Lesson Plan: Mining

Subjects: Science, math, social studies, writing
Grades: 8-12
Duration: Alaska's economy- 3-5 hours. Minerals and Alaska's economic history 1-2 hours. Simple Geology of Alaska 1-3 hours, Types of formations, types of mines 3-5 hours, Oil exploration and production 2-4 hours.
Total 10-19 hours.

Vocabulary

Hydrothermal fluid: Hot water, around 300°-500°C (572°-932°F), generally associated with igneous or metamorphic activity, and containing dissolved gas and minerals.

Magma: Molten rock

Quartz: A very common mineral with the composition SiO_2. It is usually gray or white, but can also be clear, pink (rose quartz), purple (amethyst) or yellow (citrine). Quartz if quite hard, so often remains as a product of erosion, forming sand. Sand can become sandstone (a sedimentary rock) or quartzite (a metamorphic rock).

Calcite: A common mineral with the composition $CaCO_3$. It is generally white, gray or clear and is relatively soft. It forms the rocks limestone (sedimentary) and marble (metamorphic).

Pluton: A large body of igneous rock, formed by a magma in the earth's crust that remains below the surface of the earth. Individual minerals within the plutonic rock tend to be large enough to see without magnification.

Volcano: Magma that comes to the earth's surface forms a volcano. It can erupt as lava flows, or explode into the air forming volcanic ash and other volcanic debris. Since the magma cools quickly, the minerals deposits don't have time to grow and most of them are very small.

Geologic time: The geologic time scale encompasses the time since the first rocks were formed on earth, interpreted as being about 4.6 billion years ago.

Tectonic: Relating to the global-scale motions of the outer part of the earth.

Tectonic plates: Large (up to continent-sized) chunks of the earth's crust that move slowly relative to one another over the face of the globe. They can collide, separate or slide past one another.

Subduction: Where one tectonic plate pushes underneath another plate in a zone of collision between the two plates.

Fault: A break in the earth's crust where the two sides are moving relative to one another. Along the Denali fault in Alaska, the southern side is moving west relative to the northern side, so if you were standing on one side your buddy on the other side would be moving to your right. Hence, it is a right-lateral fault. The major earthquake of November 2002 was a rupture along part of the Denali fault.

Glacial age: Alaska has experienced several episodes of extreme glacial activity. The two or three most recent glacial ages, within the last 125 thousand years or less, have left behind glacially deposited landforms of rock, gravel, sand and silt as evidence of their existence.

Orthogneiss: A metamorphic rock formed from a plutonic igneous rock with lots of quartz in it. It generally has a banded appearance, with layers formed by different minerals. It has experienced high pressure and temperature during metamorphism.

Amphibolite: A metamorphic rock formed from a dark-colored igneous rock without much quartz in it. It is generally green, or green and white and may be somewhat banded. It has experienced high pressure and temperature during metamorphism.

Greenstone: A metamorphic rock formed from a dark-colored igneous rock without much quartz in it. It is generally dark green with small minerals and no banding. It has experienced relatively low pressure and temperature metamorphism.

Shale: A sedimentary rock formed by compression and cementation of silt, clay or mud. The grains are very small, and the rock tends to break along flat surfaces.

Chert: A sedimentary rock formed from microscopically small crystals of quartz. It is hard and comes in a variety of different colors. When used for arrowheads it is called flint.

Carbonate: Any rock consisting of calcite or other minerals with CO_3 in their composition. Carbonate rocks will fizz if a weak acid (like vinegar) is squirted on them.

Hydrothermal vent: Openings (vents) in the sea floor where hydrothermal fluids escape into the ocean, also called black smokers. These are generally found where two tectonic plates move away from each other, and the fluids are known to contain high concentrations of ore-forming elements.

Students: 1) read content, 2) participate in class conversation 3) do activities and 4) do assessment.

Teacher Objective

The purpose of this unit is to expose students to the economic, social, political, geological and scientific aspects of mining and its impact on Interior Alaska.

The most important concepts in this lesson are:

- Urban media has promoted a view of mining that is not necessarily accurate.
- Without mining, modern society cannot exist in any form.
- The current economic model followed by the State and Federal Governments is not sustainable. Interior Alaska must ask and answer the questions about mining or rural towns and villages will become ghost towns.

Introduction to Mining in Interior Alaska

Activity: Before doing this exercise, list 5 good things about mining and 5 bad things about mining.

The need to study mining. To both Natives and nonNatives, mining has shaped the lifestyles of Interior Alaska as much as any other economic, political or social element. The impact has been positive and negative at the same time. Gold rushes have continually brought miners, technology, and change from the late 1800's to the present. Towns were built and died around the availability of gold and valuable minerals.

Gold mining was seen as the poor man's single avenue to wealth. No matter what a man's education or family status, hard work and luck could raise a man above the position he was locked into. Many pursued its lure and perceived promise.

Native villages welcomed trading posts and the technology they brought like traps, ammunition and outboard motors, but didn't always appreciate the type of people who came after Alaska's mineral wealth. They were often a select breed, independent, rough and not graced with good social skills.

Towns sprung up and died, men came and went, all on the perceived availability of gold and other minerals. Families in the Lower 48 were broken when men left home to become wealthy. Alaska families were broken when those men left to return to their original homes.

Activity: List five towns in your area that originated by a mining economy. Do people still live in them or are they abandoned? Name the people in your community whose families either came to the country because of mining, or have worked at mines.

Many Alaskan careers have been, are now, and will continue to be focused on minerals. The future of Alaska hinges on how the State approaches resource extraction. Unfortunately, decisions made today will not feel the full consequence for many years, and short public memory might blur the connection.

Old time prospectors and modern Native corporations have all focused on the same questions. "Where are the minerals? How can we extract them economically? How can we get supplies to the extraction point?" Those involved in exploration study how deposits were formed in order to predict where to find them. Modern technology has equipped exploration with awesome tools and resources. Some methods are far out of reach of the common man, but there are still many untouched streams in Alaska, and new tools to reach and explore them.

Gold mining was intensely popular in times past because it was seen as one of the few ways an every-day individual could become rich, whether educated or illiterate. It represented the American dream: Hard work and determination can bring a higher standard of living.

Activity: A goldpan is a great exploratory tool. The specific gravity of most precious metals is greater than that of country rock. If you can't get goldbearing sands, mix iron and brass filings with local sand and gravel, and practice panning into a tub (NOT the sink!) The whole idea is to shake and stir enough to cause the heavy materials to go to the bottom and the lighter materials to the top where they are washed off.

One way to tell where gold has been prospected and mined before is to look on a map. Any location where most of the creeks have names have seen mining activity.

Locations where larger creeks are unnamed were likely not focal points of mining/ prospecting.

Native corporations. Red Dog and Donlin Creek are large mineral deposits that have or will deliver financially for Native Corporations. Doyon, Calista, Nana, Ahtna, Shee Atica, almost all of the Native corporations are looking for mineralization to keep their corporations going financially.

Activity: Locate at least 10 mines in Alaska that are currently producing.

The urban political climate and media often paint mining as an evil element. However, this view is oversimplified and doesn't consider the foundation of the Alaskan economy.

- Money must come from somewhere. At this time (2013) forty-six cents of ever dollar the Federal Government spends is borrowed money. This mathematically, absolutely, cannot continue. The Federal contribution to States economies will, without question, decline. At the same time, the State of Alaska is experiencing a long ago predicted reduction in oil revenues from the North Slope oil reserves. That contribution to Alaska's economy is absolutely certain to drop every year.

Unalterable reality: Alaska's economy must come from somewhere. Either, we will cut government services or we will find other ways to continue funding them.

- America is the greatest consumer nation on the planet. While we look for cleaner alternate energy sources, we must realize that those alternative energy efforts utilize copper, nickel, rare earth elements etc. It takes over 100 miles of copper wire to build and connect a large wind-generator to the grid. Materials for all high tech components are extracted by mining. Without mining, green technology cannot be implemented. Residents of villages in the YK Delta say they have seen no decrease in their electric bills with the recently installed wind generators even though the Federal Government put up the money to build them.

  New rare-earth magnets are changing the face of wind power generation. Plasma TV screen technology is totally dependent on rare earth elements. Cell phones and other technology are completely reliant on the mining of silver and other conductive metals. China either owns or has rights to 98% of the known world supply of rare earth minerals. There is a sizable rare earth deposit not far from Tanana.
- It is amazing that mining opponents would rather get minerals from nations that have few or no environmental regulations than encourage mineral extraction from the US, where concern for the environment is so high and mineral extraction is safer than anywhere else. All modern technology is made from and fueled by petro-products and mining products.
- The Alaskan media and urban environment are directly and indirectly supported by the mining industry of Alaska. A huge percentage of Alaska's economy comes from extracting mining products from rural areas. Without extraction of this resource, the urban centers would soon mimic Detroit.

Activity: Randomly pick 10 items in the classroom. Identify the components of all 10. How many of them came from the mining of minerals? From the mining of petroleum (including plastics?)

The Reality of Alaska's Economy

The foundation of all true economy is production. Something must be produced to generate wealth. Economic value is either mined, logged, farmed, or is intellectual property created of, by and for high technology which is also dependent upon mining, logging and farming.

Mining includes extraction of: minerals, gas/oil and coal.

Alaska's economic options

While it appears that Anchorage is the main economic capitol of Alaska, the economy of Anchorage is rooted in supplying the oil/gas, fishing, transportation, tourism, and mining industries of the State, which all originate in rural areas of the State.

Some of the rural dollars, like mining dollars, tend to stay in the local economies, equipment purchase and repair, fuel sales, transportation, support industries like catering, welding etc. Some of those rural dollars immediately enter the hands of large corporations and leave without circulating through the hands of local people at all.

The foundation. Following are the main sources of Alaska's economy.

Tourism. Tourism is an important part of the State's economy. It enriches Alaska's people by redistributing wealth from other parts of the Nation and world. Tourism shifts wealth around the globe. There are many service jobs that come from tourism.

Communities on the Alaskan road or ferry systems are fortunate enough to have access tourist dollars. Most rural Alaskans, apart from fishing and hunting guides, do not have that opportunity. A great percentage of tourism money comes into the State and leaves immediately in the hands of the large tour companies.

Tourism is vitally important to Alaska and is a mainstay for many select communities, but is little benefit to many other regions.

Fishing. Fishing has been a major part of the Alaskan economy for over a hundred years, but, increasingly, Alaskan commercial fishing is becoming Seattle and Internationally based. The number of Alaskan fishermen, processing plants and accompanying workers continue to decline. Since there is no State income tax, thousands of foreign workers come, make money and take money, with no benefit to the state economy.

Problems with the poor king salmon returns have impacted other fisheries as well. The solution to those problems exist on an international level, and are beyond State control. The State of Alaska spends large sums of money maintaining and monitoring the fishing industry, yet is not able to provide the management necessary because of failed international policies on the open seas.

Timber. The Alaskan timber industry has been crippled since the Federal Government collapsed the economy of S.E. Alaska with logging restrictions. There are pockets of lumber production in Alaska, but for the most part, lumber production is for local consumption only, no longer for commercial export.

Farming. Most major communities in Alaska have three days food supply on hand. Beyond that time, store shelves will be bare. The need for local production of farm goods is great, but the expense of producing in Alaska is also great. Farming communities like Delta and the MatSu Valley have worked diligently to grow Alaskan crops. The cost of fertilizer, livestock feed, and winter challenges make Alaskan grown crops and dairy/beef not very competitive. Many Alaskan dairy farms are now closed down because of that economic reality.

The average age of an Alaskan farmer is 63. Few young people are getting involved in agriculture.

An exciting farming project in Bethel has proven the possibility of farming for profit in rural Alaska. Results were so good, some of the produce was actually exported to Anchorage. However, the level of ingenuity and ambition to accomplish and sustain that are rare.

Government Jobs. There is continual talk about creating more jobs, but the money to support government service jobs must originate in production derived from taxation of production. Government jobs might help keep infrastructure open so production can take place, but those jobs do not create wealth. They assist the economy to the extent that they expedite production by the private sector. The wealth that drives a true economy comes from production.

Military. The military has been a huge contributor to the economy of Alaska, in Fort Richardson and Elmandorf in Anchorage, in Eielson and Wainwright in Fairbanks, Ft. Greely in Delta, the missile site in Kodiak and many Coast Guard stations. The military has been important in supporting local economies, schools and infrastructure since WWII. Many former military men and women came her while in the military service, fell in love with Alaska and have returned as full time residents. Alaska's strategic geographic location in the world assures some level of military presence will remain in the State. However, closures are far more likely than expansion of facilities. If Eielson were closed in Fairbanks, the local economy would stagger. Military expenditures nationwide are declining. Nationwide, the military protects our ability to produce.

Oil/gas. Before the discovery and extraction of oil and gas from the North Slope, Alaska was a poor state. Fishing, mining and logging were the mainstays. Trapping supported many rural families. There was a State income tax, and services were sparse. Currently, oil production provides about 93% of state revenue.

Activity: Have students draw a colored circle graph of this proportion.

Oil production is declining on a predictable curve. The original estimates said the life of TAPS (Trans Alaska Pipeline System) would be twenty years. Production has already gone beyond original projections, and the daily flow of oil is less than 33% of the original production.

The price of oil is high, which masks the decline in production. Yet all oil development stimulus plans combined only slow the rate of decline through TAPS. There is *no plan* that includes a production increase.

State revenues will fall. Cuts will come. That is as certain as the sun rising in the morning.

The controversy continues as to the tax rate the oil companies should pay. Does reducing the amount of money the state takes from each barrel of oil stimulate the oil companies to invest more in exploration and development and therefore bring more production in the long run? Or, is the state giving away revenue to oil companies that are in a harvest mode and have no plans for further development? No one knows the answer to those questions.

Talk about massive heavy-oil deposits on the North Slope are meaningless until methods are discovered to extract the heavy oil (high viscosity oil.) At the same time, heavy oil doesn't flow well in the pipeline. There must be enough light crude left to lower the viscosity so the heavy oil can flow, especially in the winter when the oil cools rapidly. The supply of light crude is dwindling.

The decline through TAPS is undeniable and unavoidable. The methods to stimulate production are constantly debated. Development of oil in more hospitable oil fields in the US, like North Dakota have drawn attention away from Alaskan oil. There is no positive solution to the inevitable decline in production and consequent decline in State revenues.

There are a few other possible oil fields, one in the Copper River Valley, a possible gas supply in the YK Delta, possible oil and gas in Nenana West, and a few other locations. However, not all are on State lands and will not provide State revenue, and all of them combined, if they came online, would not equal the decline in North Slope oil. Again, the reality looms.

Coal. Alaskan coal has been controversial and stigmatized for over a hundred years. Most Alaskans don't realize that Alaska has ten times more BTU's in coal than it does in gas/oil combined. Alaska's coal, like the deposits at Healy, is the second cleanest coal in the world, second only to Indonesia. Military bases like Anderson and Eielson generate electricity with Healy coal using technology that *exceeds* Federal emissions requirements. UAF is totally dependent on coal for heating its buildings. Fairbanks is paying 25 cents/KWH for electricity, when nearby Anderson military base is producing clean electricity with coal for 9 cents/KWH with 16 megawatts to spare. The contrast is bewildering.

Coal has been used by Alaskans for centuries. Residents of Homer pick up coal as it is stranded on the beaches. Coal from Chickaloon, northeast of Palmer, was used to power steamships until cheap oil replaced it. Coal deposits of varying grade exist all over Alaska.

Today in western Alaska, we breath Arctic haze created by poorly burned coal in Asian countries that do not have good environmental standards. Yet Alaskans are obstructed in efforts to burn coal for heating and electric generation in extremely efficient furnaces and generators. The contradiction is baffling.

Healy coal is now transported by railroad to Seward where it is exported to Korea. Healy coal also heats UAF and Fairbanks military bases.

It seems that coal could be a good intermediary solution to Alaska's energy needs until greener solutions can be found, but the stigma against coal overshadows its utilization.

Just north of the village of Tyonek is a coal deposit worth over $2 billion. New technology (Accelergy), far better than the Fischer Trope process created by Germany in WWII (only 50% efficient), has been developed for coal liquefaction into jet fuel. The common hazards and concerns regarding open pit mining of coal would not come into play if Tyonek coal meets the standards of new coal liquefaction processes that can be conducted completely underground.

Worldwide hub. Anchorage is well situated to be a hub for worldwide transportation over the North Pole. A reduction in jet fuel costs could greatly enhance this economic opportunity.

As polar ice melts, an over-the-pole summer shipping route is being created. A good harbor on the Aleutian Islands could serve the worldwide travel that is going to happen with, or without our liking it.

Other considerations.

Melting polar ice. A note on melting polar ice: While some would like us to think that the melting of polar ice caps is the result of CO_2 emissions, many scientists recognize that all planets in the solar system are warming, even the moons of Saturn. The earth's warming is influenced far more by the sun's cycles than CO_2 emissions. The fact that the poles are warming more than other parts of the earth is due to the poles being magnetic. Magnetic solar emissions are drawn down by the earth's magnetic influence and, like a microwave, warming and melting polar ice.

At the same time, H_2O, water, is twenty five times more powerful as a greenhouse gas than CO_2. There is no way to regulate water vapor, making the CO_2 controversy difficult to understand.

Irresponsible mining. In Alaska's past, mining was done irresponsibly. Hillsides were washed away by huge monitors. Stream beds were covered with silt wiping out salmon spawning grounds. The thought of toxins didn't cross anyone's mind. Oil and waste were dumped into rivers and streams with no accountability.

Since that time, major changes in the industry have brought about a shift of awareness mandating new processes. Yet the media and urban political mindset treat mining as if old practices were still employed.

In Red Dog Mine out of Kotzebue, salmon are spawning in streams that never had salmon even during pre-contact times. The *natural* toxic levels released by erosion were too great for salmon to spawn before, but Red Dog mine has cleaned the water to the point that salmon are now invading those streams.

The worst polluter. In reality, the worst polluter in Alaska has been the Federal Government. In the past, thousands of barrels of toxic waste have been discarded and buried near communities like Galena and in remote locations like Sparrevohn and Indian Mountain. Some effort has been made to clean them up, but much rubble and contaminants still remain across the State.

The Alaska National Wildlife Refuge ANWR is, to this day, littered with pollutants visible to the naked eye, resulting from over one hundred Federal oil test wells in the 1950's. Some ANWR streams don't support fish or wildlife because of contaminants still leaching from the surface contamination… and that is in the middle of a National *wildlife refuge*! Scores of uncapped wells litter the tundra. Resident Inupiaq people cannot eat the fish from those streams.

The Federal exploratory wells in ANWR have been called "Legacy wells." More recently, Alaska Senator Lisa Murkowski called them "Travesty wells."

The Federal Government makes no effort to clean up the ANWR mess while holding Alaskans to almost impossible environmental standards on private and State lands.

Activity: Students should research the pollution in ANWR and the refusal of the Federal Government to clean it up. The Alaska State Legislature has passed several resolutions and sent them to Washington D.C. to no avail.

Economically important mineral deposits in Alaska include copper, silver, platinum, tin, coal, iron ore, borax, chromite, antimony, tungsten, nickel, molybdenum, rare earth minerals, sand, gravel and limestone.

Activity: Each student should pick one of the above minerals and research it, its history in Alaska, where it is found, the plusses and minuses of extracting it, how the state could benefit from it's extraction etc. Give the atomic weight, number of valence electrons, and the name of the compound in which it is commonly found in nature. Also give the common commercial uses.

Activity: Where is the money going to come from to balance the State budget as oil production declines: Mining resources? A State income tax? Cut State services? Or, sit around and hope someone finds more oil? This is a hard reality that MUST be faced.

Village survival. All interior villages will eventually dwindle and perhaps die if some source of economy is not implemented. There are hundreds of abandoned village sites across the State, and that number could easily grow in the next decade.

Activity: Assess your community. Where does the money come from to sustain it? Where do people's incomes come from? What would happen if State and Federal money were reduced by 50%, or 80%? What would people do? What income, other than State and Federal money comes into your local economy?

Would local workers go away to work and commute two on/two off to your community? Would they move out? What would happen if your school closed because there weren't enough students? What other potential sources of economy exist in your area?

Subsistence reduces the amount of dependence on a cash economy, but subsistence still requires some money to continue.

Activity: Add up the cost of a boat, motor, snowmachine, fourwheeler, chainsaw and fuel to run them during the year. What is the cost of guns, ammunition, nets and fishing supplies? Add the food that we do not produce in the community: coffee, tea, sugar, flour etc. How would you live subsistence if food stamps were cut off and there was no government money?

Activity: What economic opportunities exist near your community such that families could make a living and still stay in their homes? Is there commercial fishing, logging, tourism, hunting camps, mineral resources? If local families move to urban centers, how do you think they will compete with Filipino, Asian, Tongan and other groups?

Right now, all villages are living almost exclusively from programs sponsored by the State and Federal Governments. Most Native nonprofits gain all their revenues from government grants.

The Alaskan focus must immediately turn to self sufficiency in food, fuel and resources.

Villages must wake up and see that the high cost of energy, the decline in Federal and State dollars, and the lack of local economy will result in ghost towns up and down our rivers unless something is done.

If people finally move to the city, they will find a declining economy there as well. In Western Alaska, Donlin Creek holds great promise, not only for the Kuskokwim, but for the GASH (Grayling, Anvik, Holy Cross, Shageluk) villages as well. There is an estimated $70-100 billion in gold in Donlin Creek. Donlin and other mines need educated, skilled help.

Statewide, educators must see that the future of their profession is directly correlated to revenues from oil/gas/mineral extraction. Without those revenues, the State education budget will become a skeleton, and their labor an act of financial sacrifice.

During the winter of 1909, according to story, there were almost 1000 men at Georgetown on the mid-Kusko. The next winter there were less than 200. The stampede moved to Flat. Today, there are less than 10 people in Georgetown.

Flat was a boomtown. Now it is a hub of quiet.

McGrath supplied numerous goldfields and once had over 550 people, with almost 180 students in the school. Now there are 35 students in all grades combined. Mining families live in McGrath, but very few supplies come through or from McGrath. Most of the mines get their fuel from Sterling Landing. Nixon Fork gets it supplies directly from Anchorage, and Nixon Fork air traffic to Anchorage is taking Nikolai business from McGrath's economy as well. For multiple centuries people have relocated to follow the food and supply sources. The gold mines McGrath was founded to supply no longer rely on McGrath.

Activity: What do you think the future of your region will be when Federal and State monies are drastically reduced?
Name at least two abandoned towns or villages near your community.

The Options…

Village and small town economy must come from somewhere.

Fishing. Interior villages do not have the possibility of commercial fishing income, as they are too far upriver. If fish are to be harvested commercially, they must be taken downriver where their value is greatest. Recent king salmon returns have been very poor. Fishing openings are pitifully short or nonexistent even at the mouth of the Kuskokwim and Yukon Rivers.

Firefighting. Many villages have one, two or even three firefighting crews. These crews are trained, and provide the state with a great service, protecting State and private lands from damaging forest fires. But, as most village firefighters know, there is zero income during a rainy year. Crew members are reluctant to leave the village in case a sudden call will come, and they might miss their annual income. Firefighting can provide a great boost to the local economy, or it can signal a wasted summer, and no one knows ahead of time which option it will be.

Logging. Interior villages do not have the quantity or size of trees for commercial logging. They can produce for local markets, but do not have enough to export.

Trapping. Villages used to send hundreds of thousands of dollars worth of fur to Canadian markets: otter, mink, lynx, marten, wolverine, wolf etc. Our current fur harvest of any of these is minimal, even though muskrats pay $10 apiece and top marten get over $250. Trapping requires leaving homes and families for long periods of time. Current rural fuel prices take a huge bite out of trapping profits. Many old traplines are overgrown requiring much work to relocate and open up again.

Crafts. Some villagers supplement their incomes with crafts: baskets, carvings, drums and other valuables. Perhaps 1% of current village income is derived from crafts. There is a limited market for crafts sold to visitors and urban centers.

Other. Apart from the government, there appears to be *NO* foundation for a village economy.

Two-on-two-off. Many villagers and many Alaskans in general travel to the Northslope or a mine and work for two weeks then come home for two weeks. The advantage of this is there is always a steady source of income. The family is fairly secure financially. The disadvantage is, the working family member is away for half of the childrens' lives. Since it is hard to get to villages, those families generally migrate to outlying towns from major transportation centers like Anchorage, Fairbanks, Dillingham, Kotzebue etc. It is difficult to do two on two off from a remote village because of weather complications.

Economizing. Villages can reduce expenses by conversion to biomass for heating and electrification. That reduces the amount spent on energy. Yet, this does not produce anything that the outside world wants. It merely reduces the amount of dependence on external support. At the same time, conversions to alternative energy sources are reliant on dwindling State funds. The State is reluctant to put more infrastructure into villages that do not have a provable long-term future.

In order to have a viable economy, villages must produce something to exchange with the outside world.

Activity: Brainstorm ways to increase the economy of your community. Discuss the difference between local activity that reduces dependence on government, like burning wood, hunting/fishing, and a local activity that actually produces something to trade with the outside world, like crafts and trapping.

Activity: Do a rough estimate of the total income of your village. Include people's salaries, public assistance, traditional councils, tribal corporations, and city office. Don't pry into people's private business, just estimate. Consider the cost of the school and heating all the local government buildings. What is the total annual income of your community? Now estimate how much the village actually produces. This could include income from working on the Slope or while commuting from somewhere else. It could include commercial fishing, trapping, crafts or any income that is actually producing a product that the rest of the State or the world is willing to pay money for.
What is the ratio of income from the government to income from actual production?

Activity: What was the source of economy in your community 20 years ago? 50 years ago? What was the size of your community during those times? Do those options still exist? If they do, will people turn back to them if/when government money dries up? (30-50 years ago most people trapped, went to cannery in the summer or went firefighting. All of these involved leaving the village and going to another location for a period of time.) What was the ratio of government money to production back then?

In this year, 2013, without oil revenues, in order to run the State government alone, the State of Alaska would have to tax every man, woman and child $15,000 to keep State services at the level they are to maintain roads, schools, welfare and other benefits.

Activity: How many people are in your household? Multiply that times $15,000. How much tax would your family have to pay if there were no oil revenue? Does your family income equal what the state tax alone would be? How much would you have left to spend on food, clothing, housing etc? Estimate how much your whole community would have to pay the State in taxes for the services it receives.

If your community had to pay that money out of their own pockets, would they want the State services at all?

Activity: If you were to cut State spending, what would you cut?

Given the increase in the Alaska State Social Service budget alone, and the decline in TAPS, the Department of Social Services will consume *all* the income from North Slope oil by 2020. There will be no State money for any other budget: schools, public safety, transportation etc!

Something must be done. Services must be cut and more revenue must be found.

The State does have $16B in assets tucked away from years when oil income exceeded State spending, but that money will last only a little while. That money must be spent on infrastructure that will grow and sustain the economy in the future.

Production. We have mineral resources up and down our Yukon and Kuskokwim River systems. Alaskan villages could be focusing on environmentally sound mineral extraction as a means for keeping the villages alive.

Where else will the economy come from?

In years past, the hardest part of getting a mine going was raising the capitol to fund the venture. Now, the regulatory process alone takes huge amounts of time and money. Engineers, accountants and bookkeepers all must prove to State and Federal governments that processes will be followed. The time lag from project inception to production can be up to *ten years*. A local village could die in the period of time required for a project to go through the regulatory process and into production.

Subsistence vs. Mining

Pebble Mine has caused a great stir. If developed, it would be a huge mine that many perceive will threaten subsistence and the salmon industry.

The prime strategy to *oppose* Pebble should be to identify and strengthen the shortcomings in the regulatory process so Pebble cannot pass the regulatory process unless it is totally safe.

The prime strategy to *support* Pebble should be to identify the objections to Pebble and show how the regulatory process will safeguard the valid environmental concerns. Measures should be taken to assure that the regulatory process will not allow unsafe practices.

Sadly, the Pebble discussion pits Alaskans against each other on a very shallow emotional level. The problem will never be solved on that level. There will be winners and there will be losers. The problem can only be resolved by higher level thought.

Mining could destroy the local subsistence lifestyle by polluting the country, harming the fisheries, and bringing in hundreds of outsiders to compete for dwindling natural resources like moose and caribou.

Mining could also bring in enough income so local families and individuals could stay in their villages, have a high standard of living, get old and be buried there rather than relocating to urban centers, spending last days in a nursing home watching a television with English subscripts. (That's what is happening to many of our Elders.)

The questions are:

- If mining were done, could it be assured that it is done in an environmentally sound manner? Don't jump to conclusions one way or the other. Listen to both sides. Think critically and evaluate.

Activity: Write a short opinion piece. Try to be original. Don't parrot what you hear others say.

- If the Pebble mine did go through or any other mine for that matter, how should young people be prepared so they are equipped to take advantage of the economy?

If jobs go to outsiders because there are not enough skilled local people, there is no use to mine in the first place.

The message is simple. Villages need economy. State and Federal government money is absolutely certain to dwindle. There are no other visible sources of income. Western Alaska has only one thing the outside world needs: minerals. Perhaps some projects are too big. Perhaps not. Alaskans can learn from the past and do mining right, but whatever we do, it needs to be soon, as the planning and permitting process take a long time.

The need for intelligent, young, local people who have good judgement who see all sides and think on a higher level is tremendous. They are the ones who will live with the consequences and determine the outcome.

Minerals and Alaska's Political History

In the 50's, many of the residents of the Territory of Alaskan wanted Alaska to become a state. They believed that Federal decision-makers were too far removed. Federal marshals were harsh on the Native people, and not much better to the nonNatives. With much struggle, in 1959, Alaska became the 49th state. At the same time, a substantial number of Alaskans didn't want statehood, as they feared the changes. It represented another level of government. The transition was made and Alaska became a state in 1959.

Activity: Go to the Elders in your community and find what they thought about Statehood and life as a Territory. Do they think Statehood was a good or bad thing now they can look back on it?

It was clearly understood that Alaska did not, at the time of Statehood, and probably never will have the population required to support a government necessary to properly manage such a vast area, over 300 million acres.

So, as part of the Statehood Agreement Act with the Federal Government when Alaska became a state in 1959, both governments agreed that the resources of the State of Alaska would be developed. The State would get 90% of the revenue, and the Federal Government would receive 10%. The income from the development of those resources would insure that the State was well funded and well managed.

The State of Alaska was scheduled to receive 103M acres, 29% of the total area, during the Statehood Agreement Act. To this day, 100% of that 103M acres has not been transferred to the State.

Later, Native corporations received 44M acres from the Federal Government.

Not counting Native lands, there is very little privately owned land in Alaska, less than 1.5%. All land is owned either by the Federal and State governments, or Native Corporations.

The idea behind the Statehood Agreement Act was that the resources in some areas of Alaska would be developed in order to properly maintain and oversee the rest of the State. When choosing land, the State wasn't particularly interested in choosing mineralized lands, as the Agreement Act stated that resources would be developed on Federal Lands.

That agreement was short-lived.

Under the Presidency of Jimmy Carter, Federal agents came to Alaska and asked State of Alaska geologists where the mineral resources were. They were given honest, accurate information, thinking the Federal Government would make its selections avoiding those resources in honor of the Statehood Agreement Act. Instead, the administration of Jimmy Carter, with the process of ANILCA in 1980, locked up 103 million acres of Federal land from any form of development, including much of the mineral rich resource land trustingly identified by Alaska's State geologists. There is certainly a need for National Parks, but the selection of land did not honor the spirit of the Statehood Agreement Act. There was a "never again" clause in ANILCA that stated that the Federal Government would never again lock up Alaskan lands over 500 acres. That agreement too was short lived.

The Federal government, with over 60% of the state's land (222M acres), has since refused to develop resources, blocked road access to State lands, created onerous regulatory processes and done its best to prevent Alaska from developing a viable economy.

More land was recently set aside for polar bear protection than the State of Alaska got in the Statehood Agreement Act. (Polar bears got 125M acres, 22 M acres more than the State did in the Statehood Agreement Act. There are 2-3 times more polar bears now than there were in 1972, but the perceived threat is based on the receding polar ice which *might,* but has not yet, threatened their population.)

Since over 60% of Alaska is Federal land, a major portion of our state is controlled by the political climate of the Lower 48. Uninformed people and Federal judges thousands of miles away have great influence in Alaskan land and resource policy making.

The Federal government has held Alaskans to extremely stringent environmental regulations while ignoring the pollution of over one hundred Federal exploratory wells in ANWR from the 1950's.

Genuine concerns

A frequent argument against mineral extraction is that the State gets only 4% royalty from most mineral deposits, and gets upwards of 30% from combined oil revenues. That is why there is such emphasis in the Legislature on oil/gas, and a relative lack of concern for developing mineral deposits. Oil feeds government.

Yet a vibrant economy comes from the private sector. Private sector efficiently stimulates all other parts of the economy: transportation, consumables, communications etc. Government is sluggish in all its responses. The private sector is nimble, quick to adapt and efficient in making modifications to keep production on target.

Another valid concern about mineral extraction is that corporations, particularly mining corporations, have a history of not following regulations. The truth is, almost any entity, including government itself, will not follow guidelines unless monitored.

Currently Red Dog, Fort Knox, Pogo, Greens Creek and others are mining within all State and Federal regulations and provide meaningful employment for State and local economies. It is being done.

The contradiction exists that people want things the way they have always been and they don't want change. They want development and economy, but NIMBY (not in my back yard.) As long as State and Federal money sustains small towns and villages, that contradiction can continue. When both governments face their own realities and cut spending, rural Alaska will immediately feel the impact and be looking for other income sources.

Activity: Research this subject, and write a short opinion piece. Do you think the Federal Government has kept its part of the agreement when we became a State? Do you see any avenues by which the conflict between the Federal and State Governments can be resolved? The conflict is often called "Federal Overreach."

A Simple Geology of Alaska

See definitions at end of this section

There's a saying among miners that "gold is where you find it." That is obvious, of course, but it begs the questions:

- Why is the location of profitable gold so unpredictable?
- Why does Alaska have so many natural resources, and why are they found where they are?
- Why is it so hard to find natural resources like copper, lead, zinc, gold, silver, or tin?

We need to understand a little about the geology of Alaska, and the geologic processes that form economic mineral deposits in order to begin to answer these questions.

Events as big as earthquakes, volcanic eruptions, tsunamis and glaciation have shaped the overall picture in Alaska, but smaller events like annual breakup, water and wind erosion have persistently done their part as well.

Activity: Students pick one of the above: earthquake, volcanic eruption, tsunami or glaciation and research its impact on recent and past history in Alaska.

Basic Terms

There are a few terms necessary to understand the very basics of geology. Three are given here. Other terms used in this section are on page .

- **Igneous rocks:** Any rock formed from a *magma,* either plutonic or volcanic. Since the whole earth was once molten, it could be said that all rocks originated as igneous.
- **Sedimentary rocks:** Any rock formed from the consolidation of *sediments,* that is, from the products of erosion like silt, sand or pebbles.
- **Metamorphic rocks:** Any rock whose character *changes* as a result of high pressure and/or high temperature. The change may include change in texture, mineral content, and composition. At the most extreme temperatures, a metamorphic rock will melt to become a magma.

Finding the Mineral Resources

Hot hydrothermal fluids.

Mineral resources form in many ways.

One of the common ways mineral deposits are formed is when hot hydrothermal fluids carry dissolved metals from deep within the earth. These hot fluids, around 300°-500°C (572°-932°F), are usually associated with magma (molten rock) within the earth's crust. The hot hydrothermal fluids, coming in part from magma combined with water from surrounding bedrock, flow into cracks and faults through the surrounding rock. They carry metals as well as dissolved minerals like quartz and calcite from the earth's magma.

The super-hot fluids interact with the rocks they pass through, changing the makeup of those rocks. They could add to or draw minerals from those rocks.

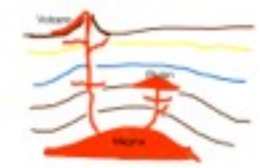
Eventually, the fluids cool and the minerals become solid, resulting in veins of quartz, calcite, and whatever else was in the fluid. If there were a lot of a certain metal in the fluid, an ore deposit may be formed.

This simple scenario involves many variables. The main factors are:

1) the **origin** of the magma and the makeup of the hydrothermal fluids it generates
   - temperature and pressure of those fluids
2) the **type** of surrounding rocks the magma goes through
   - temperature of water and composition of surrounding rocks
   - ease of the fluids flowing through through the surrounding rocks, and
3) **what happens** to the deposit after it forms. (Upthrust, erosion etc)

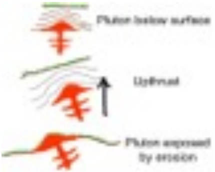
Each of these variables has to be exactly right to create the necessary conditions for valuable mineralization. The perfect combination doesn't happen very often. That's why it's hard to find a valuable mineral resource deposit in Alaska, or anywhere else for that matter.

Volcanos and plutons



When magma comes to the surface of the earth, it forms a volcano. There are several active volcanoes in Alaska, Redoubt, Spur, and Augustine being among them. There have been times in recent years when air travel into Anchorage and other centers has been interrupted because volcanic ash is terrible abrasive on jet turbine engines.

When magma solidifies deep within the earth, it forms a pluton. It then takes millions of years for tectonic forces in the earth's crust to lift the plutonic rocks upward, and for the overlying rocks to erode away so the plutons are available at the surface.



Mineral deposits can be associated with both volcanic and plutonic rocks coming two ways, either:

- within the magmas, the igneous rocks themselves, or
- in hydrothermal fluids generated by the magmas.
-

Those peripheral deposits may have come through and be resting in any kind of rock, whether igneous, metamorphic or sedimentary.

Activity: Research the origin of the word "pluton."

Other deposits. Other deposits are not related to magmas, but may be related to:

- hydrothermal fluids in hot springs
- veins in regional metamorphic rocks, or
- metals deposited from seawater in marine sedimentary rocks.

Placer. When any of the above deposits are eroded and removed by water, minerals might be re-deposited and concentrated as a placer deposit in stream gravels. As valuable minerals tend to be heavier than country rock, they work their way down towards bedrock and don't travel as far.

Glaciation after the placer process tends to gouge up the placer deposits and spread them across the country. Klondike gold was on the dry side of the mountains, and was not subjected to glaciation the way other gold sources were. That is why it was such a concentrated deposit.

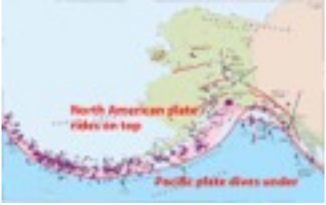
Alaska is active. One of the reasons Alaska has many mineral resources is the amount of magmatic activity over the course of geologic time. Magmas generally form in regions where the edges of tectonic plates are moving to, from, or past one another. You might say Alaskans are wealthy in minerals because we live in a land with fragmented crust, and unstable geological formations.

Going back in time over millions of years, Alaska has experienced a series of major tectonic events that have changed the shape of the land mass, formed the mountain ranges, and led to the formation of huge volumes of magma.

In recent times, the Alaska quake of 1964 was the second largest in recorded history and the largest on the North American continent. Depending on which scale used, it was either 8.6 or 9.2.

Pacific plate. As you read this, the Pacific plate along the southern edge of Alaska is diving under the North American plate at about 5-7 centimeters per year (subducting). As a result of this motion, we have active volcanoes and earthquakes in that area. Spur, Redoubt, Katmai and Augustine have all shown volcanic activity within the past 101 years. Iliamna has spewn steam, but not volcanic ash.

While this is happening, the Pacific plate slides beside the North American plate in Southeast Alaska.



The heavier oceanic plate always goes under the overriding plate. Sometimes the overriding plate is a continental plate, and sometimes it is a younger, less dense oceanic plate. Denser oceanic plates always go under (subduct.)

The earthquakes that occur in southern Alaska are caused by the release of stress. The stress builds up as the Pacific plate tries to slide under the North American plate in Southcentral and Southwest Alaska, and slides beside the North American plate in Southeast Alaska.

Southern Alaska. The southern part of the state of Alaska has formed from a number of continental blocks being pushed against Alaska at a subducting zone. The Yakatat block is still being pushed northward. The angle of tectonic compression has resulted in sliding of southern Alaska westward along the Denali fault.

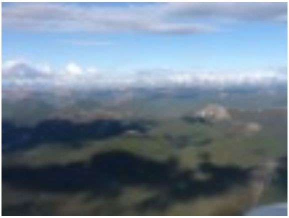
Alaska Range. The Alaska Range is still being uplifted at a rate of several mm/year, due to two forces:

- continuing compressing forces from the collision of tectonic plates in southern Alaska.
- release of pressure over thousands of years after the melting of ice from the last glacial age. Glacial ice is heavy. The release of that weight causes the landmass to rise, referred to as "glacial rebound."

The uplift and following erosion have revealed masses of deep-seated plutonic rocks and their associated mineral deposits in the Alaska Range. The exposure of the plutonic rocks resulted from the long-term compression tectonic activity along the southern edge of Alaska, originating 56-145 million years ago. (Cretaceous and Paleocene eras.)

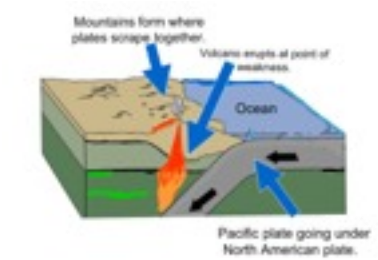
The presence of limestone in the Lime Hills indicates that region was shoreline at one point. Those hills are currently 550'-2200' above sea level.

Interior hills. The rolling hills of interior Alaska also reveal plutonic rocks similar in age to those in the Alaska Range. Donlin and Pebble are exposed plutons. The gold mines at Fort Knox and Pogo are associated with Cretaceous plutons. They contain high volume, lower grade ore.



Terranes. Just as huge independent plates on the earth's crust move against each other, there are smaller pieces of the earth's crust called "terranes" that move and grind in a similar fashion. Alaska has several terranes. Where they come together, valuable ore deposits are potential.

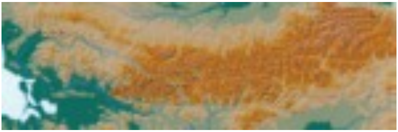
Ongoing process. In Alaska, newer (Cretaceous) plutons are surrounded by older metamorphic rocks. These metamorphic rocks include older plutonic rocks that have been metamorphized (orthogneisses, amphibolites, and greenstones) which themselves may have been associated with earlier mineral deposits.



The intrusion of igneous rocks into sedimentary and metamorphic rocks, and the following erosion around the intrusion is an ongoing process that has happened many more times than one in Alaska's geologic history.

The metamorphic terrane by Fort Knox and Pogo is thought to have moved westward into Alaska from Canada by sliding along the Tintina fault sometime before the Cretaceous. The Tintina fault is roughly parallel to, but north of, the Denali fault, but does not seem to be active anymore.

Brooks Range. To the north, the Brooks Range is made up largely of variably metamorphosed sedimentary and some volcanic rocks.



Most of these rocks were formed on or off-shore from an ancient continent > 400 million years ago, continuing to around 100 million years ago. Since then, they have been squeezed together and on top of each other by multiple tectonic forces. There are packages of rocks from different places now resting side by side because of folding and faulting.

Red Dog. The Red Dog zinc-lead mine in the western Brooks Range is found in marine sedimentary rocks including black shale, chert and carbonate. The mineralization of Red Dog is thought to have precipitated onto the seafloor from a hydrothermal vent at the bottom of the ocean when the sediments were accumulating around 300 million to 350 million years ago.

Other mineral deposits, such as gold in the Wiseman area are thought to have formed by hydrothermal fluids during metamorphism.

North Slope. The North Slope of Alaska consists of thick layers of sediments derived from the Brooks Range. The resulting sedimentary rocks are now host to the oil and gas deposits of the North Slope. Unlike most of the rest of Alaska, these rocks have not been tectonically deformed, allowing the petroleum to accumulate. More on this later.

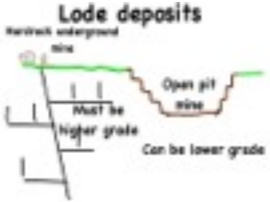
Types of Formations, Types of Mines

There are two types of mineral deposits: Lode and Placer.

Lode deposits are in their original place.

There are two mining types of mining techniques used on lode deposits, subsurface, and surface, depending on the depth of the ore.

- A **deep** rich lode deposit would be mined by subsurface methods with deep shafts, drifts, stopes and raises. This type of mining is expensive, so hardrock mines work deeper, richer deposits with narrower ore bodies. A subsurface mine seeks concentrated higher grade ore in stable competent country rock. If the mineral deposits are rich enough, they can be mined by sinking a shaft and driving drifts on those concentrations. Red Devil, Nixon Fork, Pogo and Greens Creek out of Juneau are examples of underground mines.



  Subsurface mining has less of an impact on the country, as the surface isn't disturbed.

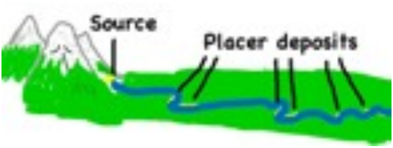
  It basically follows the veins of ore, whatever way they go.

  - A shaft goes down.
  - A drift goes sideways.
  - A stope is a large shaft that goes upward.
  - A raise is a small shaft that goes upward

An effort is made, after milling the ore, to put the tailings into mined out drifts, and cement them in.

- A **shallow** lode deposit would likely be mined from the surface by open pit mining methods. Open pit mines can move large volumes rock more easily, so they can work deposits that are lower grade. Fort Knox and future Donlin Creek are open pit mines. The proposed controversial Pebble Mine, if developed, might be an open pit mine, but there are portions of Pebble that are rich enough that it could selectively be mined by undergound hardrock methods.
  Open pit mines are often on a pluton exposed by uplifting and erosion. In an open pit mine, it is fairly easy to move overburden and ore, as all operations are above ground. However, to be successful, good planning is essential, matching the ore, milling process and support resources.

The decision between hardrock and open pit is basically a matter of the shape/extent of the deposit and its concentration.



Placer. Placer is a deposit that has been eroded, moved, concentrated by specific gravity, and is most often mined on top of bedrock from the surface. Often, considerable overburden must be removed to get to paydirt.

The type of ore is significant. When exposed, copper, Cu, will oxidize, weather, crumble and wash away. Other more durable and high density minerals like gold and cassiterite (tin ore) will placer.

The resistant minerals also tend to be high specific gravity, so they are left behind in the streams and eventually work into cracks and other areas of concentration where miners find them.

Placer claims are available to small miners as well as big companies. Gaines Creek, Moore Creek, Ophir and Iditarod are all examples of placer mines that have been worked by small-time local operators. Most of the early prospectors/miners worked gold placer deposits.

Miners in the Tolstoy area, which was/is frozen right to bedrock, used steam to dig down to and along bedrock, tunneling in frozen gravel.

Once a placer mine is reclaimed, vegetation grows back quickly. Old placer mines provide abundant moose browse.

Prospecting vs. mining. Prospecting is looking for paydirt. Mining is removing paydirt.

When old timers found signs of gold, they set up sluice boxes and rocker boxes on the streams and worked them by hand. In a very rich prospect, a rocker box could produce enough to be considered mining, but for the most part, both techniques were for finding, not mining gold.

If a prospect was worthy, the old time miner built sluice boxes to separate the gravel from the gold, and flumes to carry the water necessary to operate the sluice boxes. Much has been written on this subject.

Modern mining. Much planning and exploration must be done before a mine starts operating. The operation must match the deposit in order to be profitable. To learn about that deposit, hundreds of test holes must be drilled and core samples analyzed. What is the extent, depth, concentration and potential for the deposit? Cores from the exploratory drilling are cut and sampled. The extent and concentration of the deposit must be determined. The strategy for removing the ore can be success or total failure depending on experienced planning. Mining is a high risk venture that is made more certain by good exploratory work. Investors often have to wait 8-10 years before receiving payback.

Red Devil Mine and gold

Gold nuggets like the one on the right, can be picked up with tweezers. Fine gold, like that in the goldpan on the left, is hard to extract from the black sands in concentrates. It takes over 40,000 flecks of fine gold to make one ounce.

Black sands and gold have similar specific gravities, are very often found together, and are hard to separate.

Mercury has been used for centuries to extract fine gold from black sands and other heavy materials.

Troy ounce. Worth noting is that one ounce of gold doesn't weigh one ounce. Gold is measured in Troy ounces, which equal almost 1.1 Avoirdupois once (our current system) which is the American standard which is 1/16th of a pound. A troy ounce is about 1/14th of a pound. Also worthy of comment is that gold, when found in nature, is never pure. It always contains silver or other minerals. The purity of gold is expressed in "fine." .999 is considered pure gold. Alaskan gold averages .875 fine. So again, and ounce of gold is not an ounce of gold.

Activity: A miner recovers 175 Avoirdupois ounces of gold that is .875 fine. Gold is $1,600 a Troy ounce. Not considering smelting fees, how much money did he actually make that summer?

Gold is an amazing element. It will not tarnish or dissolve, even in acids (with the exception of aqua regia and cyanide salts.) However, gold will seem to dissolve in liquid mercury in a process called “amalgamation.” If a gold ring were dropped into liquid mercury it would seem to disappear. The gold is recoverable, but never again in the form of a ring!

Mercury has a specific gravity of 13.6, and a common country rock or a bolt will float on top of liquid mercury as seen on the right.

If liquid mercury is stirred in the bottom of a gold pan among the black sands and fine gold, it amalgamates the fine particles of gold, but won’t react with the black sands. The old timers said it “sucked up” the gold. The mercury/gold amalgam becomes thicker and the gold is not visible. The old time miners poured the amalgam into a shovel or other container, and heated it over a campfire. The mercury boiled away, leaving the gold. Miners didn’t understand the hazards of mercury vapors, and many didn’t know enough to get upwind of the process. More sophisticated amalgamation methods were used in larger mines. The mercury was recovered and recycled.

In 1906 W.W. Parks founded a cinnabar deposit across the river from what is now the small village of Red Devil. Cinnabar is mercuric sulfide (HgS). He retorted the cinnabar, produced liquid mercury, and supplied gold miners with mercury to amalgamate fine gold from their local placer mines.

The History of Red Devil Mine

At the turn of the 19th century, Nick Mellick, an experienced gold miner, won a raffle in Nome. He bought two Saint Bernard dogs and some gear, and walked the telegraph lines from Nome to Ophir, just north of McGrath.

Nick Mellick had a prospecting partner, Hans Halverson.

In 1933 Hans’ kids were playing in a creek that is now Red Devil Creek, seven miles below Sleetmute. The kids found pretty red and silvery rocks and showed them to their dad. Hans and Nick staked the creek. The price of mercury was low at the time, but they kept the claims active.

Many years passed. In 1952, the DeCoursey Mountain Mining Company began to develop the Red Devil deposits when the Federal Government declared mercury as essential to military purposes, and mercury prices rose.

An east/west runway was built in Red Devil that was a mile long. Many buildings were constructed, a cook shack, a mechanics' shop, a generator shed, bunkhouses and the mill/retort to extract the mercury. The image on the above right is facing north.

To supply the mine, a large sawmill was built on the east side of Red Devil Creek. Logs were rafted down the river, winched out and sawn there. The lumber was used for the buildings, and the slabs used for lagging and cribbing underground.

A flask. A flask of mercury is an interesting measure. In the 50's into the early 60's, Red Devil mine used thick steel cylinders with heavy screw-on caps to ship the raw liquid mercury. A flask of mercury is an exact measure… 76 pounds of mercury.

Red Devil was, at its busiest in the 50's and early 60's, the second largest mercury mine in the world. In 1960, it is said to have produced over 20,000 flasks of mercury.

However, the largest mercury mine at the time was in northern Spain. There, mercury was stored and shipped in goat stomachs. The average goat stomach could hold 76 pounds of mercury… and that is the world standard to this day. One flask Hg = 76 lbs. = one goat stomach.

Mercury has a specific gravity of 13.6, so it doesn't take much mercury to make 76 lbs.

Activity: **Specific gravity** is the relationship of the density of a substance as compared to water. Water has a density and specific gravity of 1, Hg is 13.6. What is the weight in grams of 1 liter liquid mercury? What is the volume in cc of a 76 lb flask of mercury? Weigh in grams a 2"-3" rock from your community. Fill a graduated flask half full of water. Submerge the rock. How much water in cc's did the rock displace? This is the volume of the rock. Divide the weight in grams by the volume in cc's. This is the density of the rock. Compared with water, is it even close to 13.6? Gold has a specific gravity of 19.1. What is the specific gravity of lead? Find a piece. Weight it in grams. Displace its volume in water. Divide the grams by the volume, and that is its density. Compare that with water, that's its specific gravity.

Take a piece of wood. Weigh it in cc's. Submerge it in water, holding it down with wires. What is its volume? Divide the grams by the volume and that is its density. Is that > or < 1?

Uses of mercury. At the time of Red Devil Mine, mercury had many uses, the primary one being the recovery of fine gold by amalgamation, but also included the manufacture of glass and temperature sensitive mercury switches. The hazards of liquid mercury were not recognized, or at least, not acknowledged.

Almost every American home had a mercury thermometer to measure the outdoor temperature and another to record the temperature of feverish children. Mercury was also used by hatters across the nation and in Europe to stiffen the brims of men's hats.

One old Alaskan miner in the early 1900's was said to drink mercury to relieve himself of constipation. He figured it was heavy enough to push its way through his guts and give him relief. (Ohmygosh!)

To this day, in Brazil, there are long stretches of the Amazon River where the fish cannot be eaten as the mercury content is so high. The gold dredges operating on the Maderas fork of the Amazon recover more mercury than they recover gold.

Mercury is the only metal that is liquid at room temperature, It is also a good conductor of electricity. These qualities made it valuable in liquid mercury switches that controled thermostats regulating the comfort level of all homes in the recent past. Liquid mercury is also called "quicksilver."

To this day, when weather forecasters give the atmospheric pressure, it is measured in "inches of mercury."

Originally, a tube was filled with liquid mercury and turned upside down in a plate of mercury. As mercury is quite heavy, it actually pulls a vacuum in the tube above the column of mercury. When atmospheric pressure is high, like during good weather, there is enough atmospheric pressure to hold a column of mercury more than 30" tall.

When atmospheric pressure is low, like during stormy weather, atmospheric pressure can only support a shorter column, perhaps 29.1" of mercury. Barometric pressure to this day is referred to in "inches of mercury," although digital instruments are used, not columns of Hg in glass tubes and plates.

The altimeter in an airplane doesn't contain mercury, but it measures atmospheric pressure by the standard "inches of mercury."

The name. The name "Red Devil" is interesting. The word "Red" is easy, as the compound, mercuric sulfide, cinnabar, is a beautiful blood red crystal. The "Devil" part is more indirect.

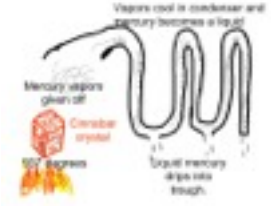
Most older people know the story of *Alice in Wonderland* and are familiar with the character, the Mad Hatter. As stated before, until the 60's, almost all people who made mens' hats went crazy. Additionally, their hair and teeth often fell out. Mercury was used in the stiffening of mens' hats. In those days, people didn't understand the symptoms of mercury poisoning, but they did know that hatters went crazy, thus, the Mad Hatter in *Alice in Wonderland.*

The "Devil" therefore came from the effects of mercury poisoning on the human body. So, cinnabar is "Red", and poisonous raw mercury will make people crazy, that's the "devil" part, thus "Red Devil."

During the time of Russian occupation of Alaska, the Russians often exhibited brutal and bizarre behavior. At the time, they believed that a concoction of mercury would cure syphilis. It has been speculated by a PhD. anthropologist that irrational behavior on the part of some of the Russians could have been the direct result of mercury poisoning in their attempts to self medicate for syphilis. They were well aware of the cinnabar deposits on the Kuskokwim River.

Cinnabar, mercuric sulfide, is a stable compound. It is safe to handle. The human body does not have the energy to break down the stable crystal into its component toxic parts: raw mercury and sulfur.

Back to the mine. Red Devil mine was opened two times, once in the 50's and again in the late 60's. During the first opening of Red Devil, raw red cinnabar crystals were heated to 937ºF, and the mercury was released as a vapor from the cinnabar, cooled and condensed into liquid mercury, then poured into flasks.



Red Devil mine never made a profit. Under the skilled oversight of local operator/miner, Bob Lyman, it broke even for a couple of years. Under all other managers, it lost money. At that time Red Devil was a fairly large operation, with perhaps 50-75 men working.

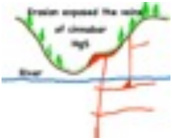
The quality of ore was high, but it is very expensive to do hardrock mining in remote Alaskan locations. The obstacles posed by keeping the operation going during the winter was the kiss of death for any possible profits. The cost of closing in the fall and re-opening in the spring was equally unprofitable. Both were tried.

During the second opening of the mine in the late 60's, the cinnabar was not retorted, instead a flotation process was used. Cinnabar concentrates were extracted and shipped to Japan. Flotation is used in the recovery of many minerals. Modern society would not exist without the flotation process, as copper would be too expensive to recover, and all our electrical wires and appliances would be far too expensive. Flotation is also used to clean water in waste recovery systems.

The local Red Devil Bar was run by a Castillian Spaniard named Mariano, who skipped the country in the late 60's with the IRS on his trail. His familiarity with mercury mining in Spain brought him to Red Devil. Red Devil mine attracted a host of characters, some good, many not, but all interesting.

A brief look at an underground mine.

Cinnabar in the Kuskokwim came as a result of volcanic intrusion. The superheated volcanic liquids came close to the surface of the earth in veins. As they cooled, the minerals in the liquids crystalized. The hot liquids were injected into the cracks shattered in the crust. (That is nature doing its own fracking.) Long term erosion exposed the valuable minerals.



In the 50's a shaft was driven on the west side of Red Devil creek, about 150 yards up from the river. It angled southward, and was, at one point, as deep as 600'. Later another small shaft, the Dolly Shaft, was driven higher up the hill to the west, but that never went deeper than 90'. A drift was driven southward from the 90' Dolly station.

Like most mine shafts, the first 50'-75' were dangerously broken overburden, but below that, the shaft got into fairly safe hardrock. The first drift driven westward from the vertical main shaft was at the 200' level. Several stopes were driven up from that drift, and many more raises.

The main idea was to get under the ore and stope or raise up on it, as mucking is no problem in a stope or raise. Gravity pulls the ore downward.

The safety of a mine depends totally on the rock formation. Some ground has fractures that allow considerable water seepage that loosens things up. Other ground is solid with minimal fractures and water seepage, although all ground seeps to some degree.

There are severe superstitions about mining, the strongest is that a woman should not go underground. Many miners would walk off the job if a woman even stepped into the skiff to go down. This happened fairly recently in Canada when the Queen of England toured a mine. Miners walked off the job. The cook in Red Devil went underground in 1968, and the grumbling never stopped after that. Many miners believe there is a female spirit of the mine who will be jealous if another woman enters.

Driving shaft. Sinking a shaft is extremely difficult. There are continual ground water problems. Shoveling blastrock is unbelievably difficult. Getting a shovel-full is an accomplishment, and all shoveling is overhead into the skiff.

Nowadays, all that is done by machinery, but is still very difficult.

Since the overburden close to the surface is very loose and unstable, there is a need to timber well until the shaft gets into stable hard rock.

Once the operation is into hard rock, the main purpose of timbering is to keep loose rocks from falling onto the miners and tracks. Some of the drifts in Red Devil mine were in such solid rock that miners did not timber at all.

At the head of the shaft is a headframe mounted by a sheave wheel. This directs the cable straight down the shaft. The hoist, which is a huge winch, is off to the side. The hoistman responds to the miners bell signals and controls two levers, the brake and power up. Every life depends on the hoistman and the position is highly respected. It is an easy job, sitting in a chair, but the responsibility is great.

Pumping problems. Water seeping into the shaft was a continual problem in Red Devil, as in other mines. The shaft was far below the level of the river. A 300 hp. electric pump had to run constantly to keep the shaft from being flooded. Generator problems instantly turned into pumping problems.

Pumps can push water tremendous heights upward, but can't "suck" far at all, because the "sucking" part is dependent on atmospheric pressure, 14.7 psi. (or close to 30" hg.)

The pump therefore can't be more than 22 feet above the water because that is the highest column of water atmospheric pressure will support. The pump operates best 2-3' above the water level and was a constant maintenance issue.

If it pumped too much water, it was too far above the water level and could burn out. If it pumped too slowly, the water would overtake the electric pump and drown it. The pump was constantly being raised and lowered, Christmas, New Years, Easter, morning and night.

Activity: Atmospheric pressure can support about 30" of Hg, depending on the weather. The specific gravity of Hg is 13.6 times greater than water. How tall a column of water can atmospheric pressure support in inches? In feet? If a pump could pull a complete vacuum (which it cannot) how tall a column of water could it push up to a pump. Do you see the limitation where a pump must be close to the water, as it can push upwards hundreds of feet, but cannot "suck" far at all. The limitation isn't the power of the pump, it is atmospheric pressure.

Later, a drift was driven at the 350' level, and for a short while, the shaft went to 600', but the pumps couldn't keep up with the water coming into the mine at that depth.

All work underground is done by air pressure and battery power. Two inch pipes supplied air pressure at 120 psi from a compressor at the top. The heavy jack hammers used for drilling required at least 90 psi. Every elbow is a 3% block. It doesn't take too many elbows to get the effective pressure below the required 90 psi. for jackhammer operation. Most of the mucking machines were operated by air pressure as well.

Activity: How many elbows would it take to reduce 120 psi to the minimum 90 psi to run a jackhammer? (Use simple math, not complex formulas.)

All the trams to haul the muck were powered by huge 12 volt batteries connected in series.

Only the stations had 120 volt AC power for lights. From there on, lighting came from the miners' battery packs and helmets.

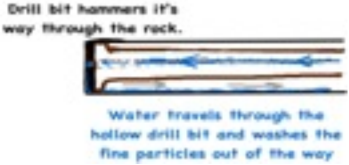
The shaft, and almost every drift, stope and raise followed a visible vein of ore. Cinnabar is easy to see, as it is a blood red crystal. In Red Devil, the cinnabar was always accompanied by stibnite, which is a very bright silvery color. Together they are a beautiful sight on the rock face, bright red and shiny silver woven together against the black rock face. They are easy to follow.

In Barometer creek, 1/2 mile downstream on the river (to the west), there was also arsenic sulfide mixed with the cinnabar. Arsenic sulfide is yellowish in color. The crystals look somewhat like a flower. Barometer Creek was never mined.

Jackhammers are heavy, almost 80 lbs. They are supplied with both water and air. The air provides pressure to extend the jackleg, which holds most of the weight, balancing the pressure upward and forward. The air pressure also drives the hammering of the drill. The 6' drill steel is hollow to allow water to flow through. The extremely hard carbide steel bit pounds against and pulverizes the rock. Water under pressure flows through the hole in middle of the drill steel and through the bit. The water washes the rock fragments out of the hole as the drill goes forward into the rock.

A skilled miner knows how to balance the drill on the jackleg.

A miner is called a “Jack.” In the old days before jackhammers, one miner held the drill steel, and the other miner hit it with an 8 lb. hammer. The holder then turned the steel and the other miner hit it again. That is why an 8 lb. hammer is called a “double jack.” It took two miners (jacks) to drill with it.



A 4 lb. hammer was called a “single jack,” because the miner held the steel and hammered by himself with the smaller hammer.

And, that’s also why it is called a “jackhammer.”

Drilling and blasting is an artform. A series of holes are drilled into the face of the drift, all of them 6’ deep. The bottom holes are called “lifters” as they go off last and lifte the whole muck pile. The photo on the right is of Eino Lepalla, one of the most skilled miners and carpenters in Alaska at that time. He worked in Red Devil in both the 50’s and 60’s. He did effortlessly what others struggled to accomplish.

Fresh dynamite isn’t dangerous, as the nitroglycerine is absorbed in a cotton-like matrix. But, if dynamite has set for a while, the nitro settles to the bottom, and a sharp blow can set it off. Miners always look for wet spots on the bottom side of the dynamite sticks, and they make sure the dynamite is turned over on a regular basis. Old powder is extremely dangerous. A solid bump can set it off.

When the holes are drilled, the miners pack each hole with one stick of dynamite as a cushion. Once the first stick of dynamite is in the hole, the miners open the end of another stick and insert an electric blasting cap. Miners are all careful to use rubber gloves, as the nitro easily penetrates the skin and gives an unbearable pounding headache.

The second stick of dynamite containing the electric cap is packed into the hole with a wooden rod, followed by many more sticks, also tightly packed. The wires from the electric cap dangle from the hole.

The electric caps were timed. Oughts, or zeros were placed in the very middle, then they followed a pattern outward from 1 second to perhaps 5-8 seconds.

If the wiring was right, the middle hole was blown first, then the others followed one second behind each other, all collapsing the rock in towards the middle hole created by the dynamite with the ought primer. At the very last, the lifters went off, lifting the muckpile. The sketch on the right is a possible blasting sequence, although the number of holes and sequence varies with the conditions.

All the wires were carefully connected in series. If one wire was wrong, the whole thing wouldn't fire, and the miners had to go back, trace the wiring and fix it. It's an eerie feeling going back down after the detonator has been pushed and nothing happens.

A good miner, like Eino, could consistently carve a beautiful hole with no irregularities. The right amount of powder, the right angles, understanding the rock, just the right amount of holes etc.

Dynamite for blasting underground is different from that used to remove stumps. Stumping powder pushes more gradually, lifting the stumps out of the ground. Powder for hardrock detonates sharply to shatter the rock. Hardrock powder would shatter a stump. It is similar to the difference between pistol and rifle powder.

After the blast is completed, the miners hose down the muckpile to take the blast gasses out of the air. Blast gas can also give a throbbing headache.

Then the miners bar down any loose hanging rocks on the ceiling. From, there mucking is done mostly by machine. The ore is put in cars driven on tracks to the station and dumped into the ore pockets, later to be hoisted to the surface.

At the very end, timber is put in place, and slabs used for lagging between the timbers. Timber really doesn't prevent cave-ins, but protects miners from smaller loose falling rocks.

Milling. In Red Devil, after the ore was hoisted to the surface, it went to the mill. The rocks were run through a huge jaw crusher.

In the 1950's the ore then went into a retort, a massive pot over a furnace. It held several tons of ore. There it was heated to above 937 F. with a diesel flame. At that temperature, the stable covalent bond between the mercury and the sulfur was broken. The mercury separated and evaporated as a vapor. The Hg fumes were carried away to a condenser that looked something like a huge pipe organ. The mercury vapor was cooled in the condenser, and raw liquid mercury dripped into a trough flowing downward to be put into flasks. The weight of the steel flask plus the mercury was around 90 lbs.

This process, of course, was dangerous. Mercury fumes were constant. Raw mercury stood in pools everywhere in the condenser room.

Strangely, there were no local stories of illness from the operation in the 50's. Many locals worked in Red Devil during that time. Perhaps lack of awareness kept people from recognizing the symptoms.

Red Devil mine was the second largest producer of mercury in the world, but the expense of mining underground in such a remote location was too costly. Adding to the cost of operation were conflicts with employees. At one point, the head mining engineer, angry with the operation, took off with all the underground maps. Later, a well engineered drift broke into, not a rich vein, but a stope that had already mined out. The stolen maps would have prevented that costly mistake.

The overhead exceeded the income. Red Devil mine closed for the first time in the very early 60's.

During the mid 60's the price of mercury rose to over $550 a flask, which was huge money at that time. The mine reopened in 1968 with the hope of recovering losses of the past. The market was in Japan, but Japan couldn't legally buy the finished mercury product, so the plan was for Red Devil Mine to ship concentrated cinnabar to Japan.

At any one time there were 4-10 Japanese "advisors." They were absolutely astounded at the salmon eggs local people threw away. One dignified professional Japanese engineer dove headfirst into the Kuskokwim River to retrieve salmon eggs someone discarded.

In the new milling process, the ore was brought from underground then run through the crusher. From there it was fed into two ball mills that had been freighted in from Hatcher Pass in Palmer.

The ball mills were cylindrical, and turned rather slowly. The ore was fed in at a given speed. The mills were lined with thick steel plates, and filled with perhaps one hundred heavy round steel balls about 3" in diameter. As the mills turned, the ore, thinned with water, was crushed fine by the tumbling balls. If it was not ground fine enough, the cinnabar and stibnite wouldn't separate from the country rock. If it was ground too fine, the process was too slow and production was decreased. Much of it was done by ear, listening to the sound of the mills working.

The cinnabar and antimony were separated from the country rock by crushing. The wet slurry from the ball mills was pumped into float cells, where the whole mix was stirred by underwater paddles.

An amazing chemical, sodium xanthate ($CH_3CH_2OCS_2Na$) was added to the slurry as a flotation agent. One end of sodium xanthate is hydro-phobic. It hates water. The other end of that long molecule has a strong affinity for sulfides.

In the float cells, the sulfide end of the xanthate attached to cinnabar and antimony, both sulfides. The other end of the sodium xanthate tried to escape the water and floated to the surface attached to air bubbles. The heavy cinnabar and stibnite were therefore floated to the top as a dark foam. The foam was paddled off the surface and run into barrels. This process with ball mills, float cells and xanthate is still widely used in different forms today.

While this sounds easy, there were complications. There is lots of iron sulfide in veins from volcanic intrusion. The sodium xanthate loves all sulfides. Worthless iron sulfide was also floated and skimmed off, contaminating the barrels of concentrate, sometimes comprising 80% of a barrel.

The slurry of concentrate was dumped onto a huge steel tray in front of the radiator of the generator. A hapless individual shoveled and stuffed the dusty concentrate through the bung hole of a 55 gallon barrel, and the barrel was shipped to Japan where the mercury was extracted by a process unknown to those in Red Devil.

Later, a mine manager was brought in who tried to mine the surface of Red Devil. One advantage of the surface ore was that the iron sulfide had oxidized into iron oxide, Fe_2O_3 rather than Fe_2S_3. The flotation process didn't touch the iron oxide, so concentrates were a beautiful red and silver color with very few iron sulfide contaminants. However, the quality of the ore brought to the mill was so low grade that process wasn't profitable either… Too many tons of country rock and not enough pounds of ore.

Around 1970, the world woke up to the hazards of mercury, and the price fell drastically. The Japanese, who had pretended to be interested in buying the mine, left with their concentrates, no commitments and no headaches.

Alaska Mines & Minerals was stuck with the cleanup.

Red Devil mine provided the only economy in that part of the Kuskokwim River.

However, AM&M paid local workers very poorly, often minimum wage for extremely hard work. Red Devil mine brought in many good people to the country, but brought in many undesirable people as well. Socially, the mine was a mixed blessing. Many current Kusko residents are descendants of those who worked during the 50's and 60's.

For decades after the mine closed in 1971, Red Devil Bar was responsible for the alcohol related accidental deaths of hundreds of people in that part of Western Alaska.

Red Devil school closed in 2008, and the post office is about to be closed (2013.) There are less than 25 people in that community.

Currently, BLM (Bureau of Land Management) is responsible for the Red Devil mine site.

In 2010 the Federal Government considered making Red Devil a super cleanup site. This would have been a huge mistake. It would stir up the contaminants and would have done no good at all unless it went down to and into cracks in bedrock where the raw mercury has certainly found it's resting place.

An average Interior Alaskan forest fire releases 12,000 metric tons of mercury. Raw cinnabar protrudes in many parts of Kusko country. Every time a forest fire burns the country, raw mercury is released. Mercury exposure is part of life in that part of the world.

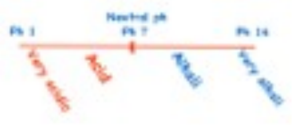
Activity: Study a topographic map of the Red Devil area. Look where the Kuskokwim cuts through the mountains. Look towards Dillingham. Does it appear that the whole Sleetmute to McGrath area, including the Holitna basin, were a lake until the Kusko cut through the mountains? If that is so, why do you think the lake didn't cut over to Dillingham? How would western Alaska be different if it had flowed to Dillingham rather than towards Bethel and the YK Delta?

The fact that Red Devil was not profitable, and, in the end, became an ecological and social burden, does not mean that underground mining is inevitably harmful. During it's operation, not one government inspector came to check on the operation. Modern mining techniques and regulations make it possible (but not guaranteed) to mine in a safe and profitable manner. Nixon Fork mine is hardrock underground, as is Greens Creek outside of Juneau. Both are done safely and in compliance with State and Federal regulations.

Red Devil taught us many lessons that do not need to be repeated.

PADrock. Modern concerns about mining often refer to PADrock:
Potential **A**cid **D**eveloping rock.

When iron sulfide is brought to the surface, it does oxidize, turning iron sulfide into iron oxide. The sulfur released combines with oxygen in the air and water to form… sulfuric acid!



Activity: Balance the following equation:

$FeS + H_2O + O_2 = Fe_2O_3 + H_2SO_4$

The concern is that sulfuric acid produced (ph< 7) will leach other minerals from the ground, causing an unfamiliar balance that might misdirect salmon. The ph altering process is constantly ongoing across Alaska, as our mineral rich soils erode, naturally exposing PADrock. However, the natural rate of acid production is far less than the potential from a mine. That is why mines, like Pebble, propose a pond over the tailings, to seal the tailings from exposure to oxygen.

Mining opponents oppose this process, as they envision the dam breaking. In the short run, dams of this type have held during severe earthquakes. In the long term, there is little likelihood that dam would stand without constant maintenance.

One way to avoid leaching by PADrock is to add natural limestone, $CaCO_3$, to the tailings.

Activity: Balance the following equation:

$H_2SO_4 + CaCO_3 =$

Limestone, which is alkaline, balances the ph of acidic substances. Limestone is available in large quantities in many locations in western Alaska. Most grains in limestone are made of skeletal fragments of marine organisms such as coral.

Near Red Dog mine on the Seward Peninsula, there are salmon in streams that never had fish before. Previously, the copper and zinc leached naturally into the local streams, preventing fish from living in the water. Now, the mine has so cleaned up the water that salmon are spawning in those streams.

Large Lode Mines

Lode mines can be either subsurface or surface mines.

Gold can exist as nuggets, as grains, as fine flakes, or as microscopic particles too small for the naked eye to see. Sometimes it is an impurity in the extraction of another base metal, like copper.

Pogo, not far from Fairbanks, is a good example of a large underground mine that uses modern mining techniques. Pogo is the largest gold mine in Alaska, producing approximately 400,000 ounces a year. Nixon Fork is also a large subsurface mine. Ore is hauled from underground by truck and tailings are hauled back underground to fill the drifts and stopes that have been mined out.

Fort Knox, near Fairbanks, is an open pit mine that successfully recovers very fine gold. Fort Knox struggled when gold went down to $220/oz. Current gold prices allow the milling of ore previously set aside as being too low grade. The mine works year round, and provides hundreds of jobs for the Fairbanks area. When Fort Knox plays out, Fairbanks residents hope that Livingood mine will have completed the permitting process and be producing.

Donlin Creek, which is on Native corporation land, will be a surface mine.

Engineers are still working on a plan for Pebble mine, determining whether it should be developed as a surface or subsurface mine. The political obstacles to Pebble are significant.

There are two parts to mining gold:

- Getting the ore out of the ground. As stated before, surface mines are much more economical to operate than subsurface mines.
- Getting the gold out of the ore. There are many techniques and processes. Often a combination of these are necessary to maximize the resource.

Getting the ore out of the ground.
Surface open pit.
Once past the weathered overburden on the surface, rock is moved by drilling and blasting.

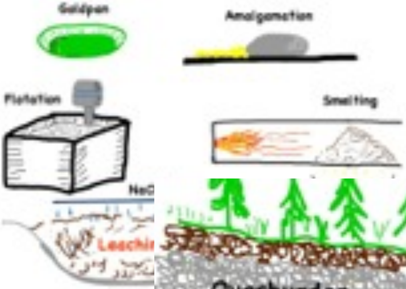
In open pit mines, drilling machines can blast tons of ore daily. Huge dozers and loaders get the ore into large trucks that haul the rock away. Some loads go to the waste pile, some set aside for a lean day, and others go to the mill. Constant sampling is necessary to direct the operation.

Subsurface. Underground operations have been described above in the section on Red Devil mine.

Extracting gold from ore.
Gold can exist as nuggets, as grains, as fine flakes, or as microscopic particles too small for the naked eye. Sometimes gold is an impurity in the extraction of another base metal, like copper.

There are several ways to extract gold. A good knowledge of all aspects of chemistry is essential for mineral extraction and mill operation.

The methods are: panning, amalgamation, froth flotation, smelting and cyanide leaching.



Panning or washing tables use gravity concentration to separate gold from country rock and black sands. This process has been practiced for thousands of years, and is good for prospecting, and, on a larger scale, with sluice boxes in placer mines.

Amalgamation with mercury. This process has been used since 1000 B.C. Mercury and gold combine in a thick, dull silvery mass, called an “amalgam.” The mercury is then removed from the amalgam by heating, and the gold remains. Of course, the fumes of the vaporized mercury are very toxic.

Small miners in other parts of the world still use the amalgamation process to gather fine gold, but it is no longer used in larger commercial mines.

Froth flotation. When gold is associated with sulfides, flotation can be used to extract it from the country rock to form concentrates. This process was described previously.

- Step one is to grind the ore finely enough to separate the target minerals from country rock. That fineness is always different and is determined by the type of rock being milled.
- Then the ore, and a chemical (like sodium xanthate) are added to a large cell (4‘x4') along with a frothing agent (to make bubbles.)
- The ore and chemicals are stirred constantly by spinning impellers.
- One end of the xanthate molecule is hydrophobic. It attaches to bubbles floating to the surface that are attempting to escape the water. The other end of the xanthate molecule attracts sulfides. The sulfide based mineral that gold is associated with attaches to the xanthate, and is lifted to the surface to be paddled off.
- The concentrate is treated, then the gold is removed by leaching, described below.

Smelting. Heating an ore or concentrate above a certain temperature, in the presence of a reducing agent, will release the desired metal from the contaminants. Often, carbon monoxide is intentionally produced. When heated, and the CO is passed over ore, it robs that ore of any oxygen molecules, forming CO_2, leaving the pure metal behind. The metal is cooled while shielded from atmospheric oxygen.

If smelting cannot work on the metal within the ore, then leaching is employed.

Cyanide leaching.
In the heap leaching process, there are two steps:

- Dissolving the gold from the finely ground ore with sodium cyanide. The ore is placed on a strong mat in a depression and a solution of sodium cyanide (NaCN) is sprayed onto the surface. The liquid seeps to the bottom and is drained away. The liquid is said to be "pregnant" when it has removed gold from the ore. The remainder of the rock, now free of the gold, is taken to a tailing pile. This process takes at least one to two months, and often longer.

Activity: Balance the following equation.

$Au + Na(CN) + O_2 + H_2O \rightarrow Na[Au(CN)_2] + NaOH$ (Hint try 8 Au)

- Removing the gold from the cyanide solution, either with with zinc or adsorbing the gold onto activated charcoal. When the solution is exposed to zinc, the more reactive zinc takes the place of the gold, and the gold precipitates out. The Na(CN) is recycled.

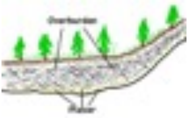
Modern processes allow the removal of gold and other minerals from ore that was completely impossible for early miners. While there are genuine concerns about cyanide and other chemicals entering the water table, Fort Knox, Pogo and other large mines use these processes all year long and have a clean record. Nearby streams remain uncontaminated, and all chemicals are contained within the milling process.

Large mines provide jobs for skilled workers and stimulate the local and State economy by buying equipment, supplies and fuel. Support services like air taxis, trucking, lodging and restaurants also benefit. Mines provide positive exports from the State and mining dollars circulate several times through the community before departing to the Lower 48.

Despite the large amount of minerals produced in Alaska, there is no smelter, as the cost of electricity to operate is so much less in China and other countries than it is in Alaska.

Local placer mines

Interior Alaska has been greatly impacted by placer mines such as Gains Creek, Ophir, Moore Creek, Spruce Creek etc. In the early 1900‘s, thousands of miners came through the country seeking placer gold. Of those that stayed, some started stores, others trapped, and started families. A few are still mining. Most miners said that Ophir was the best mining town. No one got rich, but everyone made money. The name Ophir comes from the Bible reference of a small city that was a focal point for trade, including gold.



Placer mines go after deposits that have been moved from their point of origin by erosion, and concentrated in the process because of different specific gravity.

Placer operations are fairly simple to understand. They are not easy to work. The gold, with higher specific gravity than country rock, has, through erosion, moved and settled close to, onto, or into the cracks of bedrock. The challenge before the gold miner is to:

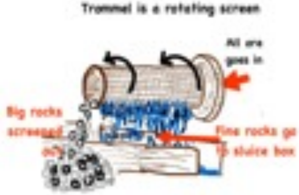
- Remove the overburden that contains little or no gold. Overburden can be as shallow as ten feet and as much as one hundred feet or more. Whether the claim is worth working or not depends on the quality of the ore and the amount of valueless overburden.
- Get to the gold rich ore that is either near, on or into bedrock. Determining where the overburden starts and where the ore begins is the challenge. The miner must constantly check with a pan, where the overburden stops and where paydirt begins. This could vary on a day to day basis. If he isn’t careful, he could haul gold to the dump or he could dilute good quality ore with tons of worthless gravel.

Most small placer claims work first stockpiling the ore, then later running the sluice boxes when there is enough ore and enough water. Many mines must build artificial ponds above their sluice boxes to capture enough water for the sluicing operation.

Shaker tables and other ingenious inventions have been built to separate gold from the country rock, and fine gold from black sands.

Sluice boxes are all basically the same. The water flows down the box. Ore is dumped into the head of the box. The country rock, with a specific gravity of only 2-3, washes away, and the heavier gold, with a specific gravity >19, settles behind the riffles in the sluice.

However, it isn’t quite that simple. Large rocks must be washed well before discarding. Fine gold often adheres to them. If clay is present, it makes the whole process extremely difficult, as the clay carries much of the fine gold away.



Sizing the materials is tremendously important. Although gold is much heavier than country rock, if there is a large rock in the sluice box and enough water is applied to get it out the other end, that large amount of water could easily wash away the fine gold as well. To solve this dilemma, the ore is sized by running it through a trommel, a slowly spinning screen while being sprayed with lots of water. The fines fall through the screen, and the bigger rocks are discharged from the end of the trommel.

The more accurately the ore can be screened, the more efficiently the sluice box can separate the gold from the country rock.

A screen that is too fine might not recover a large nugget. A screen that is too big will allow larger rocks to get into the sluice box, requiring more water, which could wash away a quantity of fine gold. A miner has to know his ore.

The angle of the sluice box is critical and so is the amount of water. If the water is too fast, gold will be lost. If the flow of water is too slow, the box will plug up with gravel. It is a balancing act: angle, amount of water, sizing the ore that goes in, and metering the ore input with the water flow.

Efficiently running a sluice box is an art, but one that pays well.

The riffles of most sluice boxes are hungarian riffles, and the beds of the sluice box comprised of screens underlain with Nomad carpeting. All materials must be very durable, as tons of rocks bounce and scrape their way through towards the tailing pile.

Gold mining is financially and physically risky, physically dangerous, and difficult. Experienced miners work their claims carefully. Miners must be mechanics, operators, geologists and carpenters. They must often do their own cooking and be on constant bear patrol, be their own medic and provide their own entertainment. Most miners are pilots and know the country like few others. They are a special breed of Alaskan.

Past problems. Gold mines used to spew silt into clear streams. The silt settled and covered the salmon eggs, choking them out, damaging the run years later. Now, placer mines must have several settling ponds that catch the silt, and the effluent is clear. Violations are easily spotted from the air.

Fortunately, chums, reds and silver salmon spawn in 3-4 year cycles, so damaging one year doesn't wipe out the whole run. Kings spawn in 2-6 year cycles, with lots of overlap. In time, they can recover. Only pinks (humpies) spawn exactly every other year. Wiping out one year can destroy that run forever.

Reclamation. Over geologic time, eroded minerals settle towards bedrock. When a placer mine turns the country upside down, the minerals that had settled beyond the reach of vegetation are brought back to the surface. This is like a farmer with a deep plow, bringing nutrients back to the surface. Willows immediately take over, then aspen, then birch. A location that was once tied up in black spruce, moss, and permafrost is turned into abundant moose browse. Unlike the past, modern mining requirements insist on the country being restored.

Challenges. Placer deposits could follow old stream beds that bare no resemblance to today's topography. Hillside placers may never have entered a stream. As miners, say, "Gold is where you find it." Seldom does the gold miner look at the cut he is working and know exactly which way the pay streak is going. He must constantly test sample with a pan to find the direction and concentrations of the placer.

Oil exploration and production

As mentioned before, 93% of the revenue of the Alaska State government results directly from oil production.

Before 1859 when oil was first extracted from the ground in Tituaville, Pennsylvania, the world relied on animal fats to light homes and whole cities. Whaling off the coast of Alaska and other northern countries produced large amounts of whale oil that burned hot and clean.

However, without the discovery of oil production from the earth, there is no way modern cities could have progressed to the level they have. Oil production has changed the face of the globe, both in trade and technology.

Activity: Imagine and discuss what the world would be like (and the whale population!) if the technology to remove oil from the ground had not been developed. Would the first car have run on whale oil? How would we light our homes? How did Alaskans light their homes before electricity?

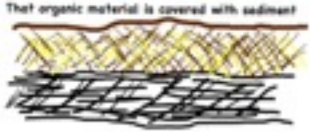
Activity: Identify the objects in the classroom: students' clothing, cell phones, any object that might be named. Was each object made in part or in whole from petroleum products? Or was it made using petroleum powered energy? Freighted by petroleum powered fuels? From what material are asphalt roads made? All plastics? Nylon, rayon, Dacron? Lubricants, paint, preservatives? It is much easier to find objects made from petroleum products than find ones that are not.

Origin of oil in the earth

There are two theories about the origin of oil in the earth: inorganic and organic.

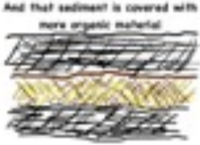
Inorganic. The inorganic, or a-biotic theory says that carbon, water and other elements combined with the heat and pressure in the lower crust of the earth to form long carbon chained molecules to become the deep oil deposits of today. Those who hold this theory believe that oil is still being formed within the earth's crust by this process.

Organic. The organic theory, which most scientists hold to, states that oil is the result of living, organic substances dying, settling, and being covered with sediment. With heat from the earth's core, and pressure from sediment on top, the oil from those living beings is converted to what we know as crude oil.



Among those who hold to the organic theory, some believe oil came from plants, and others from animals.

As those plants/animals died and deposited, the remains, particularly the fats, combined with surrounding materials, becoming a layer of hardened shale.



Movement in the earth's crust, and subducting of plates caused the diving of those shale deposits and erosion above them. They were covered with eroded sand. With time, and under pressure, the sand layer became sandstone. Most geologists believe that shale is the source rock for oil deposits. Several layers of shale and sandstone, one on top of the other became buried with other layers shale and sandstone.

The sandstone layers contained considerable salt or brackish water from the seas and rivers that covered them. When oil wells extract oil from the ground, they also pump old water that must be separated from the crude oil.

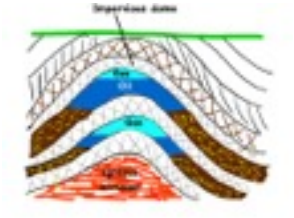
Most oil deposits do not exist in the rock formations that created them. The oil has migrated from the source rock. Oil has a lower specific gravity than water, <1. The oil from the shale tends to rise, and the heavier water in the sandstone tends to settle. There has been an exchange, so the oil has now migrated upward into marine sandstone where it is most often found. The quality of a deposit is determined by the depth and porosity of the sandstone. Younger sandstone tends to be more porous than older sandstone.

Modern exploratory techniques attempt to extract oil from shale that hasn't had the time to migrate into surrounding sandstone.

The oil continues to rise through the tiny gaps in the sandstone until it hits an impermeable cap. There must be a trap to stop and hold the oil if it is to accumulate. Most igneous and metamorphic rocks are impermeable. The trap could be in a dome or could exist against a fault.

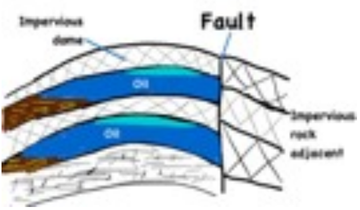
The following are necessary for oil to accumulate:

- Oil containing source rock.
- Permeable, porous strata towards which the oil can migrate.
- An overlying impermeable bed of rock and/or
  - A fault of some kind to prevent further migration.



There are three basic types of oil reserves.

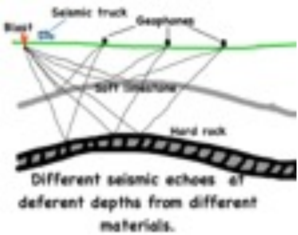
- **Structural trap reserves.** In this type, the shape of the rock, either as a dome, folds or faults confines the oil and keeps it from migrating.
- **Stratigraphic trap reserves.** This type of reserve is held in place by a fault preventing the migration of the oil.
- **Combination** of the two.



The oil geologist constantly looks for geological formations that could indicate a trap where the oil would migrate upward and be stopped.

Methods used to search for oil are:
Gravimetric. Oil bearing rock formations are less dense than other formations. Precise measurements of the gravitational force in the earth's crust can show an anomaly, or unexpected difference, in that gravitational force.Magnetometer. A magnetometer can detect the presence of iron-bearing rocks near the surface.

Seismic. Seismic readings are, by far, the best method to detect different layers, strata and densities of the earth's crust. Scientists set off explosions and listen for the echoes from within the earth. Different formations give back different echoes. As a region is mapped with seismic tests, geologists look for domes or peaks that could trap the oil.



<u>**A**ctivity:</u> Blindfold students, and tap on different objects in the classroom. Can the students identify the object by the sound of the tapping? This is *similar* to seismic testing. Different formations have different sounds. Sound can echo (bounce off), be absorbed, or pass through a material. Sound bounces off cliffs, giving an echo. Sound is absorbed by ceiling tile… and sound passes easily through hotel walls.

A combination of methods and careful planning can lead geologists to identify where the greatest likelihood of oil might be. Yet, only one hole in ten produces profitable oil. Empty holes are called "dusters."

The first hundred feet of a well is cased very strongly and cemented in, so surface water and fluids from underground don't mix. This also protects against blowouts. From there, the hole is drilled by adding lengths of steel pipe.

The lifespan of a drill bit could vary from several hours to several days, depending on the type of rock being drilled.

Drill bits are made from diamonds embedded into a steel bit. Diamonds are extremely hard, and are able to cut rock. The only problem is keeping them from flaking off of the bit.

As the bit penetrates the earth, the slurry emerging from the well hole is constantly sampled for clues about the rock being drilled. At times, a core bit will be used and the core removed, sampled and analyzed. A core bit doesn't pulverize all of the rock, but saves an inner core that can be recovered, sampled and tested.

For many years, drill rigs could only drill straight, either on an angle or straight down. More modern drills are able to drill down, and then curve, and even go horizontally. The drill bit is rotating, but is not connected by spinning pipe. The slurry is washed out of the hole by fluids injected at the bit. This development has radically changed oil exploration and recovery.

Exploration, Development and Recovery of oil.

There are three separate components of delivering oil to market.

- **Exploration.** The State of Alaska has the second highest incentives for oil exploration in the world. The State reimburses much of the cost of exploratory wells.
- **Development.** Development is building the infrastructure necessary to get the oil from a new well to the facilities.
- **Recovery.** Recovery is getting the oil out of the ground and getting it into the pipeline. Most oil fields in Alaska are in harvest mode, and all legacy fields are declining in production.

Utilization of Natural Gas from the North Slope.

In the North Slope of Alaska, there are trillions of cubit feet of natural gas. Natural gas is now injected back into the ground, creating the pressure necessary to push the existing crude oil to the wells. Natural gas drives the oil through the permeable rock better than water or atmospheric air. Without the pressure provided by re-injecting natural gas, many oil wells would cease producing.

There are several options for removing gas from the North Slope:

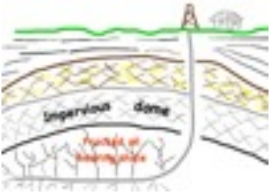
- Build a pipeline from the North Slope to Fairbanks, and, from there, pipe the oil down the railbelt towards Anchorage. This is called the “bullet line” or,
- Build a large pipeline from the North Slope to Fairbanks and from Fairbanks to Valdez to ship to International markets. The size of the pipe and other logistics are dependent on foreign markets that have made no commitments to date. The world market for natural gas is constantly fluctuating, so planning and developing 5-10 years in advance for any pipeline is extremely risky.
- Generate electricity on the North Slope with the natural gas and send electricity south to Fairbanks and other Interior locations. To date, this seems to be bad math.
- A temporary solution for Fairbanks is to truck the natural gas from the North Slope. This requires liquefaction on the Slope and storage in or near Fairbanks, the price of which is in the multiple millions. Only 15% of Fairbanks is on the natural gas

infrastructure, so the benefit to Fairbanks will not be fair to all residents. Some will enjoy reduced heating costs, but most will not.

There are huge questions about the future price and international market of natural gas. The supply of gas in Cook Inlet is unknown. Does Anchorage need natural gas, or will it be an exporter of gas? The whole AGIA project, that guaranteed Trans Canada Corp. $500 million seems to be permanently stalled. At the time, the math was good. Now that plan appears to be a boondoggle.

Fracking for oil. Once the oil drill has penetrated sideways, and been extracted, tremendous hydraulic pressure can be exerted in the lower portion of the well, breaking or fracking the rocks. Those fractures in the sandstone give more surface area for oil to seep from, and greatly increase the ability to efficiently extract oil from the well.

Opponents to fracking are concerned that a fracture in the impervious cap might allow gas and oil into local water supplies directly above. The danger or safety of fracking is totally dependent on the material in the dome over the reservoir. If there were no dome or upper obstruction for oil migration, the oil and gas would have seeped to the surface long ago.



Many scientists feel that it is better to frack in a known bed maximizing the resource than drilling numerous holes in other places hoping to find an equivalent amount of oil.

CO_2 Emissions

Hydrocarbons are produced as part of the natural cycle by photosynthesis. Water and carbon dioxide unite in different combinations to produce plant fibers and animal fats. If indeed, crude oil is the result of plants or animals being compressed below the earth's surface, the CO_2 that was once trapped inside the earth's crust as crude oil is now being released. We are not releasing any CO_2 that was not here before. It was once free, then was sequestered in the earth's crust and is now being freed again.

When hydrocarbons burn, water and carbon dioxide are byproducts of that combustion. When our cars, trucks, jets, electric generators etc burn fuel, CO_2 is most definitely emitted. However, consider:

As we burn hydrocarbon fuels today, we are releasing back into the atmosphere the CO_2 that was part of the atmosphere during the days of dinosaurs and large plants.

There is considerable concern today about CO_2 emissions. Four statements can be made regarding that:

- The CO_2 emitted today was once free in the atmosphere. We are now releasing that which was trapped deep in the earth's crust for millennia.
- Of all the CO_2 produced in the world, only 4% is anthropogenic (caused by man.) Without question, rotting plants, volcanism, and the oceans of the world emit the major portion… 96%. At the same time, that same CO_2 is constantly used by plants in photosynthesis to make plant fiber across the planet. If there were no CO_2, there would be no photosynthesis, and therefore life on earth would cease. It isn't like CO_2 is being stockpiled. Plants constantly use it to grow and make food for animals.
- Water vapor is twenty five times more powerful than CO_2 as a greenhouse gas. There is certainly no way for government to regulate the amount of water vapor in the atmosphere.
- A greater concern for global warming is the release of methane, CH_4, of which there are giga-tons trapped on the ocean floor. Methane is far more powerful as a greenhouse gas than CO_2. If all the methane were released, the greenhouse effect would be truly life threatening. Increases in ocean temperatures is therefore, of far greater concern than the minuscule impact of 4% of the CO_2 produced on the earth. Undersea volcanism also contributes greatly to increases in ocean temperatures that contribute to warming of ocean currents and the methane deposits..

CO_2 emissions from the combustion of hydrocarbons is a genuine concern, but has been hugely exaggerated in comparison with other weather changing agents.

Conclusion

Mining has been part of Alaska's past, and can be an ever increasing part of Alaska's future.

Certainly, there were irresponsible mining activities in the past, but public awareness has changed the face of mining.

The Federal Government is obligated, as part of the Statehood Agreement Act, to not just allow, but to *assist and encourage* the development of resources in Alaska so the vast area and few people populating that area can have meaningful jobs and services.

Alaska's economy, social services, education, roads, transportation etc are all directly connected to the State budget, which is directly connected to wise mineral extraction.

Consider:

- The Federal contribution to all states budgets must decline as the international dynamic will not allow the US to borrow or print money as in the past. There are no new tax revenues. The Federal debt exceeds $16.5 trillion dollars. Federal contributions to states economies *must* decrease.
- State revenues from North Slope oil extraction will most certainly decline.
- There is currently no economical way to get the trillions of cubic feet of natural gas from the North Slope. The international LNG market is unstable and impossible to predict.

- Revenue from fishing will not increase. Whatever revenues that exist are sliding towards Seattle and international stakeholders.
- Tourist dollars are not likely to increase as gas prices go up. At the same time, most tourist dollars go directly to international corporations that shuffle people in and out of our State. Tourist dollars do not circulate well.
- The Federal Government effectively shut down Alaska's logging industry. The little logging that goes on is for local consumption. Logging will not contribute to the State's economy.
- The military investment in Alaska will not increase. Several planned operations in JBER, Eielson, Wainwright and Greely have been shut down or postponed. Alaska's bases must constantly be defended by our Congressional delegation in Washington D.C.
- Public sentiment and environmental concerns will not allow Alaska to develop its multi-billion dollar coal resources.
- Traditional activities: trapping and firefighting will not increase. Trapping separates families, and the cost of fuel takes a huge bite out of trapping income. Firefighting money is directly connected to State revenue, which will decline.

What does Alaska have to offer the world in exchange for the goods and services we consume?

Alaska has many commodities: copper, silver, platinum, tin, coal, iron ore, borax, chromite, antimony, tungsten, nickel, molybdenum, rare earth minerals, sand, gravel and limestone.

Young people need to become aware and prepare themselves for the economy of the future which will either involve mining or poverty.

Science Concepts

Ph.
Specific gravity
Covalent bonds
Atmospheric pressure, psi
Permeable, semipermeable

Assessment

Mining Intro

Why is it important to study mining?

What are Alaska's economic options? List each one and give a brief summary of its future.

From your class discussions, write a paragraph each on the past, present and future economy of your community.

Write a short paragraph describing the Statehood Agreement Act, and how it has played out in Alaska.

Geology

Why does Alaska have so many geological resources?

Define:

Igneous rocks
Sedimentary rocks.
Metamorphic rocks.

Describe the main factors in the development of a mineral deposit.

Describe the effects of the Pacific Plate diving under the North American plate in Alaska.

How is the geology of the North Slope different from the rest of Alaska such that it can contain vast oil deposits?

Define:

Fault
Hydrothermal vent
Tectonic plates and terranes
Pluton
Shale
Sandstone
Sodium xanthate

What is the difference between a lode deposit and a placer deposit?

Describe the difference between a surface and subsurface lode mine.

What is the difference between prospecting and mining?

What is the difference between a Troy ounce, and an Avoirdupois ounce?

A miner got 957 Avoirdupois ounces of gold that were .815 fine. If the gold price is currently $1,452/ Troy ounce, how much was his cleanup worth?

What is the chemical symbol for mercury, and what was its primary use in Alaska?

What is amalgamation?

Which is heavier a Troy ounce or an Avoirdupois once?
What is “fine” and what is the average fine of Alaskan gold?

How much does a flask of mercury weigh, and where did that world standard from?
Unique quality of mercury. It is the only metal that is____ __ ___ ___.

Explain the name “Red Devil.”

What weather reference is used of mercury to this day?

Label the parts of a mine (Image, shaft, drift, stope, raise.) Alan insert image.

Describe the difference between retorting and flotation of cinnebar. What is the almost magical chemical that causes flotation to work with sulfides?

What is PADrock? Name two ways to protect PADrock from reducing the ph downstream.

What determines whether a mine is shaft or open pit?

Name three lode mines in Alaska.

Name three placer mines either contemporary or historical.

List and briefly describe five methods of extracting minerals from ore.

Describe the challenges before a placer miner.

Describe how a sluice box works. Use a simple illustration and a short paragraph.

Oil

What percentage of Alaska’s economy comes from oil extraction from the North Slope?

What are the two theories of oil origin? What are the two sub=theories of the second one?

What is the most important feature of oil concentration? Draw this.

There are three methods used in searching for oil. Name and describe in word and by illustration the most important one.

What are the three stages of oil extraction?

Briefly describe the problems in getting the massive North Slope gas reserves to market.

What is fracking? When could it be safe and when is it not safe?

What percentage of the earth's CO_2 production in a year is anthropogenic? What are the other sources of CO_2 production? Name two greenhouse gasses that are far more dangerous than CO_2.

Writing activities

Write one to two pages on any of the following:

- Write a summary of the impact of mining on your part of Alaska.
- What what your community look like if both Federal and State governments cut spending by 50%. Write a 1 page opinion piece.
- Write a story of a village person who has lived in a village all his/her life, and is faced with people leaving when there is no economy.
- Write a letter to your Congressman telling him what you think about the Federal Government not cleaning over 100 wells in ANWR, a wildlife reserve that is polluted.
- Write a letter to local miners telling them your thoughts about how mining should occur.
- What careers do you see for young people wanting to stay in your region?
- Write a convincing argument for or against Pebble Mine.