**Chapter 15**

**Mineral Resources**

**Lecture Outline:**

1. Introduction to Minerals
   1. *Minerals* are elements or compounds of elements that occur naturally in Earth’s crust and have precise chemical compositions
      1. *Sulfides* are mineral compounds in which certain elements are combined chemically with sulfur
      2. *Oxides* are mineral compounds in which elements are combined chemically with oxygen
      3. *Rocks* are naturally formed aggregates, or mixtures, of minerals and have varied chemical compositions
         1. An *ore* is a rock that contains a large enough concentration of a particular mineral to be profitably mined and extracted
         2. Ores are classified as either high-grade or low-grade
      4. Minerals are metallic or nonmetallic
         1. *Metals* are minerals such as iron, aluminum, and copper, which are malleable, lustrous, and good conductors of heat and electricity
         2. *Nonmetallic minerals*, such as sand, stone, salt and phosphates, lack these characteristics
   2. Mineral distribution and formation
      1. Mineral deposits in Earth’s crust are unevenly distributed
      2. Formation of mineral deposits
         1. Concentrations of minerals within Earth’s crust are the result of several natural processes
            1. *Magmatic concentration*  produces iron, copper, nickel, and chromium
            2. H*ydrothermal processes* produce gold, silver, copper, lead, and zinc
            3. *Sedimentation* produces iron, manganese, phosphorus, sulfur, copper
            4. E*vaporation* produces salt, borax, potassium, salts, gypsum
   3. How minerals are found, extracted, and processed
      1. Discovering mineral deposits
         1. Aerial or satellite photography sometimes discloses geologic formations associated with certain types of mineral deposits
         2. Aircraft, satellite instruments, 3-D maps, and seismographs are also used to provide clues about mineral deposits
      2. Extracting minerals
         1. *Surface mining* extracts minerals near the surface, while *subsurface mining* extracts minerals too deep to be removed by surface mining
            1. In surface mining, *overburden* and vegetation must first be removed before scooping minerals out

*Open-pit* and *strip mining* are two kinds of surface mining

Quarries and *spoil banks* are the respective result of each type of mining

* + - * 1. Subsurface mining may be done with a *shaft mine* or a *slope mine*

Subsurface mining disturbs the land less than surface mining

Subsurface mining is more expensive and hazardous for miners

* + 1. Processing minerals
       1. Processing minerals often involves *smelting*
       2. Molten iron and *slag* result from the process of smelting

1. Environmental Impacts of Minerals
   1. Mining and the environment
      1. Mining disturbs large areas of land, destroys existing vegetation, amplifies erosion, and leads to air and water pollution
      2. Mining affects water quality
         1. In the U.S., mining has contributed to the contamination of at least 11,800 miles of streams and rivers
         2. *Acid mine drainage* is washed into soil and water by precipitation runoff
      3. Cost-benefit analysis of mine development
         1. Environmental economists suggest that before a decision is made to develop a mine, analysis should be performed that includes the benefits of the mine in dollar terms versus the benefits in dollar terms of preserving the land intact for wildlife habitat, indigenous people, watershed protection, and recreation
         2. It should include the cost of damage to the environment caused by extracting and processing mineral resources
   2. Environmental impacts of refining minerals
      1. Approximately 80% or more of mined ore consists of impurities that become wastes after processing
         1. *Tailings* are usually left in giant piles on the ground or in ponds near the processing plants
         2. Tailings contain toxic materials and contaminate air, soil and water
      2. Other impurities contained in many mineral ores are sulfur, lead, cadmium, arsenic, and zinc
      3. One of the most significant environmental impacts in mineral production is the large amount of energy required to mine and refine minerals
   3. Restoration of mining lands
      1. The goals of reclamation include preventing further degradation and erosion of the land, eliminating or neutralizing local sources of toxic pollutants, and making the land productive for purposes other than mining
      2. Lands degraded by mining are often called *derelict lands*, their restoration is mainly limited by lack of funding
      3. The Surface Mining Control and Reclamation Act of 1977 requires reclamation of areas that were surface mined for coal
      4. Creative approaches to cleaning up mining areas
         1. A series of wetlands constructed in the affected drainage basin is an effective way to help clean up former mining lands
         2. An inexpensive approach uses cow manure to increase the pH of the mine drainage water, thus increasing bacterial growth and precipitating toxic materials out of the basic water
         3. Plants are used to remove heavy metals from former mining lands through a process called *phytoremediation*
2. Minerals: an International Perspective
   1. U.S. and world use
      1. Humans have consumed more minerals since World War II than were consumed in the previous 5000 years
      2. Industrialization increases the demand for minerals, developing countries that at one time met their mineral needs with domestic supplies become increasingly reliant on foreign supplies as development occurs
   2. Distribution versus consumption
      1. Will we run out of important minerals?
         1. *Mineral reserves* are currently profitable to extract, whereas *mineral resources* are potential resources that may be profitable to extract in the future
         2. The combination of mineral’s reserves and resources is its *total resources* or *world reserve base*
            1. Estimates of the world reserve base fluctuate with economic, technological, and political changes
            2. It is extremely difficult to forecast future mineral supplies
3. Increasing the Supply of Minerals
   1. Locating and mining new deposits
      1. Many known mineral reserves have not yet been exploited
      2. Geologists consider it likely that deep deposits buried 10km or more in the Earth’s crust will someday be discovered and exploited
   2. Minerals in Antarctica
      1. The Antarctic Treaty (1961) limits activity in Antarctica to peaceful uses such as scientific studies; nobody owns Antarctica
      2. The Environmental Protection Protocol to the Antarctic Treaty (Madrid Protocol of 1990) includes a moratorium on mineral exploration and development for a minimum of 50 years
      3. Polar regions such as Antarctica are extremely vulnerable to human activities
   3. Minerals from the ocean
      1. Minerals can be extracted from seawater
      2. The sea floor may be mined where minerals have accumulated
         1. *Manganese nodules* are widespread on the ocean floor
         2. It is not clear which country has the legal right to minerals in international waters
      3. The U.N. Convention of the Law of the Sea (UNCLOS – 1994) protects the resources of the ocean
   4. Advanced mining and processing technologies
      1. As minerals grow scarcer, economic and political pressure to exploit low-grade ores will increase
      2. Despite advanced technology, limiting factors in obtaining minerals from low-grade ores may be water and environmental costs
      3. *Biomining*
         1. In some cases, microorganisms are used to extract minerals from low-grade ores
         2. This process has been used to mine copper, gold and phosphates
4. Using Substitution and Conservation to Expand Mineral Supplies
   1. Finding mineral substitutes
      1. Economics partly drives the search for substitutes; one effective way to cut production costs is to substitute an inexpensive or abundant material for an expensive or scarce one
         1. Plastics, ceramic composites, and high-strength glass fibers are examples of substitutes
         2. Use of tin, lead, and steel have been drastically decreased in the past 35 years due to plastic substitutes
      2. Certain minerals have no known substitutes
   2. Mineral conservation
      1. *Reuse*
         1. Reuse extends mineral resources, reduces mineral consumption and reduces pollution
         2. Reuse helps save tax money by reducing litter and solid waste
         3. The benefits of reuse are greater than those of recycling
      2. *Recycling*
         1. Recycling converts mineral resources into new products; it saves unspoiled land from the disruption of mining, reduces the amount of solid waste that must be disposed, and decreases energy consumption and pollution
         2. Significant amounts of gold, lead, nickel, steel, copper, zinc, and aluminum are recycled
         3. About 44% of the aluminum cans in the U.S. are currently recycled
      3. Changing our mineral requirements
         1. We can reduce mineral consumption by becoming a low-waste society
         2. We consume fewer resources if products are durable and repairable
         3. *Sustainable manufacturing* is a system based on industrial waste minimization; it requires that companies provide information about their waste products to other industries
      4. Dematerialization
         1. The decrease of the weight of products over time is known as *dematerialization*
         2. It reduces the quantity of waste during both production and consumption
         3. Dematerialization can lead to the increase of consumption of both materials and minerals due to increased replacement of such items