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Minerals and Mining

Chapter Objectives

This chapter will help students:

Outline types of mineral resources and how they contribute to our products and society

Describe the major methods of mining

Characterize the environmental and social impacts of mining

Assess reclamation efforts and mining policy

Evaluate ways to encourage sustainable use of mineral resources

Lecture Outline

I. **Central Case: Mining for…** Cell Phones?

A. To function properly, cell phones and other electronic devices require tantalum, mined in the Democratic Republic of the Congo, among other places.

B. Capacitors—the components that store energy and regulate current in miniature circuit boards—contain tantalum.

C. Tantalum is a mineral found in columbite-tantalite or *coltan*.

D. As high technology boomed in the late 1990s, global prices for tantalum skyrocketed.

E. At the same time, the Congo was embroiled in a complicated civil war. Armies of all sides forced people to mine coltan in order to raise money to fund the war.

F. International protest grew, but at the same time, coltan also supplied miners with at least some money in a very poor area of the world.

G. Tantalum prices crashed when demand fell as the high-tech boom went bust and other nations ramped up their mining efforts. Today African miners mine for other minerals in similar conditions.

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H. The case shows how our wealthy high-tech economy can be integrally linked to poor miners in poor and developing parts of the world.

II. Earth's Mineral Resources

A. Rocks provide the minerals we use.

1. A **rock** is a solid aggregation of minerals, and a **mineral** is a naturally occurring solid chemical element or inorganic compound with a crystal structure, a specific chemical composition, and distinct physical properties.
2. We depend on a wide array of mineral resources as raw materials for the products we use in our everyday lives, and so we mine and process these resources.

B. We obtain minerals by mining.

1. **Mining** refers to the systematic removal of rock, soil, or other material for the purpose of extracting minerals of economic interest.

C. Metals are extracted from ores.

1. A **metal** is a type of chemical element, or a mass of such an element, that typically is lustrous, opaque, malleable, and can conduct heat and electricity.
2. Most metals are not found in a pure state in Earth's crust, but instead are present within **ore**, a mineral or grouping of minerals from which we extract metals.
3. Copper, iron, lead, gold, and aluminum are among the many economically valuable metals we extract from mined ore. These metals and others serve so many purposes that our modern lives would be impossible without them.

D. We process metals after mining ore.

1. Sometimes we mix, melt, and fuse a metal with another metal or a nonmetal substance to form an *alloy*.
2. In a process known as **smelting**, ore is heated beyond its melting point and combined with other metals or chemicals.
3. Processing minerals impacts the environment.
   a. Most methods are water-intensive and energy-intensive.
   b. Moreover, many chemical reactions and heating processes used for extracting metals from ore emit air pollution. Smelting plants in particular have long been hotspots of toxic air pollution.
   c. In addition, soil and water commonly become polluted by **tailings**, portions of ore left over after metals have been extracted.

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   d. Tailings may leach heavy metals present in the ore waste as well as chemicals applied in the extraction process.

E. We also mine nonmetallic minerals and fuels.

   1. Sand and gravel (the most commonly mined mineral resources) provide fill and construction materials, including those used to manufacture concrete.
   2. Gemstones are treasured for their rarity and beauty.
   3. We also mine substances we use for fuel.

III. Mining Methods and their Impacts

A. Strip mining removes surface layers of soil and rock.

   1. When a resource sits in shallow horizontal deposits near the surface, the most effective mining method is often **strip mining**, whereby layers of surface soil and rock are removed from large areas to expose the resource.
   2. Strip mining for coal and oil sands can be economically efficient, but it causes severe environmental impacts.
      a. By completely removing vegetative cover and nutrient-rich topsoil, strip mining obliterates natural communities over large areas.
      b. Soil from refilled areas easily erodes.
      c. Strip mining also pollutes waterways through the process of **acid drainage**, which occurs when sulfide minerals in newly exposed rock surfaces react with oxygen and rainwater to produce sulfuric acid.

B. In subsurface mining, miners work underground.

   1. When a resource occurs in concentrated pockets or seams deep underground, and the earth allows for safe tunneling, then mining companies pursue **subsurface mining**. In this approach, shafts are excavated deep into the ground, and networks of tunnels are dug or blasted out to follow deposits of the mineral.
   2. We use subsurface mining for metals such as zinc, lead, nickel, tin, gold, copper, and uranium, as well as for diamonds, phosphate, salt, and potash. In addition, a great deal of coal is mined using the subsurface technique.
   3. Subsurface mining is the most dangerous form of mining, and is one of society's most dangerous occupations.

C. Open pit mining creates immense holes in the ground.

   1. When a mineral is spread widely and evenly throughout a rock formation, or when the earth is unsuitable for tunneling, the method of choice is **open pit mining**. This essentially involves digging a gigantic hole and removing the desired ore and its surrounding waste rock.

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2. Open pit mining is used for copper, iron, gold, diamonds, and coal, among other resources. We also extract clay, gravel, sand, and stone such as limestone, granite, marble, and slate using this technique, but we generally call these pits *quarries*.
3. The sheer size of these mines means that the degree of habitat loss and aesthetic degradation is considerable.
4. Another impact is chemical contamination from acid drainage as water runs off the waste heaps or collects in the pit.

D. Placer mining uses running water to isolate minerals.

1. To search for these metals and gems, miners sift through material in modern or ancient riverbed deposits, generally using running water to separate lightweight mud and gravel from heavier minerals of value. This technique is called placer mining.
2. Other than the many social impacts of placer mining in places like the Congo, it is environmentally destructive because most methods wash large amounts of debris into streams, making them uninhabitable for fish and other life for many miles downstream.

E. Mountaintop mining reshapes ridges and can fill valleys.

1. When a resource is in underground seams near the tops of ridges or mountains, we may practice mountaintop removal mining, in which several hundred vertical feet of mountaintop may be removed to allow recovery of entire seams of the resource.
2. Mountaintop removal has expanded in recent years because it is an economically efficient way for companies to extract coal.
3. Scientists are finding that dumping tons of debris into valleys degrades or destroys immense areas of habitat, clogs streams and rivers, and pollutes waterways with acid drainage.
4. People living near the sites experience social and health effects.
5. Although the people of Appalachia have long relied on the coal industry for employment, mountaintop removal is so efficient that fewer workers are needed for mining.
6. Critics of mountaintop removal mining argue that valley filling violates the Clean Water Act.

F. Solution mining dissolves and extracts resources in place.

1. When a deposit is especially deep and the resource can be dissolved in a liquid, miners may use a technique called *solution mining* or *in-situ recovery*. In this technique, a narrow borehole is drilled deep into the ground to reach the deposit, and water, acid, or another liquid is injected down the borehole to leach the resource from the surrounding rock and dissolve it in the liquid. The resulting solution is then sucked out, and the desired resource is isolated.

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2. Solution mining generally exerts less environmental impact than other mining techniques, because less area at the surface is disturbed.

G. Some mining occurs in the ocean.

1. As land resources become scarcer and as undersea mining technology develops, mining companies may turn increasingly to the seas.

2. Impacts of undersea mining are largely unknown, but such mining would undoubtedly destroy marine habitats and organisms that have not yet been studied. It would also likely cause some metals to diffuse into the water column at toxic concentrations and enter the food chain.

H. Restoration of mined sites is often only partly effective.

1. Because of the environmental impacts of mining, governments of the United States and other developed nations now require that mining companies restore, or reclaim, surface-mined sites following mining. The aim of such restoration, or **reclamation**, is to restore the site to a condition similar to its condition before mining.

2. Even on sites that are restored, effects from mining (such as soil and water damage from acid drainage) can be severe and long-lasting. Moreover, reclaimed sites do not generally regain the same biotic communities that were naturally present before mining.

I. An 1872 law still guides U.S. mining policy.

1. The **General Mining Act of 1872** encourages people and companies to prospect for minerals on federally owned land by allowing any U.S. citizen or any company with permission to do business in the United States to stake a claim on any plot of public land open to mining.

2. The law may have made good sense in 1872, but the United States has changed a great deal since then, and many question the law's current suitability.

3. Critics have tried to amend the law many times over the years, mostly without success.

4. The General Mining Act of 1872 covers a wide variety of metals, gemstones, uranium, and minerals used for building materials.

IV. Toward Sustainable Mineral Use

A. Minerals are nonrenewable resources in limited supply.

1. As minerals become scarcer, demand for them increases and their price rises.

B. Several factors affect how long mineral deposits may last.

1. Discovery of new reserves

2. New extraction technologies

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3. Changing social and technological dynamics
4. Changing consumption patterns
5. Recycling

C. We can make our mineral use more sustainable.

D. We can recycle rare materials from e-waste.

V. Conclusion

A. We depend on a diversity of minerals and metals to help give products wide use in our society.

B. We mine these nonrenewable resources by various methods, according to how the minerals are distributed.

C. Economically efficient mining methods have greatly contributed to our material wealth, but they have also resulted in extensive environmental impacts, ranging from habitat loss to acid drainage.

D. Restoration efforts and enhanced regulation help to minimize the environmental and social impacts of mining, although to some extent these impacts will always exist.

E. We can lengthen our access to mineral resources and make our mineral use more sustainable by maximizing the recovery and recycling of key minerals.

Key Terms

acid drainage
General Mining Act of 1872
mineral
mining
mountaintop removal
open pit mining
ore
placer mining
reclamation
rock
smelting
strip mining
subsurface mining
tailings

Teaching Tips

1. Ask students to generate a list of environmental problems and write them on the board. As a group, analyze each problem to determine how extracting natural resources affects it. For example, water quality might be impacted by the process of mountaintop removal to extract coal. Allow students to use the textbook if they need more information.

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