Mining companies are required to provide alternative sources of water if they are responsible for water loss or poor water quality.

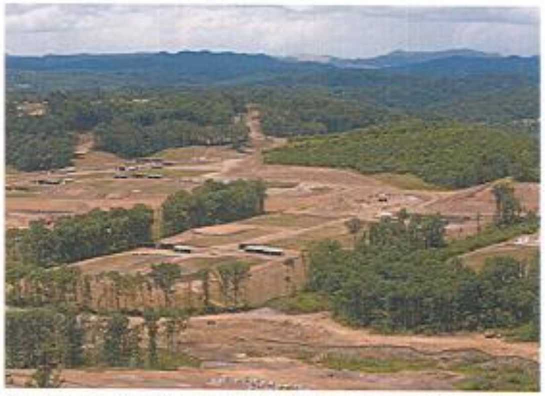
SURFACE SUBSIDENCE

When minerals are removed from underground mines, the surface above may *subside* or sink. A room-and-pillar mine generally has no subsidence on the surface, unless the pillars fail after the mine closes. However, longwall or block caving methods will—by design—cause surface subsidence. So precautions are necessary to avoid mining under surface structures (buildings, highways, etc.) and may call for a plan to restore the surface structures after mining ends.

Many areas rely on groundwater for irrigation or drinking water. When there is subsidence, the water supply can be disrupted. In most cases, the interruption is temporary; in others it is permanent.

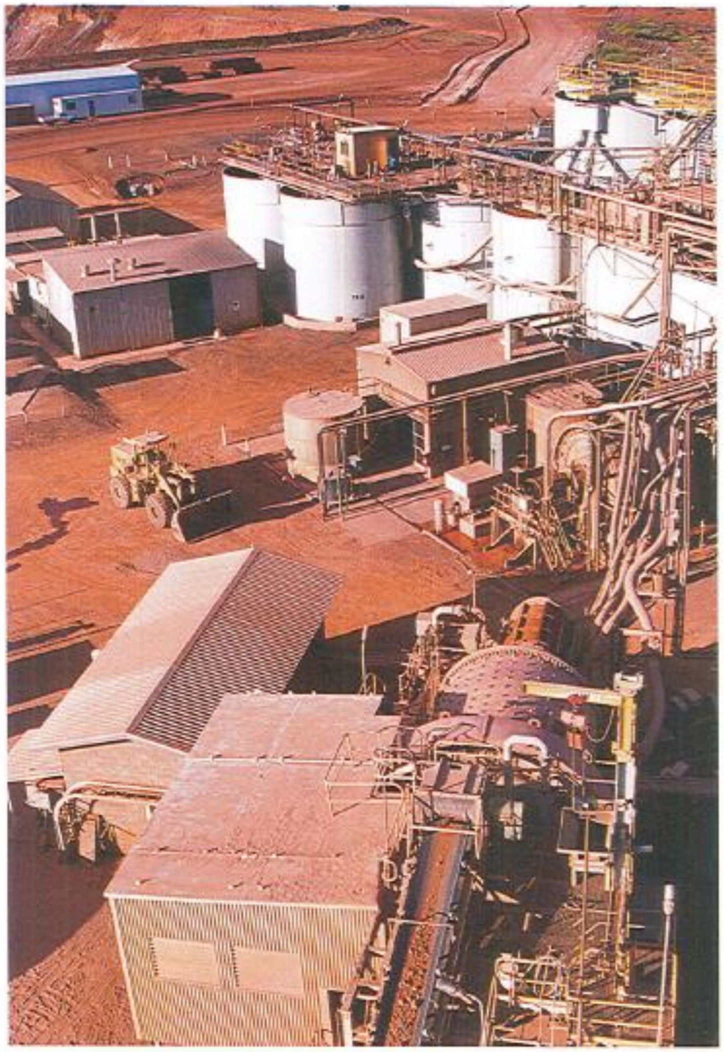
The Summit Bechtel Family National Scout Reserve

The BSA Summit Bechtel Family National Scout Reserve was a mining site before reclamation and conversion to the Boy Scouts of America's new high-adventure facility. The pictures here show the Summit site as a 1900s underground coal mine, and as we know it now. This is a good example of how mine reclamation returns mined land to other uses.



Today the Summit has been transformed into the BSA's world-class high-adventure base.

The smokeless coal formerly mined from the land of the BSA Summit fueled the steam shovels, steam drills, steam trains, and steamships that built the Panama Canal in 1904–1914. This photo shows a mine and tipple. Coal was lifted from the mine to the surface and prepared for shipping.



Mineral Processing

Companies mine minerals to sell at a profit to customers who need and demand them. However, most minerals cannot be sold immediately after they are extracted, because customers can't use them in that form. Mineral processing gets the minerals ready for the customers. Processing converts rock into a form that is usable, transforming it into such things as a gold bar, or separating it into different sizes for sand and gravel, or in the case of coal, it's cleaned to reduce pollution when it's burned.

Mineral processing can be simple with only a few transformation steps, or it can take many steps to release the minerals or metals. Each step uses specialized tools and equipment. The equipment used in modern mineral processing is huge, highly automated, and worth millions of dollars.

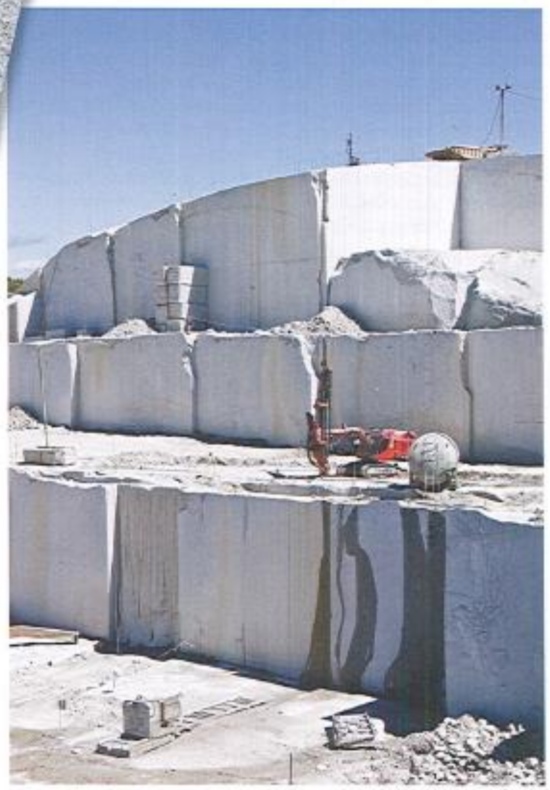
One responsibility of the mineral processing engineer and metallurgist is devising methods to remove valuable minerals from the ore rock after it is hauled out of the mine.

Processing Methods

Separating and purifying an ore into a useful product can be difficult. In gold-bearing ores, for example, the gold particles may be microscopic. The mining industry has found ways to recover gold from grades as low as 0.01 ounce of gold per *ton* of ore. To put it another way, a ball of gold ore 3 feet in diameter would contain the equivalent weight in gold of only 10 Cheerios® (one-hundredth of an ounce).

Rock Cutting

Dimension stone is natural stone or rock that is cut to specific sizes or shapes. To make dimension stone, diamond saws and wedges separate large blocks of rock in quarries. The blocks are cut into smaller pieces: from small slate roofing tiles and walkway pavers to large rectangular slabs for granite kitchen and bath countertops and marble monuments or interior walls.



Material Separation

To separate different sizes of materials, screens are used. A mixture of sand and gravel may be fed into a series of screens to separate the various sizes. The fine sand might be used in a sand trap on a golf course, while the gravel could be used to make concrete or road base.

Crushing and Grinding

Many mineral processing plants have equipment to break different sizes of rocks into smaller ones. Large, heavy-duty crushers can reduce boulders the size of an automobile. Some crushers pinch the rocks between moving walls and fixed walls, much like a hammer and anvil.

Other kinds of crushers drop the rocks onto hard materials or other rocks to break them. In coal processing, for example, the coal is softer than the rocks, so the coal shatters. Rotary breakers reduce the size of the coal, which passes through holes in a drum. The larger rocks are rejected out one end.

After going through a crusher, rocks may be ground to a fine powder using a *mill*. A mill is a cylinder or drum filled with rock, water, and steel balls or rods. As it rotates, the steel balls crush and grind the rock into tiny particles making it possible later to separate the mineral from the waste rock. Modern grinding mills may be up to 40 feet in diameter, and use 30,000 horsepower. A typical family car may have only 200 horsepower.

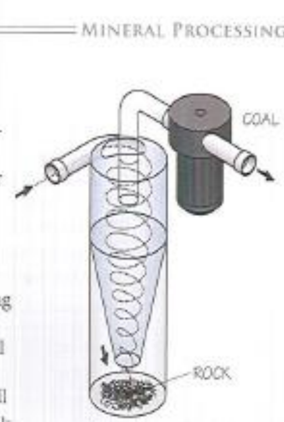
Crushed stone from primary crusher

Grinding releases the individual mineral crystals that make up the rock. Once the different mineral crystals are separated, they can be concentrated for higher purity. Separation methods use the different physical and chemical properties of distinctive mineral crystals. For example, magnetic separators concentrate magnetic mineral crystals, such as magnetite, from nonmagnetic mineral crystals, such as quartz.

Gravity separators separate heavy, dense minerals such as gold from lighter rock fragments. An example of a simple gravity separator is the prospector's gold pan.

Cyclone Separation

Coal coming directly from the mine is contaminated with heavier rock and sulfur-bearing minerals such as pyrite. A type of gravity separator called a cyclone is used to separate out the lighter coal. The cyclone swirls a slurry (a mixture of water and solids) of pulverized coal and rock.



A cyclone separator uses density to separate coal from waste (rock and pyrite).

Flotation

Flotation is a chemical process for separation using a vat, or *flotation cell*, filled with water and a chemical called a *flotation agent*. Tiny ore mineral particles are added to the cell to form a slurry. Agitating it creates air bubbles, which mix with all the tiny particles. The air bubbles stick to the valuable mineral particles, lifting them to the surface to be skimmed off as foam; the waste minerals sink. In some cases, the desired mineral sinks and the waste minerals float to the top.

Chemical Processes

Some minerals can be chemically dissolved, then recrystallized or precipitated into a highly pure solid form. Examples include titanium dioxide used in sunscreen to block ultraviolet radiation; sodium carbonate used in baking soda; and table salt formed by the evaporation of seawater. Some metal mines use a technique called *heap leaching* to chemically dissolve and separate valuable metals such as gold, copper, and silver from a pile of crushed rock.

Flotation cell

You can try the flotation method yourself. Throw some peanuts and sand into water, and both will sink. If you mix the peanuts and sand and drop them into a glass of carbonated water (such as soda), you will see that the oily peanuts attach to the gas bubbles (the oil acts as a flotation agent) and float to the top, while the sand sinks to the bottom.

Smelting

Metal-containing minerals are concentrated by mineral processing and shipped to a smelter where high temperatures transform the metal-bearing mineral into pure metal. During smelting a *flux*, such as limestone, is added to the molten metal to combine with unwanted impurities called *gangue*. The combined gangue and flux form *slag* that is separated from the molten metal. The molten metal is then poured into a mold to make very pure bars or ingots.

Smelting involves a chemical change to the raw material, but in refining, the final material is usually chemically identical to the original one, only purer.

The molten gold being poured here will soon become gold ingots.

Refining

Refining is usually the last step in processing metals. After smelting, a metal is dissolved in acid and electroplated (deposited in a thin layer by electrolysis) as an almost pure metal. In copper production, the copper coming from the smelter may contain impurities such as arsenic. The copper is dissolved in acid and then plated out in a way similar to how a car battery works, by creating an electric current. The pure copper is sold to make wire or other products.

Copper waiting to be manufactured

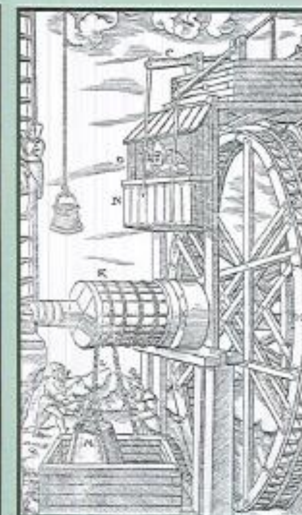
Calcination

Another process of heat-treating rock or mineral is called *calcination*. In one example, calcination is used to transform calcite, the major component in limestone, into lime. (This was mentioned in the "Rocks and Minerals" section). Gypsum is calcined at 250 to 300 degrees Fahrenheit to remove the water of crystallization as water vapor. Calcined gypsum is called *stucco*.

Waste Products

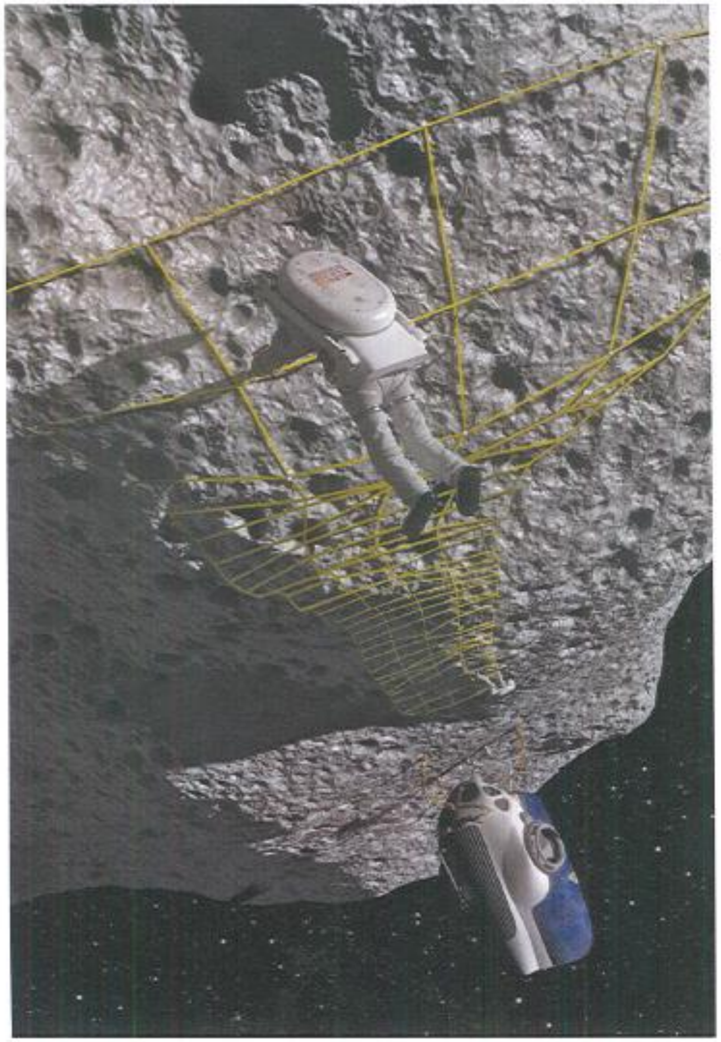
After processing ore to recover valuable minerals, the leftover materials are called *refuse*, *gangue*, or *tailings*. These must be disposed of in an environmentally safe manner. Disposal facilities are designed to hold all the waste generated during decades of mining and processing plant operations.

Processing rocks and minerals is done in a plant that houses all the equipment and has storage space for ore, processed materials, and waste. Mineral processing requires moving and storing large volumes of rock, water, tailings, and finished products. Mineral processing plants can look very complicated with all the tanks, silos, conveyors, and pipes that transport materials from one stage to the next.



Georgius Agricola (1494–1555), a German scholar and scientist, is known as "the father of mineralogy" and is considered the founder of geology as a science. Agricola wrote on many subjects, including history and paleontology (the study of ancient life forms; fossils) as well as metallurgy and geology. His publications were based on his field observations.

His book *De Re Metallica*, published in 1556, was among the first and most important books on mining and mineral extraction. While natural resources had been obtained from the earth for thousands of years before then, his was the first complete work on the subject. Agricola explained and illustrated metal veins, exploration and surveying methods, and types of mining machines. His explanation of water mills and water power was especially important for its time—from crushing rocks to mine-shaft ventilation to separating minerals by gravity—centuries before the use of steam power. *De Re Metallica* championed the importance of metals in human civilization.



Mining in the Future

In the future, mineral deposits most easily mined from Earth will be depleted. Miners will need to dig deeper and work in more challenging conditions to mine newly discovered deposits. Other potential sources of minerals exist beyond these, however. It may sound like science fiction to talk about mining the oceans or interplanetary space, but we already harvest minerals from the ocean. Also, detailed plans are in the works to mine the moon, near-Earth asteroids, and even other planets.

Miners have many reasons to look beyond the usual places for minerals. A mineral deposit in a remote location on Earth might not have water, electrical power, roads, or workers nearby, and the cost to install or obtain these might be excessive. In addition, the grade might not be high enough; that is, the mineral concentration might not be at the necessary level to cover the cost of the machines and processes to mine it. Also, an unfriendly country might control the only source of a certain mineral, charging high prices for it or preventing others from extracting it. Wars are sometimes fought over such resources.

Finally, the environmental cost of mining "the usual places" may be too high in terms of loss of species (biodiversity), water and air pollution, damage to Earth's natural landscapes, or any combination of these.

Mining the Ocean and Seabed

Electrolysis removes magnesium metal from seawater in one step. The magnesium forms alloys with other metals, especially aluminum.

If you have ever tasted ocean water, you know how salty it is. The ocean is Earth's greatest storehouse of minerals. Besides hydrogen and oxygen that make up water, the most abundant elements in the ocean are sodium and chlorine, the elements that form salt. While these elements come mostly from surface erosion of the continental landmass, most sodium is leached from the ocean floor and most chlorine is emitted from Earth's interior by volcanoes and hydrothermal vents.

Other abundant elements dissolved in seawater are magnesium, sulfur, calcium, potassium, carbon, bromine, boron, strontium, and fluorine. Some are already mined from the oceans. You are eating salt harvested from seawater if the package says "sea salt." Common salt is obtained from seawater by collecting it in ponds where the sun's energy evaporates the water. The salt is left behind as sodium chloride crystals and is then harvested for consumption. Salt is used for seasoning and preserving food. It is also used in water softening and for deicing roads in wintertime.

Bromine, too, is extracted from seawater. It is used in flame retardants; water purification, particularly in swimming pools and hot tubs; pesticides; over-the-counter and prescription drugs; and photography.

Iodine is mined from ocean water by harvesting seaweed. Its dry weight can have up to 0.45 percent iodine. Without iodine as a catalyst, or booster, plastic drinking bottles would not be possible. Other uses for iodine include pesticides, medical applications, pharmaceuticals, and stain-resistant chemicals.

Seaweed

The shallow near-shore realm concentrates some minerals. Gravel for concrete and beach reconstruction is mined by dredging the sea bottom close to shore. Titanium dioxide is mined along beaches and offshore sandbars as the minerals rutile, anatase, leucoxene, and ilmenite. These are heavier than the rest of the sand grains, so gravity processing easily separates them.

Diamonds and tin are also dredged from shallow waters close to shore. Mining these depends on dredging and gravity separation that can handle large volumes of materials.

Uncut diamonds

Deep-Sea Mining

Volcanic activity and hydrothermal vents on the ocean floor yield iron, manganese, copper, cobalt, and zinc. Harvesting these requires deep-sea mining methods. The crushing pressure of the water, frigid temperatures, and total darkness are among the challenges of deep-sea mining. New exploration methods are needed—mobile exploration platforms for deep-sea drilling and mapping, and remote sampling techniques. Remote-control methods and robotics are likely answers to the challenges.

Some minerals might be scooped off the ocean bottom at a depth of two to three miles (13,000 to 18,000 feet). Manganese nodules, composed mostly of manganese and iron compounds, might be mined this way. The nodules are valued for other metals they contain—copper, nickel, and cobalt.

For locating, sampling, and drilling these hard-to-reach deposits, new approaches are necessary. How can these minerals be dug from the ocean floor? How can they be brought to the surface? Can they be processed in factory ships or shipped to processing plants onshore? What is to be done with leftover materials after separating the desired metals? These are questions that still must be answered for a successful deep-sea mining operation.

Manganese nodule

Protecting the Marine Environment

The environmental impacts of ocean mining must be considered before launching any operations. Where unique marine habitats exist, mine operations face restrictions.

- Seasonal limitations may be necessary to protect marine organisms during special life stages such as breeding and egg or embryo development.
- Dredging changes seabed topography which may need to be restored.
- Mining could displace certain bottom-dwellers. Miners will need to consider how long it would take for these organisms to recover and reestablish colonies.
- Miners will need to limit the amount of disturbed seafloor sediment that increases cloudiness or turbidity (measure of light transmitted through water).

Mining in Space

Most of the Apollo astronauts were not geologists, so they received extensive training in geology before their moon missions. It was essential for them to know about rocks before they landed. Rocks would reveal how Earth and the moon were similar and whether they shared a common origin.

In 1972, the last moon mission landed a geologist-astronaut on the lunar surface so that a better geological assessment could be made. Harrison H. "Jack" Schmitt, holder of a Ph.D. in geology, could expertly judge the rocky terrain and quickly saw the potential mineral wealth right at his feet. He later proposed commercial ventures to mine lunar helium-3, which could theoretically be used for fuel for nuclear fusion, replacing nuclear fission and fossil fuels.

Developing such space enterprises would help to use resources from space to support human space activities and settlement, and help develop efficient and cost-effective ways to launch large payloads from Earth into deep space.

Iron, nickel, platinum, and cobalt are among the valuable elements that may be mined from asteroids or other cosmic bodies.

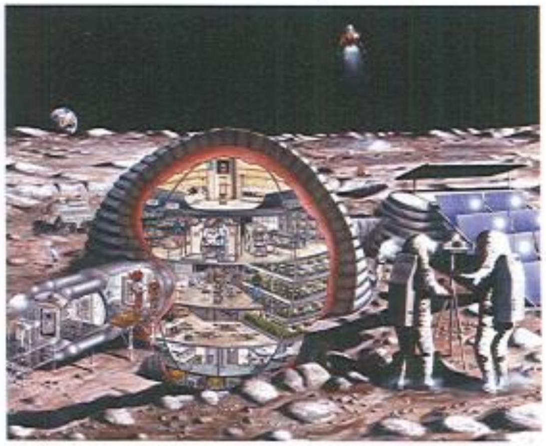
Challenges of Space Mining

Mining methods in space would resemble those on Earth, but adjusted for the absence of oxygen and differences in gravity. Surface methods will be used when minerals are at or near the surface. Devices will collect magnetic metals and minerals such as those associated with iron meteorites. Underground shafts will be dug when the target is a deep lode or vein. Space miners will likely melt ice to get water and to generate oxygen for breathing.

For interplanetary mining, the equipment would have to be shipped or manufactured in space on site, or shipped as parts from Earth, then assembled on-site. Space mining poses major transportation challenges at every stage that must yet be overcome. Designs are on the drawing boards, however, for space barges, space tugs, and power-generation systems.

Another issue is whether to process raw materials on-site, ship them to mills on Earth, or transport them to mills on specially designed space stations. Interplanetary shipping of large, bulky loads will be expensive, so processing on-site will probably be more cost-effective. This does not eliminate the problem, since refined metals and maybe industrial minerals will have to be shipped, too.

Solar generators or nuclear energy could provide the electrical power necessary for all the operations needed in space mining.



Just like on Earth, an interplanetary exploration team must decide whether to use robot or human operators.

Hauling, crushing, and screening all depend on gravity to some extent, so these steps need modification for smaller cosmic bodies with less gravity. Enclosed circuits using magnetic, electric, or pneumatic (air pressure) transport may solve the problem, or previously unforeseen technology may be developed. Flotation processes will face the similar challenges of low gravity, limited water, and exposure to the hazards of space.

High cost is the main concern for any space operation. Today it would take billions of dollars to explore, mine, and ship mere ounces of materials to Earth. Instead of bringing the minerals to Earth, space mining might best be applied as what is called "in situ resource utilization," where materials are found, extracted, processed, and used right at the site. Mined materials would be used for constructing and maintaining space stations or human settlements in near and deep space.

Even so, interplanetary mining remains an expensive proposition. Only space-faring nations with the incentive and economic means could plan such ventures.

Mining Landfills

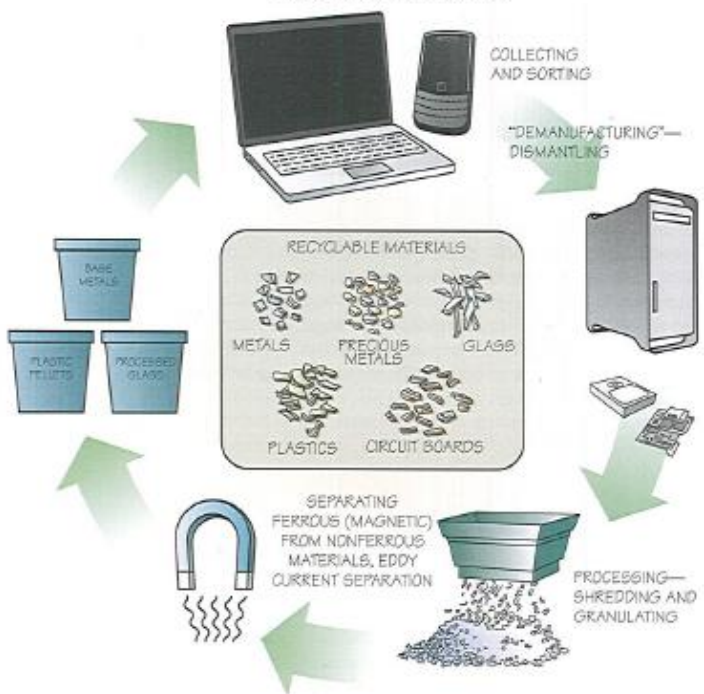
You are finished with an electronic device that no longer works and is too costly to repair. Everything we use has a life expectancy—the time when it becomes obsolete, it no longer performs its intended function, or it isn't needed anymore. The item enters the *waste stream:* the flow of waste from its point of origin through its treatment to its disposal. What we toss out may end up in a sanitary landfill, waste incinerator, recycling center, or open-air dump.

According to the U.S. Environmental Protection Agency, for every million cell phones recycled, we recover 35,274 pounds of copper, 772 pounds of silver, 75 pounds of gold, and 33 pounds of palladium. Recovering these metals saves energy and reduces the extraction of raw metals from the earth.

Many cities and towns have recycling programs. Most people are familiar with curbside recycling—we put recyclable household items (typically paper, plastics, glass, and aluminum) in a bin and take them to the curb, and municipal sanitation workers haul them to a recycling facility for sorting and distribution. Some communities have recycling centers where citizens drop off their recyclables. Once sorted and separated into different categories, the recyclables can be used to make new products.

Not all recycling centers accept electronic waste. Before you decide to throw out any electronic devices, check the municipal policy in your area. More and more centers now recycle electronics, from cell phones and laptops to TVs and other electronic devices. After sorting, the devices are dismantled and processed. Many of them contain contaminants such as lead, cadmium, and beryllium, which require special handling and disposal or recycling. Many metals, such as gold, silver, platinum, palladium, copper, tin, and zinc, can be recovered in recycling. Glass and plastics also are recovered and recycled.

These recycled materials—no longer destined for landfills or incinerators—are recovered and used to create new products. Garden furniture, license plate frames, nonfood containers, replacement auto parts, art, and jewelry are among the many types of goods produced from recycled materials. Rechargeable batteries are recycled into other rechargeable battery products.



Recycling Electronic Goods

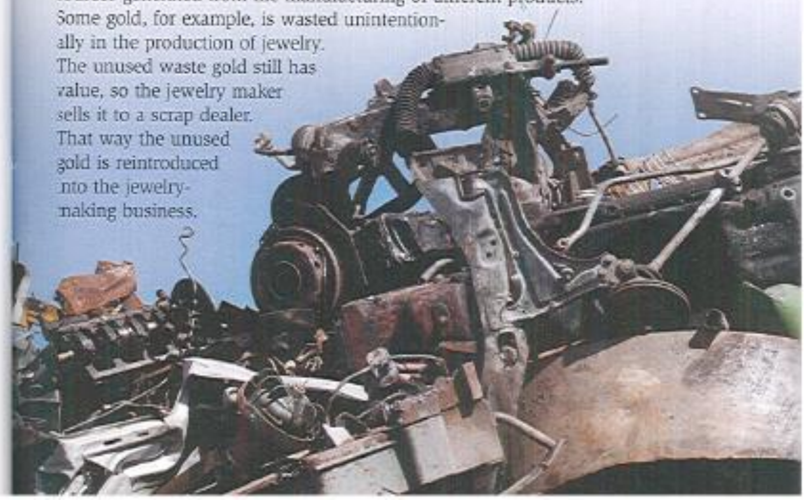
It's always best to recycle whatever you can. Most Americans know the expression "Reduce, Reuse, Recycle," but do most of us really do that?

Recycling Metals

Most metals remain usable even after the products that use them have reached the end of their lifespan. Recycling metals saves the energy that is used to separate them from their ores. Also, the hauling of the recycled objects is usually shorter than from distant mined sources, further saving energy and the materials used in mining.

Worldwide demand for metals grows steadily at 1 to 3 percent annually. Even this apparently slow growth rate means additions must continually be made to the metal supply. New supplies come from new mine developments, expansions of existing operations, increased recycling, or all three.

Typically called scrap metal, recycled metal is categorized as either new or old scrap. *New scrap* comes from pre-consumer sources generated from the manufacturing of different products. Some gold, for example, is wasted unintentionally in the production of jewelry. The unused waste gold still has value, so the jewelry maker sells it to a scrap dealer. That way the unused gold is reintroduced into the jewelry-making business.



We are able to account for about 85 percent of all the gold ever mined. About 15 percent is lost, mainly in electronics because the amount of gold in each device is too tiny to be recovered economically. The rest of the world's mined gold is held as heirloom jewelry, coins, and gold bullion (bars or ingots).

Old scrap comes from post-consumer supplies generated when an item has reached the end of its usefulness. Cast-off jewelry, dental gold (gold teeth), and the gold components of unwanted electronics are good examples of old-scrap gold. Copper is another commonly recycled metal. A third or more of annual consumption comes from recycled scrap copper.

Other metals typically recycled at scrap yards include aluminum, brass, lead, silver, platinum, iron, steel, and zinc. Most of these are recycled by manufacturers as new scrap. Much of the old scrap is rescued from the waste stream and recycled by individuals committed to salvaging such materials.

Recycling one aluminum can saves enough energy to run a TV for three hours.
Source: Can Manufacturers Institute

Sanitary landfills will probably be one source of minerals in the future. Metals and other materials could be extracted from them, processed, and refined for reuse.

"Recycling" Landfills

Except for the items that people conscientiously recycle and reuse, the vast majority of material entering the waste stream is picked up as municipal waste and placed in sanitary landfills. Waste in landfills is buried between layers of earth and isolated from the environment until it breaks down biologically, chemically, and physically.

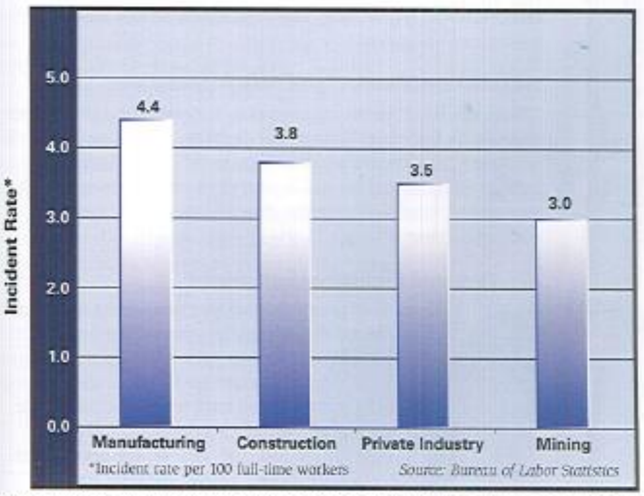
Mining municipal landfills will require special skills and techniques to protect air, water, and soil from contamination. Care will be needed to restore or reclaim the sites for uses such as farming, forestry, recreation (golf courses, public parks, zoos, ball fields, etc.), or industrial parks for factories and other businesses.

Most of the consumer waste in landfills still has value. How could we recycle everything? Organics (substances of plant or animal origin) could serve as compost and be used as fuel. Solids such as plastics could become fuels or the basis for new products. Glass could be recycled for new glass or energy-saving insulation. One innovation is to use glass fibers with cement to form a stronger type of concrete.

Health and Safety in Mines

At one time, mining was the most dangerous occupation in the United States. Making mines healthier and safer places is the responsibility of everyone involved—mine owners and workers, and federal and state governments. Improvements in mining engineering, education and training, government regulation, and industry leadership and decreasing community tolerance of mining incidents has led to a significant reduction in mining incidents and disasters.

Today, mining is among the safest industries in the United States as measured by nonfatal injury rates (see the chart).



2011 nonfatal occupational injury and illness rates for the private sector industry

Operating a healthy and safe mine requires planning and active participation of all workers, from senior managers to miners. Mining companies understand that safety is a moral obligation necessary to minimize losses. Safety and health laws and regulations cover all facets of mining: planning, operations, maintenance, equipment, training, blasting, air quality, emergency response, etc. The U.S. Mine Safety and Health Administration and state agencies enforce mine health and safety laws and regulations.

The industry strives continually to improve safety. Many companies working with the National Mining Association have launched the CORESafety program to do just that. It plans to optimize mine safety by improving mine engineering, work processes, and working conditions.

Tools for Mine Health and Safety

It is difficult to eliminate all risk from mining, so the focus is on managing risk at an acceptable level—for miners, management, government, and society. Some tools and techniques used in American mines to this end include hazard identification and risk assessment, personal protective equipment, environmental monitoring, and the introduction of automation for mining equipment.

Hazard Identification and Risk Assessment

"Being prepared" in mining means to anticipate and understand the risks in the mine. What is the likelihood that something will go wrong, and what is likely to happen if it does? Examples include the potential for gas or dust explosion in underground coal mines, mine wall collapse, fire, and mobile equipment striking a miner.

Personal Protective Equipment

Miners wear personal protective equipment to guard against injury. A hard hat protects the head; safety glasses protect eyes; earplugs or earmuffs minimize exposure to noise; gloves protect hands; and hard-toed boots minimize the risk of foot injury from impact, slip/trip, pinch, heat and cold, etc. Where needed, respirators protect against inhaling harmful dust, fumes, or gases.

Experts believe it is more effective to eliminate hazards where they occur. An example is using roof bolts to prevent roof fall accidents by holding up an underground mine roof. Steel rods, 4 to 16 feet long, anchor the roof rock in place. Ventilation systems help ensure air quality. When coal rock releases flammable methane gas, ventilation dilutes its concentration. Large fans on the surface and auxiliary fans inside the mine provide ventilation throughout underground tunnels and shafts to accomplish this.

Underground miners use a "self-rescue device" for protection from carbon monoxide gas and when escaping from smoke and toxic gases in case of fire or explosion.

Environmental Monitoring Technology

Different instruments, often handheld devices, detect harmful and flammable gases, dust, fumes, noise, or radiation, and ensure that adequate oxygen is present. Some monitor many gases at the same time. Others measure airflow in the ventilation system.

Instruments may be stationary or attached to mobile equipment. They measure environmental factors—such as carbon monoxide levels—in the mine, relying on telemetry (wireless communication) to send data to central control stations. Computers monitor ventilation fans in underground mines. Other devices track the position of miners so that mobile equipment doesn't run into them.

Detection systems warn miners of any developing fire. Alarms announce the need to take action. It may mean to evacuate the mine or, in an underground mine, to seek shelter in a refuge chamber. GPS networks help surface mines pinpoint equipment and help isolate hazards as they occur.

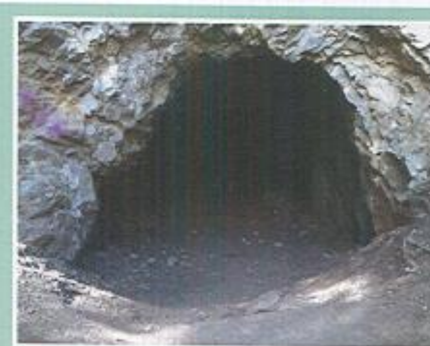
Remote Control and Automation

Computer technology has radically improved mine safety and health. Many mining machines are remotely controlled to keep the miner from exposure to moving parts, dust, noise, unstable ground, etc. The introduction of robotics is helping miners reduce exposure to unnecessary risks. Some surface mines now use haul trucks that run without a driver, using satellite navigation and robotics.

Mine rescue work uses a track-mounted robot to explore mines, reducing the need to send workers into potentially dangerous conditions.

Automation and robotics will increasingly be used as people mine deeper deposits less accessible to miners, such as very thin deposits.

Abandoned Mines—Keep Out!



Mines are not like caverns open to the public for tours and recreation. Every year, dozens of people are injured or killed in accidents on mine property. Active mines are dangerous places even for highly trained workers and are regularly inspected for hazardous conditions, unlike abandoned mines. These are not inspected and probably not ventilated, which means toxic or explosive gases may be present. Tripping and falling is common in abandoned mines—they are unlit and have no guardrails.

Quarry ponds, too, are dangerous. Diving into them is extremely risky because pond depth can vary greatly and abruptly. Riding dirt bikes and quads (four-wheelers) or otherwise trespassing on mine property is dangerous and illegal. High walls or steep cliffs may not be well marked.

The MSHA has a national public-awareness education campaign warning people how dangerous it is to explore and play on active and abandoned mine sites. The "Stay Out—Stay Alive" program joins with more than 70 federal and state agencies, private groups, businesses, and individuals to educate the public.

"Stay Out—Stay Alive" partners visit schools, communities, and youth groups to teach them about staying clear of active and abandoned mines. To arrange a presentation for your troop, contact your local MSHA office or state mining agency. Information is available at http://www.msha.gov/SOSA/SOSAhome.asp.

The BSA Summit Bechtel Family National Scout Reserve in West Virginia has successfully been reclaimed and converted from an underground coal mining site to a recreational area enjoyed by thousands.

Sustainability in Mining

Sustainability relates to harvesting resources in ways that do not squander them or permanently damage the environment. A sustainable lifestyle or society meets today's needs without using up natural resources for future generations.

Recycling is a way to make minerals "partially renewable."

Mining in Society

By now, you know how important mining is in our society. You have learned the old saying of miners: "If it can't be grown, it has to be mined." Mining provides, directly or indirectly, many of the raw materials needed to sustain life and maintain civilization. Unlike raw materials that are grown, the products of mining are *not* renewable. The mineral resources available to us are limited by our ingenuity to find and recover them safely.

Renewable resources can be replenished or replaced over time and measured in human terms, such as within generations. An example is growing new trees for lumber after harvesting the site by logging.

Metallic, most forms of energy, and industrial minerals, however, are nonrenewable resources. They cannot be replenished at rates that match human timeframes. Minerals require vast stretches of geologic time to concentrate them in deposits suitable for mining.

Mining directly affects the natural environment while working to meet the needs of a modern global economy. In this way, the job of mining is unique. The industry must find and extract mineral resources, while keeping in mind that sustainability calls for meeting the needs of future generations and conserving the environment. That means balancing the demand for products and materials with good stewardship of the land.

The U.S. Environmental Protection Agency was formed in 1970. The Boy Scouts of America introduced the Environmental Science merit badge in 1972 to teach Scouts about conservation and care of the environment. In 1977, Congress passed the Surface Mining Control and Reclamation Act to regulate the environmental impacts of mining. In 1983, the United Nations appointed the World Commission on Environment and Development to unite member countries in pursuing sustainable development.

For more about sustainability and renewable resources, see the *Sustainability* merit badge pamphlet.

When it comes to sustainability, most mining operations face these challenges:

- Dwindling mineral resources have forced operations to move nearer to areas that are environmentally or culturally sensitive, or more densely populated.
- Population growth has moved people closer to existing mining operations.
- New mineral resources tend to be found in remote locations, often in undeveloped countries.
- Greater environmental awareness among the public, elected officials, and the media have brought mining operations under closer scrutiny.

A Framework for Sustainability

The *Sustainability* merit badge pamphlet shows a model of the three P's—people, prosperity, and the planet—tied to the three E's—equity (fairness), economy, and environment. In mining, a fourth ethical component—governance, or safety—can be added to the mix. Each essential element depends on the other. Improvements in one area often come at the expense of another. Consider each element in the framework and how the elements interact.

People and Community

A mining company is made up of people—its workers, as well as its customers and neighboring communities. Responsible companies recognize community (people) priorities while planning, when mining, and during reclamation.

Sustainability and mining

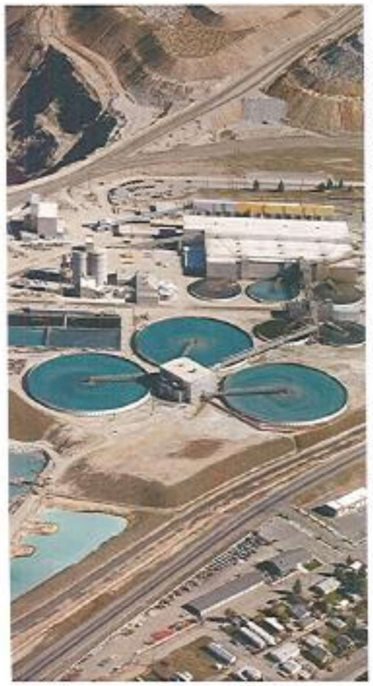
For example, when planning a new coal mine in southwest Pennsylvania, the mine company met with more than 200 citizen groups to explain how the mine would be a good neighbor. In another instance, the geologist for a new stone quarry near Washington, D.C., explained the geology and rocks to 20,000 second-graders. Through them, he reached their parents, who initially opposed the mine. As a result, local opposition ended 18 months later. Treating people fairly is important to maintaining a positive footing.

Planet and Environment

Earth provides essential resources for life. Without air to breathe, food to eat, and water to drink, we would not survive. Other resources add convenience and comfort to our lives. As our quality of life improves, few of us would want to go back to the way things were before we had cars, paved roads, electricity, indoor plumbing, and cell phones.

Mineral resources can be wasted by poor mining methods. Responsible companies respect the environment by using and producing resources wisely. They take into account environmental impacts in each stage of the mine's life.

Water and air used by mineral processing operations are subject to strict environmental regulation. The goal is to reduce the effects of mining operations to balance the benefits that society receives from the mined resources. Mineral processing plants treat water to remove solid or dissolved substances before releasing water into the environment. Water is treated so that it is not cloudy; it has a neutral pH (not acidic or basic); and impurities are below natural levels of local streams. Other equipment removes dust, toxic gases, and other compounds to prevent them from entering surrounding air.



Interactions

People, businesses, and the environment are all essential parts of sustainability; they interact. Responsible mining companies recognize these interactions and know how to be good neighbors and stewards of the land. As a Scout, think about how you can make a difference through the Scout Law and principles of sustainability. Consider these examples of how a Scout is:

Trustworthy. Sustainability starts with you. As a young leader, you can help by recycling and by advocating low-impact solutions to everyday issues.

Loyal. Demonstrate sustainability by reminding others how we share limited resources.

Helpful. Make a difference in your family and community—and help our world—by using only what you need.

Clean. Respect our world and the valuable resources we consume every day. Set an example by disposing of all waste properly, using less, and protecting resources more.

Land reclaimed for recreational use

Mine Land Reclamation

Mine land reclamation is a part of sustainability. Before mining begins, the condition of the land is assessed. Land use, watersheds, topography, and wildlife habitat are considered. The future effect of mining on each is determined, and plans are made to restore the land. One goal of mine land reclamation is to return the land to as good or better condition than it was before mining began. In this way, reclamation is similar to Scouting's no-trace principles.

Oftentimes land uses change after mining. The goal is to prepare the land for better use. For example, the King Coal Highway being built across southern West Virginia links surface mine reclamation sites together to complete the construction of the highway. When mining is finished, the highway will need only the road surface constructed, saving millions of dollars.

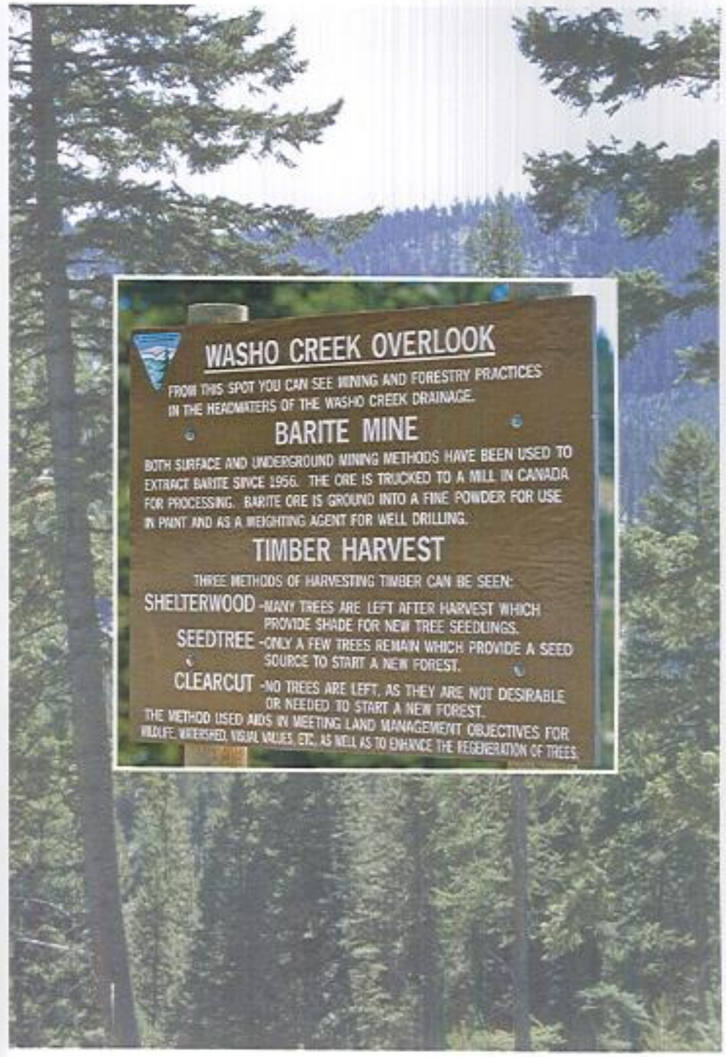
Land reclaimed for commercial and residential use

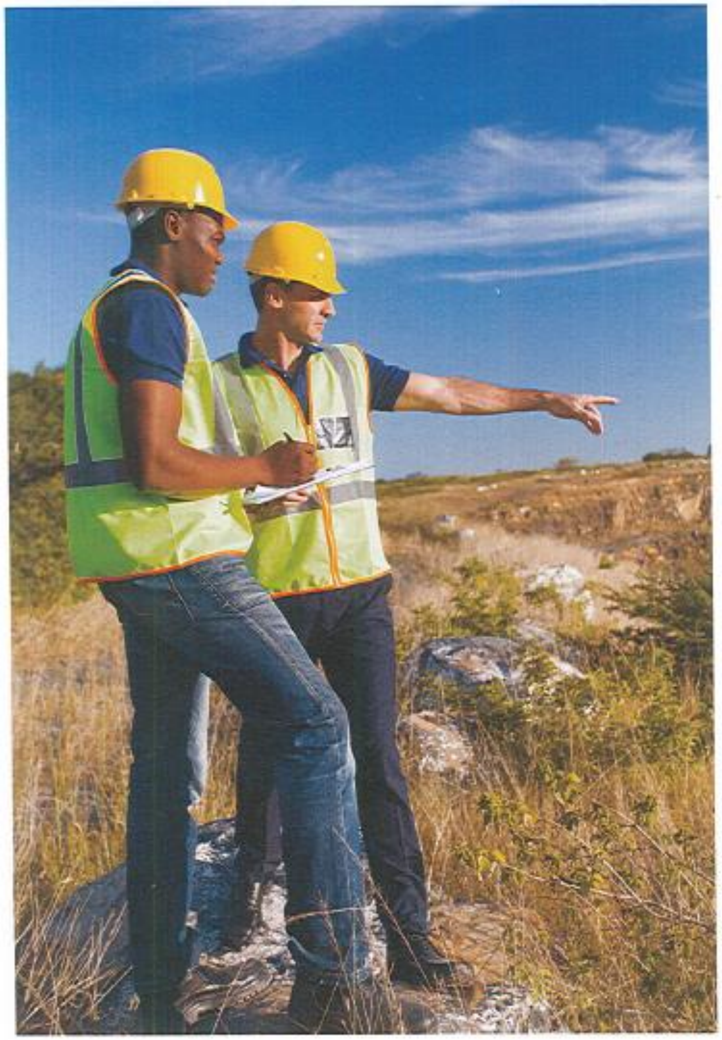
Mine reclamation efforts in progress

To restore mine land or improve the land to beneficial use, steps are taken to preserve qualities that have special value, such as topsoil and vegetation. Reclamation begins with stockpiling topsoil. Then the topsoil is planted with native vegetation to help prevent erosion of the stockpile and preserve native plant species. This topsoil is then spread over the disturbed land when mining ends.

The mining industry takes mine land reclamation and restoration seriously. The industry sees how stewardship of the land, from which it draws its livelihood and wealth, adds great value to communities. It also helps enrich the public's understanding of the reclamation and restoration process.

Land reclaimed for use as an airport





Careers in Mining

When most people think about what a miner does, the first image that springs to mind is the miner heading underground with a headlamp, hardhat, simple tools, and a lunch pail. Or you may think about the shovel operator, haul-truck driver, or someone working a bulldozer or front-end loader. These images have triggered the imaginations of artists and writers who have passed them down to us over time.

A career in the mining industry includes many more occupations than these. The cycle of developing mineral resources has many parts, and all offer interesting, well-paying career opportunities.

Mine workers take satisfaction in knowing they provide essential minerals and fuels that benefit society. Discovering and providing the minerals that increase our standard of living, minimizing environmental impacts, and contributing to a safe work situation are all benefits of a mining career. A mining career offers the prospect of travel, the challenge of working with advanced technology, and the opportunity for career advancement with increased responsibilities.

This illustration shows the sequence of events in mining and related careers.
Source: Mineral Resources Education Program of British Columbia

Mining Personnel

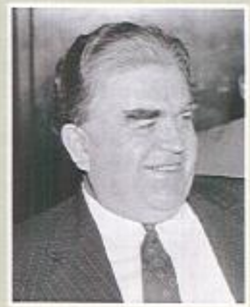
Some positions in mining are paid hourly. People working in the mine itself are mostly equipment operators. Those working at a surface mine include drillers and blasters; dragline, shovel, and excavator operators; front-end loader and bulldozer operators; haul-truck drivers; and support personnel. In an underground mine, workers operate cutting machines, shuttle cars, roof bolters, scoops, longwall shearers, jumbo drills, loaders, haul trucks, belt conveyors, trains, and other mobile equipment.

An operating mine might be in a remote location, along with the operations office and any connected processing plant. The division offices and company headquarters, however, or technical support are generally located in a large town or city.

The workers at a processing plant operate equipment for crushing and screening; physical and chemical procedures, especially in metal mines; haulage and mobile equipment; lab work; mapping and surveying; and other tasks. These are supported by software specialists, mechanics, welders, machinists, electricians, general laborers, and equipment manufacturers.

Technical Personnel

The minimum educational requirement for technical workers typically is a high school diploma. An associate degree or trade school education will help the worker meet requirements for positions of greater responsibility and higher pay. An example is the electrical certification required for an underground electrician, who is paid more than a typical laborer in a coal mine. Underground professionals tend to earn more than their counterparts in surface mining. Many trade skills are obtained through programs provided by the mining company in combination with on-the-job training or community colleges.



John Llewellyn Lewis (1880–1969) was an American leader of organized labor. From 1920 to 1960 he served as president of the United Mine Workers of America. He also worked to establish the Congress of Industrial Organizations, organizing millions of industrial workers in the 1930s. Under his leadership, coal miners won high wages, an eight-hour work day, good pensions, and good medical benefits.

The creation of the UMWA Welfare and Retirement Fund was perhaps his greatest legacy. The fund helped establish eight regional hospitals and many medical clinics in Appalachian coal country. In 1964, President Lyndon Johnson awarded Lewis the Presidential Medal of Freedom, the highest civilian decoration in the country, recognizing his many contributions to the labor movement.

Professional Personnel

Many different kinds of professionals are needed to explore for minerals and to mine them; to plan new operations; or to manage a mine. Mining professionals include geologists, mining and geological engineers, metallurgists, civil engineers, mine managers, and environmental specialists. These positions require a college degree, and in some cases, graduate degrees.

Professional personnel evaluate the mineral or ore deposit for its economic potential. They create mining plans based on those evaluations. Scientists and engineers work together to plan and build the processing plant(s) needed to treat the ore or rocks after they are hauled out of the mine.

It takes many thousands of people to mine all the minerals and fuels we rely on and use. Mining provides above-average income to miners; pays taxes to local, state, and federal governments; and often works with local communities to improve the quality of life for its neighbors.

Careers Supporting the Mining Industry

Equipment manufacturers and service companies support the mining industry, too. A wide variety of products is delivered to mines, ranging from office supplies to explosives, to heavy equipment. Service companies may provide security for the mine site; workers for short-term maintenance positions such as welders, mechanics, and electricians; and consulting engineers for almost every aspect of mining and processing.

There are careers in regulating the mining industry on local, state, or federal levels. These include health and safety inspectors, reclamation and water quality technicians and inspectors, and environmental quality experts.

Herbert Clark Hoover (1874–1964), was a mining engineer and scholar before he became the 31st president of the United States (1929–1933). His mining career began in 1897, in the gold fields of Western Australia. He later traveled to the Far East, where he worked for the Chinese Bureau of Mines as chief engineer and then as general manager of the Chinese Engineering and Mining Corporation. Hoover became an independent mining consultant in 1908, setting up offices worldwide. His mining ventures brought him wealth, but he was also famous as a published scholar.

Mining Resources

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Archaeology, Composite Materials, Energy, Engineering, Environmental Science, Geology, Surveying, and *Sustainability* merit badge pamphlets

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Website:
http://www.themoreyoudig.com

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Society for Mining, Metallurgy, and Exploration
Website: http://www.smenet.org

U.S. Geological Survey Minerals Information
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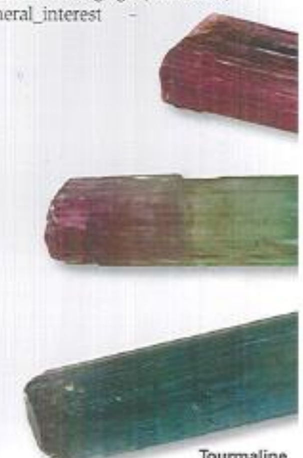

Tourmaline

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SME
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