

Grade: 6-8

Where Do Minerals Come From?

Lesson #B6: Mine a Pie

Time: 2 class periods

Overview:

Students mine a plot of "land" and determine a profit or loss based on the choices made.

Essential Questions:

How are minerals extracted?

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Source: Adapted from Alaska Resources Kit: Minerals and Energy, Module D-Ecology/Economy Rev 1996

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Overview:

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Essential Questions:

How are minerals extracted?

Assessment

Can students:
Analyze a solution to the problem of extracting minerals profitably, and describe the effects of federal and state law on mining?

Vocabulary

- Contour
- Environmental Impact Statement
- Environmental Protection Act
- Land Lease
- Manufacturing
- Milling
- Placer Mining
- Profit
- Reclamation
- Refining
- Strip Mining or Open Pit Mining
- Tailings
- Surface Mining Control and Reclamation Act of 1977
- Underground Mining

Alaska Standards

Addressed:

Science GLEs

The student demonstrates an understanding

-that solving problems involves different ways of thinking by: [6]

SE2.1 identifying and designing a solution to a problem. [6][7]

SE2.2 comparing the student's work to the work of peers in order to identify multiple paths that can be used to investigate a question or problem. (L)

[7] [8] SE2.1 identifying, designing, testing, and revising solutions to a local problem. (L)

[8] SE2.2 comparing the student's work to the work of peers in order to identify multiple paths that can be used to investigate and evaluate potential solutions to a question or problem. (L)

-of how to integrate scientific knowledge and technology to

address problems by: [6] SE1.1 recognizing that technology cannot always provide successful solutions [7] SE1.1 describing how public policy affects the student's life.

Geography E1) understand how resources have been developed and used; F3) analyze resource management practices to assess their impact on future environmental quality; Government and Citizenship F4) understand the role of price in resource allocation;

9) understand those features of the economy of the state that make it unique, including the importance of natural resources, government ownership and management of resources, G3) identify and compare the costs and benefits when making choices

Reading GLEs

The student follows written directions by

[6] [7] [8] 2.6.1 Completing a task by following written, multi-step directions

Teacher Information and Procedure

Prior knowledge for students: None

Materials needed:

For Each Pie (recommended 1 for 2 students):

- Gallon Ziplock bags
- Pie tin or plastic bowl
- Materials for pies (substitutions of mud, gravel, sand, etc. may be made for oats and flour):
 - oats (2 cups/pie)
 - flour (2 cups/pie)
 - water
 - 15-bean soup mix
 - wheat puffs or other cereal
- Blue frosting or cake sprinkles (1 tube/6 pies)
- Green cake sprinkles (1 sm tube/30 pies)
- Whipped topping (1 lrg bucket/4 pies)

Other Materials:

- Paper towel
- Newspaper or something to cover desks
- Plates, Forks, Spoons
- Flat toothpicks
- Calculators
- Copies of the following (if you can use different colors of paper it will help students to keep track of all the different sheets):
 - Dig, Dig, Dig directions sheet
 - Cost/Income Charts
 - Mine Reclamation Cost Sheet
 - Cost Tally Sheet
 - Mineral Income Tally Sheet
 - Profit/Loss Tally Sheet

What to do in advance:

Read the background information and all of the directions for the activity.

Make pies (See directions) and revise the mineral income chart if necessary.

What to do during the lesson:

- **Gear up:**

Give students the handout "Laws that Affect Mining" and have them complete the quick matching exercise. Discuss the answers, and the purposes and possible effects of the laws.

- **Explore:**

Introduction: In this activity students will be mining a portion of a pie containing beans which represent a variety of minerals. It is assumed that all areas of the pie have the same chance of being profitable. The students will have to pick their proposed mining areas based on economic and environmental considerations. They may not mine in preserved areas, or near water resources, and they must design a reclamation plan. They must lease their land, pay for employees, equipment, and transportation, in addition to extracting as little material as possible, yet maintaining a high mineral profit.

After the area is mined and milled, the students reclaim the land. Students then calculate the amount of money made from their extraction compared to the amount of money it cost them to mine it to determine if their company had a profit. After companies determine their losses and gains, they then examine their choices to determine if they could have made more money with a wiser choice.

This lesson can be as complicated or as simple as the teacher wishes to make it. Delete some of the steps or tasks depending on the time available and the abilities of your students.

1) Discuss the minerals mined in Alaska. The following are the minerals found in Alaska: Sub-bituminous Coal, Bituminous Coal, Anthracite Coal, Copper, Zinc, Silver, Jade, Gold, Tin, Platinum. Explain to the class that they will be working in teams to represent a company mining a small plot of land, and mining beans that represent the different Alaskan mineral commodities. Show them which bean represents each commodity. On this property they may find some or all of the resources mined in Alaska. Discuss why geologically this would not likely be true. Explain that most mines only mine one or two valuable minerals, that which is most abundant in the area and economically worth recovering.

2) Review the costs of mining. Although money can be made, it costs money to buying/leasing land, mining it, preparing it, transporting it and reclaiming it. Discuss the economic risks of not knowing for certain what you will find under the ground.

3) Discuss that state law, governing metal mines, and the Surface Mining Control and Reclamation Act of 1977, governing coal mines, require that mines must be restored to federal and state guidelines to ensure the area is safe and stabilized. Discuss that some state and federal money comes from mining taxes and revenues.

4) Divide the class into mining teams (companies). Explain each team represents one mining company interested in leasing up to 2 square miles of land out of an 8 square mile area. The company has an idea what minerals could be recovered from this plot of land (see Minerals Income Chart), but there is no way of really knowing abundance until the digging begins.

5) Pass out the Dig, Dig, Dig directions, charts, and tally sheets. Read through the following directions aloud once with students before passing out the pies. (These directions follow the student sheet Dig, Dig, Dig in more detail.)

1. Each team receives a pie and chooses a part of it to mine. This pie represents 8 square miles of land and you will be mining a part of it. You may choose a $1/16$, $1/8$, $3/16$ or $1/4$ of the pie to mine. You may not mine any area that is preserved (green sparkles). You may choose an area containing a river or lake, but you must leave at least 1 cm of that water (blue frosting) untouched.

2. After your team chooses the area you will mine, mark the area by drawing a line in the cool whip with a toothpick and dividing it into $1/16$ sections. (Showing whether you chose $1/16$, $2/16$, $3/16$ or $4/16$).

3. Now you need to pay to lease your land. See the Cost/Income Chart sheet. Look under Lease Cost Chart. Choose the price which describes the size plot you choose. Find the Cost Tally Sheet. Put the price to lease your land next to LEASE COST.

4. Now write how you plan to reclaim your mine on a sheet of paper titled Reclamation Plan. It can be more expensive or take different techniques to reclaim an area which is exposed to the wind or sloped. Wind can blow soil and seeds away, so sometimes one has to plant seedlings. Slopes can have a lot of water erosion and land slides; therefore, one must shape different contours to help secure the soil and top layers.

5. Next you need to figure out how much it will cost you to reclaim your land after you mine it. Use the Reclamation Cost Sheet to figure out the cost to reclaim your land. The prevailing winds in the flow chart refer to the wind which always blows from the back to the front of the room. Follow the flow chart for each $1/16$ th you will mine. If you choose $3/16$ of the pie, you would go through the flow chart 3 times. Each time you would follow the chart for a different

1/ 16th. After you have the price for all your sections, add them together to get the total price for reclaiming your mine. Write this on the Cost Tally Sheet next to RECLAMATION COST.

6. Figure the tax for leasing the land using the formula on the Cost Tally sheet and write it next to TAX.

7. Use the Employee Cost Chart on the Cost/Income Chart sheet to hire employees to mine your area. Write it next to EMPLOYEE COSTS on the Cost Tally Sheet.

8. Choose mining tools from the tool list found on the Cost/Income Chart sheet. You may choose more than one tool, and may add tools while mining, but you must pay for every tool used. Write the cost for each tool you choose on the Cost Tally Sheet next to EQUIPMENT COST.

9. Get your purchased tools. When you are mining you may NOT use your hands. You MUST extract ONLY using the tools provided. At any time during the activity you may buy additional tools. AT NO TIME MAY YOU USE YOUR HANDS, even when the minerals have been extracted and you are trying to "clean them up" (milling.) Mine the plot. All minerals found are extracted and placed on a plate. Remove minerals carefully with as little environmental disturbance as possible. Anyone mining in a preserved area (green sparkle) or too close to the water will be fined (by the teacher).

10. Mill the minerals, meaning remove the gunk from the mineral, and categorize them into piles.

11. After mining and milling, tally the amount of money made from each of the minerals found using the Minerals Income Tally Sheet.

12. Explain that Alaskan bulk items may be more expensive to transport if the mine is far from a port. Calculate the amount of money it will take to transport your coal to port using the formula on the Cost Tally Sheet under COAL TRANSPORT COSTS. Record your answer.

13. Add the total amount of money made on the Mineral Income Tally Sheet.

14. Add up the total amount of money spent on Cost Tally Sheet. Write the total money made and the total costs on the Profit/Loss Tally Sheet.

15. Subtract the total costs from total made to determine whether your company had a loss or a profit.

6) Students follow the directions on the Dig, Dig, Dig instruction sheet to complete this activity. You may choose to do steps 3, 5-8 and 11-15 together as a class, to assist students with the forms.

7) Give the students 5-10 minutes to reclaim their mine after they've finished milling. Check to see that they have followed their reclamation plan and that the area has been sufficiently restored. If it has not, fine them, charge them more employee time, and require they fix their area.

- **Generalize:**

Compare the costs, incomes, and profits of the companies. On their profit/loss sheets, teams analyze why they think they lost or made money and design a plan for increasing profits next time. Share the teams' company analyses.

List and discuss all the "pieces of the puzzle" that must be solved in order to have a profitable mine: Are there minerals present? What will it cost to get (or try to get) the minerals? What will it cost to transport them to buyers? How much of the mineral will we be able to get? What are the laws and regulations that must be followed, and what will that cost? (etc)

Discuss these questions:

How would it affect our lives if no one could afford to extract minerals?

Why and how does public policy affect mining? What would happen if there were no laws governing mining?

- **Assess:**

Ask each student to write a summary of the activity, discussing the factors that must be considered before deciding to mine. They should also discuss the potential public impacts of mining and the purpose of laws to regulate mining.

Related Resources in the AMEREF Kit

- On the AMEREF CD:
 - o Rocks & Minerals Overview
 - o Rocks & Minerals Game
 - o A Golden Promise-Fort Knox Video
 - o Overview of Mines in Alaska
 - o Links to Geology, Mining, Energy, and Forestry Related Websites
 - o Generalized Geologic Map of Alaska-Werdon, Szumigala, & Davidson
 - o Mineral Identification Overview-AMEREF

- Alaska Rock and Mineral Collection (40 specimens): Scott Resources
- Alaska's Oil/Gas & Minerals Industry: Alaska Geographic
- Rich Earth: Alaska's Mineral Industry: Alaska Geographic
- The Golden Gamble: Alaska Geographic
- Hard Rock and Placer Mining in Alaska: The Searchers Video
- Alaska Coal: Pioneering in a New Environment Video
- Sleeper Mine: The Awakening Giant Video
- Alaska Minerals: Facts, Figures and Trivia: BLM
- Alaska's Place in the International Minerals Industry: Alaska Miners Association
- The Mining Industry and Minerals Newspaper: National Energy Foundation
- Mining Reclamation Newspaper: National Energy Foundation
- Rivers of Gold-Placer Mining in Alaska Handout: USGS
- Rock Kit Specimen Overview Poster: AMEREF
- The Interaction of Federal Environmental Public Land Laws Poster: AMEREF
- Example of an Operating Molybdenum Mine Poster: AMEREF
- Alaska's Mineral Deposits Poster: AMEREF
- Hidden Treasures: Alaska Minerals Poster and Information Poster: Juneau Mineral Information Center
- From Mountains to Metals: The Story of Rocks, Minerals, and the Mining Industry Poster: National Energy Foundation
- Mining Reclamation-Responsible Reuse of Lands Through Planning, Management, and Technology Poster: National Energy Foundation

Extensions, adaptations, and more resources:

If you have a limited time, or want to challenge your students with more real life scenarios, then include a time factor. Make each minute worth 1 month. After 12 minutes of mining, charge them another year of wages for their employees. You may choose to mine for 1, 2 or 3 years. Usually 2 years is sufficient. You may also choose someone to purchase the minerals/metals. Encourage students to save room during their mining time to mill their minerals. When the time is up, have a purchaser (teacher, principal, custodian) buy the minerals which are "clean" enough to make it worth purchasing them. The students should only tally profits from those minerals which were sold.

Simplify the activity by using only one or two types of minerals.

Graph the classes' profits and costs.

Research local mines, including the jobs they support, the tools they use, what they mine, and where they sell it.

Find out the actual cost per ton of each of the minerals in today's market, and compare with the costs used for this simulation.

Research the minerals that are mined in Alaska and how money from mining may help the state economy.

Brainstorm careers in mining.

Research to find out more about the Surface Mining Control and Reclamation Act of 1977 and other laws that affect mining in Alaska. Find out what kind of permits are required for mining.

Background

Mining has played a major role in Alaska since the first days of the Klondike Gold Rush in the late 1800's. Before the advancement of large scrapers and bulldozers, mining was mainly done on a small scale using pans, sluice boxes, or small dredges along river beds. With the advent of track bulldozers in the late 1920's to the big bulldozers and drag lines of the 1950's, Alaska's large mineral deposits have become increasingly economical to mine.

There are many mineral commodities mined today in the state, including: copper, gold, jade, lead, platinum, sand and gravel, silver, tin, zinc, coal, oil and natural gas. There are different types of mining techniques used in Alaska including placer, strip or open pit, and underground mining. Generally, Alaska zinc and coal are mined above ground. Alaska silver and gold are mined underground, as seen in Southeast, or in placer mines as seen in the Interior.

Before a company decides to open a mine, the area must be tested and explored to predict if the mine will yield a profit. If the geologic testing proves favorable, the company will decide to go ahead and begin the permitting process through the local, state, and federal government. During this permitting process the company must pay to have an environmental impact statement (EIS) conducted on the proposed area. An EIS is a study which determines the potential hazards to safety, wildlife, habitats, and air/water quality, to name a few, from which the company, public, and agencies can respond on the various development reviews. From this information the permits may or may not be awarded.

After a company purchases or leases a piece of land, they must determine if the area is worthwhile to mine and receive permission to do so from local, state, and federal government agencies. The company will then make the investment to build roads, housing, milling facilities, and prepare the area to mine. This requires an enormous amount of planning and design, and could cost the company hundreds of millions of dollars. Even after all of the studies and exploration, the mining company always takes an economic risk. All of their studies are only educated guesses about the mineral amount and quality and the future economic conditions.

The mined material is called ore; it is the rock which contains the valuable mineral. Sometimes the mineral is found as a vein or chunk. Sometimes it is intermixed with the rock. You could think of an ore like a cookie with big chocolate chips and tiny bits of finely crushed nuts. Both the large chunks of chocolate and the tiny bits of nut would be the mineral and the whole cookie (flour, sugar, eggs, . . .) the ore.

After the ore is extracted from the ground, it is taken to the mill. This facility is usually located near the mine. During the milling process, the mineral is extracted from the ore by crushing it with large steel balls or rods, and separated using large magnets, gravity, or chemicals. The wastes, called tailings, are the left over rock from this extraction process. The milled mineral, called concentrate, is then sent on to a smelter or a refinery to be made into its purest form. Some mining companies mill, smelt, refine, and mine. Others only mine and mill, selling their concentrate to someone else who will process it and sell it to the manufacturer.

In Alaska, as in other states, the state and federal government tax mining companies. This money is used to help run state and federal government. A mine in Alaska may be in operation anywhere from 5-50+ years depending on the mineral they are mining, the location, the mining technology being used, the amount of mineral to be extracted, and the market value of the product.

Mining is not a delicate procedure. It involves moving a lot of the Earth's crust to extract the minerals we use in our everyday lives. The Surface Mining Control and Reclamation Act of 1977 and the state reclamation laws address some of the environmental concerns of mining. These laws require a mined area be returned to a natural, safe state and without harm to other resources. This means contours and vegetation are returned to the area to stabilize erosion and provide suitable habitat. Surface and ground water is protected from contamination, and the area is made safe and usable. The permitting process of mining requires that the company wishing to mine an area state, in explicit detail, their plans to reclaim a mine. They must also indicate how they will pay for this reclamation. The cost for reclamation is included in the cost of mining.

Laws that Affect Mining

Can you match each law with its name?

Environmental Protection Act

A law that requires an approved reclamation plan before a miner or mining company engages in a mining operation

Surface Mining Control and Reclamation Act of 1977

A law that requires mining companies and other developers to prepare an Environmental Impact Statement analyzing the long-term effects on the environment that may result from their operations.

Alaska State Statute 27.19.030

A federal law which requires a coal mine area to be returned to a natural, safe state and without harm to other resources.

Teacher Directions for Making Mine-A-Pies (not edible)

It takes approximately 1/2 hour to make 15 pies if an adult is making them in assembly line fashion.

Mix the ingredients below (enough for 5-6 pies): You may substitute any of these ingredients. You may also use mud, sand, gravel, and soil, beads, buttons, metal nuts, etc. instead of food items.

- 5-10 cups oats
- 10-12 cups flour
- 3-4 cups beans/cereal (1 bag of 15 bean soup and 1 ½ cups cereal)

Note: see the Minerals Income Chart on the Cost/Income Chart page and make sure you have all of the kinds of beans named. If not, or if you are using other substitutions, you will need to change the chart. The following are the minerals found in Alaska from most to least abundant: Sub-bituminous Coal, Bituminous Coal, Anthracite Coal, Copper, Zinc, Silver, Jade, Gold, Tin, Platinum. You might want to attempt to include amounts of each bean or substitution in proportions that follow that order.

- Water to make moist, about the consistency of cookie dough.

Glop mixture into the pie pan. Pat it down gently leaving the top layer with contours and mountains.

Cover with a thin layer of cool whip* to make the top soil. You may choose to omit the cool whip on parts of the pie, as some areas in Alaska do not have sufficient top soil.

Use blue frosting to mark rivers, a wetland and/or lake.

Sprinkle green cake sprinkles (or glitter) on top to represent a preserved area (cover about 1/4 of the pie).

Place in a Ziplock bag, (do not close), to keep moist.

* Test the topping. Some brands will stand over night, others need to be put on right before the activity.

DIG, DIG, DIG

Follow the steps outlined below:

1. Choose a plot of land to mine. It can not be bigger than 1/4 of the pie. You may choose 1/16, 1/8, 3/16, or 1/4 of the pie.
2. Draw the area YOU will mine on your pie using the toothpick. Divide it into 1/16 sections.
3. Figure out the amount of money it will cost you to lease the land you chose by using the chart called Lease Cost Chart. Write it next to LEASE COST on the Cost Tally Sheet.
4. Write how you will reclaim your mine once your are finished extracting the minerals. Write your idea on a piece of paper called Reclamation Plan.
5. Figure out how much money it will cost to reclaim each 1/16 section your mined area using the flow chart on the sheet called Mine Reclamation Costs. Write it next to RECLAMATION COST on the Cost Tally Sheet.
6. Figure out the amount of tax you will need to pay on your lease using the formula on the Cost Tally Sheet. Write the amount next to TAX on the Cost Tally Sheet.
7. Use the Employee Cost Chart to figure the cost to hire employees to mine your area. Write this amount next to: EMPLOYEE COSTS on the Cost Tally Sheet.
8. Choose your tools from the Equipment Cost Chart and write their prices next to: EQUIPMENT COSTS on the Cost Tally Sheet.
9. Mine your area. Place all the minerals on a plate. You may NOT USE YOUR HANDS. You may not mine within 1 cm of any water or in a preserved area.
10. Remove all of the extra “goo” stuck to the mineral. You may NOT USE YOUR HANDS. Put all the minerals into similar piles.
11. Use the Minerals Income Sheet to figure out what you took out of the ground. Then use the Minerals Income Tally Sheet to figure out how much money you made from each thing you mined.
12. If you mined any coal, figure out how much money it cost YOU to transport (move) this bulk resource to a port for shipping. Use the formula on the Cost Tally Sheet under COAL TRANSPORT. Write the price next to: COAL TRANSPORT COSTS.
13. Add up all the money you made on the Minerals Income Tally Sheet. Write the total on the Profit/Loss Tally Sheet.
14. Add up all your mining costs on the Cost Tally Sheet. Write the total on the Profit or Loss Tally Sheet.
15. Subtract all of the money it cost you to mine from the money you made. If you have money left over, this is the money your mine made this year, or your PROFIT. If you do not have any money left over and you have a negative number, this is the money you lost.

COST/INCOME CHARTS

LEASE COST CHART

SIZE OF MINE		COST
1/16 of the pie		\$ 150,000
1/8 of the pie		\$ 300,000
3/16 of the pie		\$ 450,000
1/4 of the pie		\$ 600,000

EMPLOYEE COST CHART (for 1 year)

SIZE OF MINE	FORMULA	COST
1/16 of the pie	10 people X 50,000/yr	\$ 500,000
1/8 of the pie	20 people X 50,000/yr	\$ 1,000,000
3/16 of the pie	30 people X 50,000/yr	\$ 1,500,000
1/4 of the pie	40 people X 50,000/yr	\$ 2,000,000

EQUIPMENT COST CHART

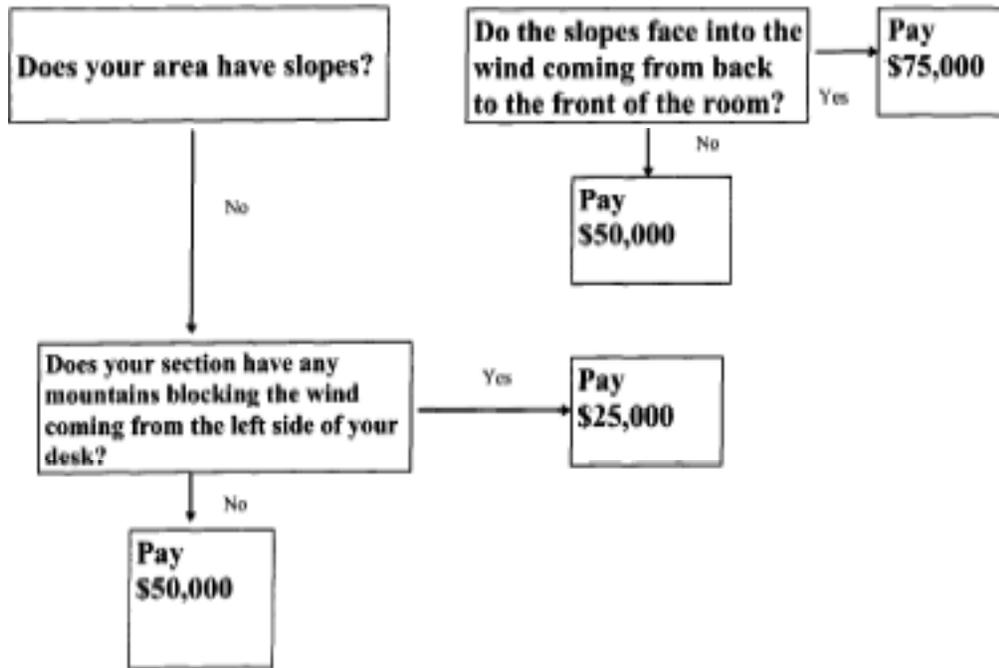
TOOL		COST
Toothpick		\$ 20,000
Fork		\$ 100,000
Spoon		\$ 200,000

MINERALS INCOME CHART

THING	MINERAL	PRICE
Wheat Puff	Sub-Bituminous Coal	\$ 5,000
Lentil	Bituminous Coal	\$ 6,500
Black Bean	Anthracite Coal	\$ 10,000
Kidney Bean	Copper	\$ 50,000
Black Eyed Pea	Silver	\$ 75,000
Split Pea	Jade	\$ 25,000
Yellow Pea	Gold	\$ 500,000
Pinto Bean	Tin	\$ 10,000
Lima Bean	Zinc	\$ 50,000
Chick Peas	Platinum	\$ 750,000

MINE RECLAMATION COSTS

Follow the flow chart for each 1/16 you choose to mine. Treat each 1/16 individually. Some of your sections may be more expensive than others.



Write the price for each of your 1/16 sections on the lines below. After you have figured the reclamation price for each of your sections, add them together to get your total RECLAMATION COST.

Section 1 _____
 Section 2 _____
 Section 3 _____
 Section 4 _____
 TOTAL _____

Company Name _____

Cost Tally Sheet

Lease Cost _____

Reclamation Cost _____

Tax=Lease Cost divided by 5

Your Tax _____

Employee Costs _____

Equipment Costs
Tools:

Coal Transport Costs

Chunks of coal x \$1500

Your Coal Transport Cost _____

Total costs of your Mining Operation _____

Company Name _____

Mineral Income Tally Sheet

Thing	Mineral Represented	# of chunks	Value per chunk	Income (Multiply # of chunks by value per chunk)
	Sub-Bituminous Coal		\$5000	
	Bituminous Coal		\$6,500	
	Anthracite Coal		\$10,000	
	Copper		\$50,000	
	Silver		\$75,000	
	Jade		\$25,000	
	Gold		\$500,000	
	Tin		\$10,000	
	Zinc		\$50,000	
	Platinum		\$750,000	
Total Income				

Company Name _____

Profit/Loss Tally Sheet

Enter your **Total Income** from Mineral Income Tally Sheet _____

Enter your Total Cost from Cost Tally Sheet _____

Subtract to get your Company's **Profit** _____

Why do you think your company made or lost money?

Make a plan increase your profit next time you mine and write
it here and on
the back of the sheet.