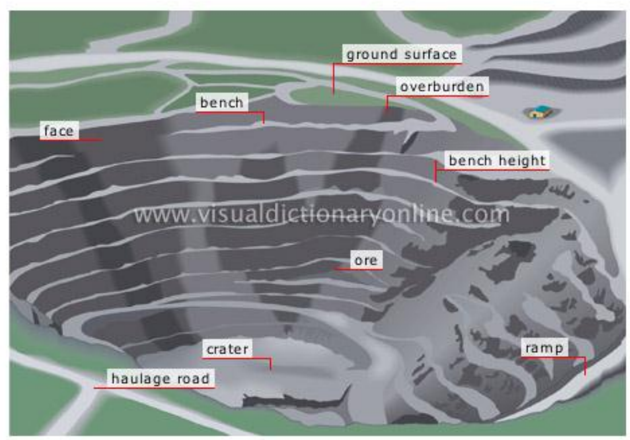
A *mineral resource* is a concentration of naturally occurring material from the Earth's crust that can be extracted and processed into useful products and raw materials at an affordable cost. We know how to find and extract more than 100 minerals from Earth's crust. Examples include fossil fuels (such as coal), metallic minerals (such as aluminum and iron) and nonmetallic minerals (such as sand and gravel).

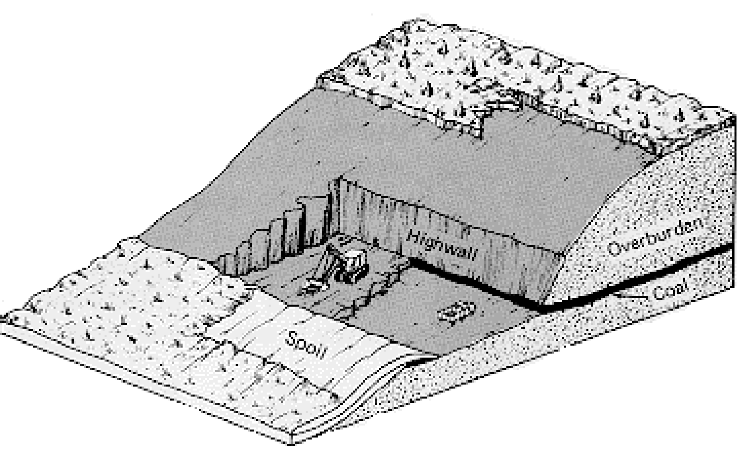
An *ore* is rock that contains large enough concentrations of a particular mineral – often a metal – to make it profitable for mining and processing. A *high-grade ore* contains a fairly large amount of the desired non-renewable mineral resource, whereas a *low-grade ore* contains a smaller amount. Most published estimates of the supply of a given mineral resource refer to its *reserves* – identified resources from which the mineral can be extracted profitably at current prices. Reserves increase when new profitable deposits are found and when higher prices or improved mining technology make it profitable to extract deposits that previously were considered too expensive to extract.

<u>Ways to Remove Mineral Deposits</u>
After suitable mineral deposits are located, several different mining techniques are used to remove them, depending on their location and type. Shallow deposits are removed by *surface mining* and deep deposits are removed by *subsurface mining*.

In *surface mining*, gigantic mechanized equipment strips away the *overburden*, the soil and rock overlying a useful mineral deposit. It is usually discarded as waste material called *spoils*. When ore deposits that contain metals, such as gold, are dredged from streams, the unused materials (called *tailings*) are usually left on the land. If forests are present, they are also removed. Surface mining is used to extract about 90% of the nonfuel mineral and rock resources and 60% of the coal used in the United States.

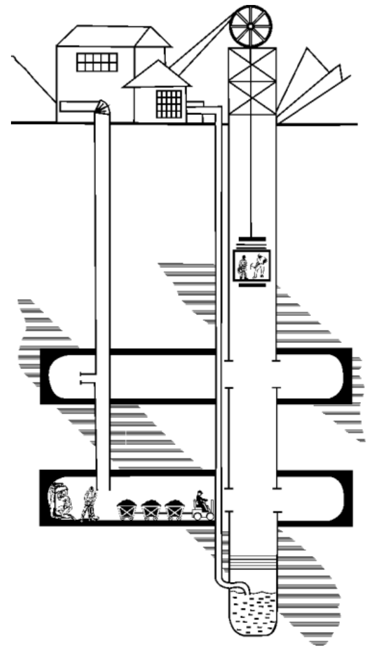
The type of surface mining used depends on two factors: the resource being sought and the local topography. In *open-pit mining* (diagram to the right), machines dig holes and remove ores (of metals such as iron, copper, and gold), sand, gravel, and stone (such as limestone and marble). *Strip mining* is useful and economical for extracting mineral deposits that lie close to Earth's surface in large horizontal beds. In *area strip mining*, used where the terrain is fairly flat, gigantic earthmovers strip away the overburden, and power shovels – some as tall as a 20-story building – remove the mineral deposit. The resulting trench is filled with overburden, and a new cut is made parallel to the previous one. This process is repeated over the entire site.





Contour strip mining (diagram to the left) is used mostly to mine coal on hilly or mountainous terrain. A huge power shovel cuts a series of terraces into the side of a hill. An earthmover removes the overburden, a power shovel extracts the coal, and the overburden from each new terrace is dumped onto the one below. Unless the land is restored, a wall of dirt is left in front of a highly erodible bank of soil and rock called a highwall.

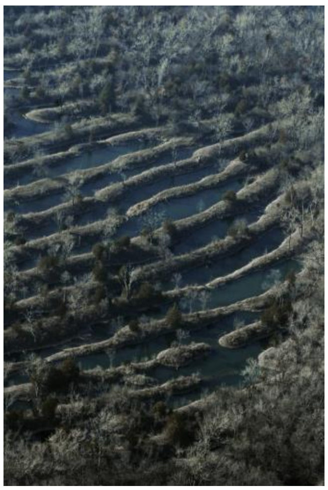
Another surface mining method is *mountaintop removal*. In the Appalachian Mountain area of the United States, where this form of mining is prominent, explosives, large power shovels, and huge machines called draglines are used to remove the top of a mountain and expose seams of coal, which are then removed.



Subsurface mining (diagram to the right) is used to remove coal and metal ores that are too deep to be extracted by surface mining. Miners dig a vertical shaft, blast open subsurface tunnels and chambers to reach the deposit, and use machinery to remove the ore or coal and transport it to the surface.

Environmental Effects

Mining can do long-term harm to the environment in a number of ways. One type of damage is scarring and disruption of the land surface. For example, area strip mining often leaves a series of hills, like waves of rubble, called *spoil banks* (picture below). Spoils and tailings are very susceptible to chemical weathering



and erosion by water and wind. Re-growth of vegetation on these banks is quite slow because they have no topsoil and thus have to follow the long path of primary ecological succession. In mountaintop removal, colossal machines are used to plow great volumes of waste rock and dirt into valleys below the mountaintops, destroying forests, burying mountain streams, and increasing flood hazards. Toxic wastewater, produced when coal is processed, is often stored in these valleys behind coal waste sludge dams, which can overflow or collapse, releasing toxic substances such as selenium, arsenic, and mercury. According to the EPA, some 1200 miles of Appalachia's rivers and streams have been buried and 470 of its largest mountains have disappeared, leaving behind barren land and gigantic pits, some as large as Manhattan Island.

Another problem is *subsidence* – the collapse of land above some underground mines. In can tilt and damage houses, crack sewer lines, break gas mains, and disrupt groundwater systems. Mining operations also produce large amounts of solid waste – three-fourths of all U.S. solid waste. Finally, mining can cause major pollution of water and air. This is because wind and water erosion cause toxin-laced mining wastes to be deposited in areas other than the mining site. For example, *acid mine drainage* occurs when rainwater seeping through a mine or mine waste pile carries sulfuric acid (H_2SO_4, produced when aerobic bacteria act on iron sulfide minerals in spoils) to nearby streams and groundwater. In addition, large amounts of water used to process ore often contain pollutants such as sulfuric acid, mercury, and arsenic. This contaminates water supplies. Mining operations can also emit toxic chemicals into the atmosphere. In the United States, the mining industry produces more toxic emissions than any other industry – typically accounting for almost half of such emissions.

Ore extracted by mining typically has two components: the *ore mineral*, containing the desired metal, and waste material called *gangue* (pronounced "gang"). Removing the gangue from ores produces tailings. Particles of toxic metals blown by wind or leached from tailings by rainfall can contaminate surface water and groundwater. After removal of the gangue, heat or chemical solvents are used to extract metals from ores. Heating ores to release metals is called *smelting*. Without effective pollution control equipment, smelting emits enormous quantities of air pollutants, including sulfur dioxide and suspended particles, which damage vegetation and acidify soils in surrounding areas. An example of using chemicals to remove metals from their ores is the use of solutions of highly toxic cyanide salts to extract gold from its ore. After extracting the gold, some mining companies have declared bankruptcy and walked away from their mining operations, leaving behind large amounts of cyanide-laden water in leaking holding ponds. A glaring example is the Summitville gold mine site near Alamosa, Colorado.

Cookie Mining Lab Questions

1. Were you able to reclaim the land? (You'll have to use your imagination a little here) **Mine reclamation** is the process of creating useful landscapes that meet a variety of goals, typically creating productive ecosystems (or sometimes industrial or municipal land) from mined land. It includes all aspects of this work, including material placement, stabilizing, capping, re-grading, placing cover soils, re-vegetation, and maintenance.

2. Do you think the mining process is faster or slower if you know you must reclaim the land? Why?

3. Explain why legislation that requires land to be reclaimed after mining makes mining more expensive.

4. Contrast open-pit mining and strip mining.

5. Describe FOUR environmental effects of mining.

6. Describe how acid mine drainage can occur.

7. What is ore? What is gangue?

8. Describe two ways metals are extracted from the ores.