). Since metamorphic rocks form from other rocks, a good strategy in class is to show the students a sample of the original rock, then show the metamorphic form. For example:

Original Rock +	*Heat and Pressure* =	**Metamorphic Rock**
Sandstone		Quartzite
Shale		Slate
Granite		Gneiss
Limestone		Marble

Upon completing these activities the student will be able to:
1) Describe how metamorphic rocks form.
2) Explain why many metamorphic rocks show foliation.
3) Be able to identify some representative metamorphic rocks.

Teacher Information

Metamorphic Rocks:

Any type of rock can be **metamorphosed** (transformed) by the high temperatures and pressures associated with burial or tectonic collisions (mountain building). They commonly become folded, recrystallized, more dense, and **foliated** (layered). Depending on the degree of metamorphism, the resulting rock may look similar to the original rock or look very different.

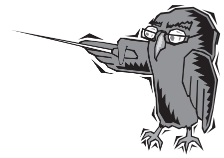
The two most distinct features of metamorphic rocks are **foliation** and **recrystallization**. **Foliation** refers to the preferred alignment or arrangement of minerals that is expressed as layering in a metamorphic rock. Foliation forms perpendicular to the direction of pressure. It includes flat breaking planes called **cleavage** in slate, wavy layers defined by mica flakes called **schistosity** in schist, and wavy bands of different coloured minerals called **gneissic banding** in gneiss.

Recrystallization refers to an increase in crystal size and the recombination of elements in original mineral grains to form new minerals. Recrystallized limestone, for example, changes from mud-size calcite grains to interlocking calcite crystals big enough to see with the naked eye. In shale, original mud-size clay minerals recombine and grow into large crystals of mica and other silicate minerals.

Geologists describe the degree of metamorphism as **low grade** or **high grade** based on the metamorphic structures and minerals observed in the rock. Low grade rocks are still recognizable as the original rock, exhibiting minor recrystallization or cleavage. Geologists commonly use the prefix "meta-" to indicate the low degree of metamorphism, as in "meta-sedimentary sequence, meta-basalt, meta-greywacke", etc. High grade rocks bear little resemblance to the originals, overprinted with new, larger mineral crystals and schistosity or gneissic banding.

Choose metamorphic rocks with distinctive foliation for your class to examine. Some good examples to use include mica schist, gneiss, augen gneiss,slate, phyllite and marble.

Teacher Information



Tips for Activity #1

1) The Plasticine is soft, so if the students press too hard or fold it, the colours will run together.

2) Use about 10 pennies in a hand-size lump of clay.

Answers:

1. *Tectonic plates colliding, magma rising up through the crust or lava baking rocks on the Earth's surface, and the weight of rock piling on top of other rocks all cause metamorphosis of rocks in nature.*

2. ***b, the car crusher,*** *is most like metamorphic squeezing*

3. *This answer will depend on the rock samples they examine. Sedimentary layers are generally more even than those in metamorphic rocks, the exception being cleavage in slate which is commonly very planar. Sedimentary layering is also commonly defined by grain size, degree of cementation, or amount of organic material, while metamorphic layering is related to orientation of flat (or elongate) mineral grains or to mineralogy (e.g. dark, mafic minerals alternating with light coloured, silicate minerals).*

4. *It originated as loose sediment on the sea floor. During burial it became lithified to form a sedimentary rock. Finally, through powerful geological processes it was squeezed, deforming the rock and fossils in it to form a metamorphic rock.*

Reading

Metamorphic Rocks

Introduction:

Rocks continuously cycle through the three different types. Igneous rocks are weathered and broken down into bits that may be moved, then deposited and later become sedimentary rocks. Sedimentary rocks can be buried deep in the crust where they melt to form magma that then becomes igneous rock. All rocks can be transformed by geologic processes into metamorphic rocks.

Metamorphism refers to the changes in rocks caused by **pressure** (squeezing) and **heat** encountered when they are buried deep in the crust or are involved in mountain building. If the temperature and pressure are too high, rock will melt forming a magma that will turn into igneous rock when it cools. Heat and squeeze the rock *just right*, however, and it will behave like a plastic - easily bent and folded, but not easily broken!

Metamorphic rocks commonly have sharp or wavy layers that geologists called **foliation**. This forms in a metamorphosed rock when the pressure causes the minerals to be rearranged or realigned. Pressure also makes the rock more dense as it is squeezed into a smaller space. This means that 1 m^3 of quartzite weighs more than 1 m^3 of sandstone from which it is formed.

Here are the names of some rocks and the name of the metamorphic rock they turn into when they are heated and squeezed. Sed = sedimentary, Ign = igneous, and Met = metamorphic

Original Rock + ***Heat and Pressure*** = **Metamorphic Rock**

Sandstone (Sed) ⟶ Quartzite (Met)

Shale (Sed) ⟶ Slate (Met) ⟶ Mica Schist (Met)
(more heat and pressure)

Limestone (Sed) ⟶ Marble (Met)

Granite (Ign) ⟶ Gneiss (Met)

Activity #1: The Metamorphic Transformation

Introduction:

Metamorphic rocks form from other pre-existing rocks. They result from high pressures and temperatures encountered by rocks that are deeply buried in the crust or are involved in mountain building.
Using the Plasticine igneous rock you made in the first lab, you will simulate the pressure on rocks that become buried in the crust, and observe the metamorphic results.

Materials:

- 1 Plasticine igneous rock • gneiss
- your hands • layered sedimentary rock (sandstone or siltstone)
- large lump of clay with many pennies shoved into it at all angles

Procedure:

1. Place your Plasticine rock model on the table.
2. Press down on it with your hands until it flattens to about one third the starting thickness.
3. Slice through the flattened rock with a butter knife. Compare its appearance with a metamorphic gneiss.
4. Draw what you see in your lab book.

Questions:

1. In this lab you squeezed the rock with your hands. In nature, where would pressure cause similar in changes in real rock?

2. Which of the following machines most closely matches what happens in the metamorphic process?
   a) a cement mixer b) a car crusher c) a blast furnace

3. Look at the **foliation** (layering) created in your Plasticine model and compare it to the layers observed in a sedimentary rock. How are they different?

4. You find a rock that looks very strange to you. It is folded and has several deformed fossil clam shells in it. Your friend Eric asks you how it formed. What would you tell him?

Videos, Guest Speakers and Publications

Videos

In addition to the video resources provided with this unit, the following videos are available from the respective companies or by contacting MineralsEd:

1. Mining Association of Canada — *Transformations* **(14 minutes);**
   Mining Association of Canada — *Rock Video* **(8 minutes)** (English or French).

   Contact: The Mining Association of Canada Ph.(613) 233-9391
   809 - 350 Sparks Street,
   Ottawa, ON K1R 7S8

2. Dyno Nobel Ltd. - *"Dance of the Detonators"* **(3:45 minutes)**

   Contact: Western Regional Manager Ph. (403) 263-9160
   #192-200 Rivercrest Dr., S.E. Fax. (403) 236-5625
   Calgary, AB T2C 2X5

Publications & Guest Speakers

The following groups and places offer mineral relevant information and outreach:

1. Natural Resources Canada
FACTS LINE Ph. (613) 947-6767
NRCAN's Facts Line features current information on the Canadian Minerals industry, sometimes weeks before it is published. It offers profiles and the outlook for 40 mineral commodities and information on exploration developments and promising deposits in Canada.

Natural Resources Canada - Geological Survey of Canada
Publication Office, Ph. (613) 995-4342
601 Booth Street,
Ottawa, ON K1A 0E8

Natural Resources Canada - Geological Survey of Canada (Pacific)

Suite 1500-605 Robson Street	Ph. (604) 666-0517
Vancouver, BC V6B 5J3	
Reception:	Ph. (604)666-0529
Email: gscvan@gsc.nrcan.gc.ca	Fax: (604)666-1124
Maps & Publications:	Ph. (604)666-0271
Email: gscvan@gsc.nrcan.gc.ca	Fax: (604)666-1337
Library:	Ph. (604)666-3812
Email: libvan@gsc.nrcan.gc.ca	Fax: (604)666-7186

2. **Ministry Of Employment & Investment, Energy & Minerals Division**
   Communications and Public Affairs Branch
   Parliament Buildings — Ph. (250) 952-0542
   1810 Blanshard Street
   PO Box 9322 Stn Prov Gov't
   Victoria, BC V8W 9N3

3. **Mining Association of British Columbia**
   900-808 West Hastings Street — Ph. (604) 681-4321
   Vancouver, BC V6C 2X4 — Fax. (604) 681-5305
   • www.mining.bc.ca

4. **Geological Association of Canada** — Ph. (604) 684-7254
   • www.gac.ca

5. **Association for Mineral Exploration BC**
   800 - 889 West Pender Street — Ph. (604) 689-5271
   Vancouver V6C 3B2 — Fax: (604) 681-2363
   www.amebc.ca

6. **Coal Association of Canada**
   Public Relations
   50 - 205 9th Ave. S.E. — Ph. (403) 262-1544
   Calgary, AB T2G 0R3
   • Coal Kit
   • www.coal.ca
7. **Britannia Mine Museum**
   Box 188 — Ph. 1 (800) 896-4044

Britannia Beach, BC V0N 1J0
•Rocks and Minerals Sets
•Teacher Information Packages
•Mining and Geoscience Activities
•Gold Panning and Tours
• http://britanniaminemuseum.ca

8. **Science World**
1455 Quebec Street — Ph. (604) 443-7443
Vancouver, BC V6A 3Z7 — Fax. (604) 682-2923
•Scientists & Innovators in the Schools
•Teacher Evenings
•Email: sisinfo@scienceworld.ca
• www.scienceworld.ca

9. **The Northern Miner** — Ph. (416) 445-6641
12 Concorde Place, Suite 800
Toronto, ON M3C 4J2
•Canadian Mines Handbook
•The Northern Miner
•Mining Explained
• www.northernminer.com

10. **Pacific Museum of the Earth** — Ph. (604) 822-6992
Earth and Ocean Sciences Building
University of British Columbia
6339 Stores Road
Vancouver, BC V6T 1Z4
•School group visits
• www.eos.ubc.ca/resources/museum/index.html

11. **Yukon Dan**
PO Box 18152 — Ph. (604) 948-4941
1215C - 56 Street
Delta, BC V4L 2M4
•Gold panning workshops in the classroom for all ages
•www.yukondan.com

12. **McAbee Fossil Beds**

Cache Creek, BC Ph. (250) 374-7164
• Students dig the fossil beds and are able to keep their find
• Digging season runs from May to October. There is an on-site guide daily from 9:00 - 4:00 during the high season in July/August
• Email: DaveL@sageserve.com (Dave Langevin)
• Web: www.dll-fossils.com

13. **SFU Earth Sciences Lab**
Simon Fraser University Ph. (778) 782-4925
Burnaby, British Columbia
•Contact: Ms. Robbie Dunlop

14. **The Exploration Place**
333 Becott Place Ph. (250) 562-1612
Prince George, British Columbia
(Mailing address: P.O Box 1779, Prince George, B.C. V2L 4V7)
• On-site and virtual exhibitions on a variety of topics including Earth Science
• Offers Science To Go! Resource packages for rental
• Email: info@theexplorationplace.com
• Web: www.theexplorationplace.com

15. **Rossland Mining Museum and Le Roi Mine**
Highway Junction 22 and 3BPh. 1 (888) 448-7444
Rossland, B.C.
(Mailing address: P.O. Box 26, Rossland, B.C. V0G 1Y0)
•Highlights:the Le Roi mine tour, gold panning and mineral collection
• Tours run May - August
•Email: museum@rossland.com
• Web: www.rosslandmuseum.ca

16. **The Snaza'ist Centre / Mascot Gold Mine Tours**
5800 Highway 3 Ph. 1 (888) 799-8733
PO Box 20
Hedley, B.C. V0X 1K0
• Offers Mascot gold mine tour including 200 metre tunnel
• Interpretive Centre with visual and audio displays of history of the Mascot Gold Mine, the Similkameen Valley, and First Nations History.
• Email: info@mascotmine.com
• Web: www.mascotmine.com

17. Science North

This is a science centre in Sudbury, ON that has online activities for students including interactive "Groundwork: Exploring for Minerals in Canada" that helps students learn about mineral exploration.
• Web: www.sciencenorth.on.ca/groundwork/

18. BCIT (British Columbia Institute of Technology)
A post-secondary technical school currently offering a two year *Mining and Mineral Exploration Technology* diploma program.
• Web: www.mining.bcit.ca

19. UBC Norman B. Keevil Institute of Mining Engineering
5th Floor, 6350 Stores Road — Ph. (604) 822-2540
University of British Columbia — Fax: (604) 822-5599
Vancouver, BC V6T 1Z4
• Web: www.mining.ubc.ca

Unit Evaluation

All teachers that receive the ***resource kit*** **are requested to complete this form. The first part refers to the** ***inservice presentation*** **and the second is when the** ***teacher has taught the unit.***

This is an extremely important process. We want to make this as teacher friendly as possible. Your assistance will help with revisions that will provide additional supplements to your kit.

Inservice Presentation and Evaluation

1. Name: ____

   School: ____

   Location of Workshop: ____

   Grades and Subjects Taught:

   ____

   ____

   ____

2. How can we improve the inservice? Include time, costs, location, materials, concepts, ideas, etc.

   ____

   ____

   ____

   ____

   ____

   ____

   ____

   ____

   ____

Now that you have used your Resource Unit and Kit, please take a few moments and fill out this evaluation form and send it to: **MineralsEd, 900 - 808 West Hastings Street, Vancouver BC, V6C 2X4**, or fax to 604-681-5303.

1. Were the units clear in their approach for: Teachers? _________________________
   Students? _________________________

2. Were the resources adequate?
   ____
   ____

3. Were the activities appropriate for grade and subject?
   ____
   ____
   ____

4. How did you evaluate your students on the unit?
   ____
   ____
   ____

5. Would you be interested in presenting these units to other teachers and be a part of the contributing team?
   ____

6. Would you be interested in sharing information to further enhance this program?
   ____

Name:

School:

Address: