Chapter 16
Mineral Resources
Overview of Chapter 16

- Introduction to Minerals
- Environmental Impact of Minerals
- An International Perspective
- Increasing the Supply of Minerals
- Substitution and Conservation
Introduction to Minerals

- **Minerals**
  - Elements or compounds of elements that occur naturally in Earth’s crust

- **Rocks**
  - Naturally formed aggregates of minerals

- **Examples of Minerals**
  - Concrete (mixture of sand, gravel and limestone)
## Important Minerals and Their Uses

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>Aircraft, motor vehicles, packaging (cans, foil), water treatment</td>
</tr>
<tr>
<td>Chromium</td>
<td>Chrome plate, dyes and paints, steel alloys (cutlery)</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Corrosion and wear-resistant alloys, pigments (cobalt blue)</td>
</tr>
<tr>
<td>Gold</td>
<td>Jewelry, money, restorative dentistry</td>
</tr>
<tr>
<td>Iron</td>
<td>Steel (alloy of iron) buildings and machinery</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Beverage cans, electronic devices, firecrackers, flares</td>
</tr>
<tr>
<td>Mercury</td>
<td>Industrial chemicals, electric and electronic applications, batteries</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>High-temperature alloys for aircraft, industrial motors</td>
</tr>
</tbody>
</table>

*Table 16.1 Some Important Minerals and Their Uses.*
Mineral Distribution and Formation

- Abundant minerals in crust
  - Aluminum and iron
- Scarce minerals in crust
  - Copper, chromium, and molybdenum
- Distributed unevenly across globe
  - If found in low abundance, mining is not profitable
Formation of Mineral Deposits

- **Result of natural processes**
  - **Magmatic concentration**
    - As magma cools heavier elements (Fe and Mg) settle
    - Responsible for deposits of Fe, Cu, Ni, Cr
  - **Hydrothermal processes**
    - Minerals are carried and deposited by water heated deep in earth’s crust
  - **Sedimentation**
    - Weathered particles are transported by water and deposited as sediment on sea floor or shore
  - **Evaporation**
    - Salts are left behind after water body dries up
Discovering Mineral Deposits

- Scientists (geologists) use a variety of instruments and measurements
  - Aerial or satellite photography
  - Seismographs
- Combine this with knowledge of how minerals are formed
Extracting Minerals

- **Surface Mining**
  - Mineral and energy resources are extracted near Earth’s surface by removing soil, subsoil and overlying rock strata
  - More common because less expensive
  - Two kinds: open pit and strip mining

- **Subsurface Mining**
  - Mineral and energy resources are extracted from deep underground deposits
  - Two kinds: shaft mine and slope mine
Strip mining removes overburden along narrow strips to reach the ore beneath.
Processing Minerals

- **Smelting** - process in which ore is melted at high temps to separate impurities from the molten metal.
Environmental Impacts of Mining

- Disturbs large area
  - Prone to erosion
- Uses large quantities of water
  - Must pump water out of mine to keep it dry
- Acid Mine Drainage (AMD)
  - Pollution caused when sulfuric acid and dissolved lead, arsenic or cadmium wash out of mines into nearby waterways
Acid Mine Drainage
# Environmental Impacts of Refining Minerals

## Table 16.2  Ore and Waste Production for Selected Minerals

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Amount of Mined Ore (Million Tons)</th>
<th>Percentage of Ore That Becomes Waste During Refining*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron ore</td>
<td>2958</td>
<td>60</td>
</tr>
<tr>
<td>Copper</td>
<td>1663</td>
<td>99</td>
</tr>
<tr>
<td>Gold</td>
<td>745</td>
<td>99.99</td>
</tr>
<tr>
<td>Lead</td>
<td>267</td>
<td>97.5</td>
</tr>
<tr>
<td>Aluminum</td>
<td>128</td>
<td>81</td>
</tr>
</tbody>
</table>

*Data do not include the overburden of rock and soil that originally covered the ore deposits.  
Environmental Impacts of Refining Minerals

- 80% or more of mined ore consists of impurities - called tailings
  - Contain toxic materials
- Smelting plants emit large amounts of air pollutants
- Requires a lot of energy (fossil fuels combustion)
Case-In-Point Copper Basin, TN
Restoration of Mining Lands

- Goals: prevent further degradation and erosion of land, eliminate local sources of toxins and make land productive for another purpose
Restoration of Mining Land

- Creative Approaches
  - Wetlands
    - Trap and filter pollutants before they get into streams
    - Initially expensive, but cost effective compared to using lime to decrease acidity
  - Phytoremediation
    - Use of specific plants to absorb and accumulate toxic materials in soil
Minerals: An International Perspective

- **Highly developed countries**
  - Rely on mineral deposits in developing countries
  - They have exhausted their own supplies

- **Developing countries**
  - Governments lack financial resources to handle pollution
  - Acid mine drainage, air and water pollution
North American Consumption of Selected Metals

The bar chart shows the U.S. and Canadian consumption of selected metals as a percent of world total consumption.

- **Lead**: Highest consumption with a value close to 36.
- **Aluminum**: Slightly lower than Lead, around 32.
- **Copper**: Follows Aluminum, approximately 30.
- **Zinc**: Lower than Copper, around 24.
- **Gold**: Lowest consumption among the listed metals, around 6.
Will We Run Out of Important Metals?

- **Mineral Reserves**
  - Mineral deposits that have been identified and are currently profitable to extract

- **Mineral Resources**
  - Any undiscovered mineral deposits or known deposits of low-grade ore that are currently unprofitable to extract

- Estimates of reserves and resources fluctuate with economy
Increasing Supply of Minerals – Locating and Mining New Deposits

- Many known mineral deposits have not yet been exploited
  - Difficult to access
  - Insufficient technology
  - Located too deep
    - Ex: 10 km or deeper
Minerals in Antarctica

- No substantial mineral deposits identified to date
- Antarctica Treaty (1961)
  - Limits activity to peaceful uses (i.e., scientific studies)
- Madrid Protocol (1990)
  - Moratorium on mineral exploration and development for minimum of 50 years
Minerals from the Ocean

- May provide us with future supplies
  - Extracting minerals from seawater
  - Mining seafloor - Manganese nodules
Advance Mining and Processing Technologies

- Special techniques to make use of large, low-grade mineral deposits world-wide
- Biomining
  - Using microorganisms to extract minerals from low-grade ores
Finding Mineral Substitutes

- Important goal in manufacturing
- Substitute expensive/scarce mineral resources for inexpensive/abundant ones
- Examples:
  - Using plastic, glass or aluminum in place of tin
  - Using glass fibers instead of copper wiring in telephone cables
Mineral Conservation

- Includes reuse and recycling of existing mineral supplies
  - Reuse - using items over and over again
    - Reduces both mineral consumption and pollution
  - Recycling - converting item into new product
    - Reduces land destruction from mining
    - Reduces solid waste
Changing Our Mineral Requirements

- Must change our “throw away” mentality

![Graph showing mineral resource depletion over time with options for use, recycling, and substitution](image-url)
(a) Massive amounts of solid waste are produced at all steps in the traditional flow of minerals, from mining the mineral to discarding the used-up product.

(b) The flow of minerals in a low-waste society is more complex, with sustainable manufacturing, consumer reuse, and consumer recycling practiced at intermediate steps.