1 **Introduction to Environmental Geology, 5e**
Chapter 15
Mineral Resources and Environment

2 **Mineral Resources & the Environment: summary in haiku form**
Petroleum, gas,
coal, uranium, et al.
There's only so much...

3 **Case History: Mine Transformation**
- An award-winning golf course near Golden, Colorado, is now located on land where used to be an open-pit quarry for 100 years
- The mine produced clay from layers between the limestone beds to make bricks
- The bricks were used as a building material for buildings in the Denver area, including the Colorado governor's mansion
- Fossil Trace Golf Club: A unique instance of mine reclamation

4 **Minerals and Human Use**
- Backbone of modern societies
- Availability of mineral resources as a measure of the wealth of a society
- Important in people's daily life as well as in overall economy
- Processed materials from minerals accounting for 5 percent of the U.S. GDP
- Mineral resources are nonrenewable

5 **Common Use of Mineral Products**
Table 15.1

6 **Mineral Resources and Reserves**
- Mineral resources: Usable economic commodity (profitable) extracted from naturally formed material (elements, compounds, minerals, or rocks)
- Reserve: Portion of a resource that is identified and *currently* available to be extracted legally
- Defining factors: Geologic, technological, economic, and legal factors

7 **Mineral Resources and Reserves**
Figure 15.2

8 **Types of Mineral Resources**
Based on how we use them
- Materials for metal production and technology
- Construction materials
- Agricultural industry (fertilizers)
- Mineral resources for chemical industry
- Others (precious gem stones, cosmetics, food, etc.)
- Energy mineral resources

9 **Mineral Resources Problems**
- Nonrenewable resources
- Finite amount of mineral resources and growing demands of the resources

-
- Supply shortage due to the growing global industrialization, with more developed countries consuming disproportionate share of mineral resources
-
- The erratic distribution of the resources and uneven consumption of the resources. Highly developed countries use the most of the resources

10 **Responses to Limited Availability**

- Find more sources
-
- Find a substitute
-
- Recycle
-
- Use less and make more efficient use of what is available
-
- Do without

11 **Responses to Limited Availability**

Figure 15.3

12 **Geology of Mineral Resources**

Metallic ore: Useful metallic minerals that can be mined for a profit

- Mining potential depending upon technology, economics, and politics with an emphasis on profitability, technological feasibility, and demands
-
- Concentration factor: Concentration necessary for profitable mining (e.g., for gold is about 5,000)
  - Variable with types of metals
  - Variable over time

13 **Genesis of Mineral Resources**

Table 15.3

14 **Plate Tectonics and Minerals**

- Plate tectonic boundaries related to the origins of many ore deposits, Fe, Au, Cu, and Hg, etc.
- Plate tectonic processes (high temp, high pressure, and partial melting) promoting release and enrichment of metals along plate boundaries
- Ore deposits at divergent boundaries is related to the migration (movement) of ocean water
- Ore deposits at convergent boundaries: Related to partial melting of seawater-saturated rocks of the oceanic lithosphere in a subduction zone
- Danger in oversimplification, not all directly related to plate boundaries

15 **Other Minerals from the Sea**

Mineral resources on the bottom of the ocean are vast

- Sulfide deposits: Massive sulfide deposits containing zinc, copper, iron, and trace amounts of silver are produced at the black smokers along the oceanic ridges, from which the hot, dark-colored, mineral-rich water emerges as hot springs
- Manganese oxide nodules: cover vast areas of the deep-ocean floor (up to 50 percent in certain area), containing manganese (24 percent) and iron (14 percent), with secondary copper (1 percent), nickel (1 percent), and cobalt (0.25 percent). Most abundant in where sediment is at a minimum, generally at depths of 5 to 7 km
- Cobalt-enriched manganese crusts: Present in the mid- and southwest Pacific, on flanks of seamounts, volcanic ridges, and islands

16 **Mineral Resources and**

Environmental Impact

Environmental impact

- From mineral exploration and testing
-
- From mineral mining
-
- From mineral resources refining
-
- From mining waste disposal

17 **Environment Impact**

The impact depends upon many factors

- Mining procedures
- Hydrologic conditions
- Climate factors
- Types of rocks and soils
- Topography

18 **Impact from Exploration and Testing**

- Mineral exploration and testing
  - Surface mapping, geochemical, geophysical, and remote-sensing data collection
  - Test drilling
  -
- Impact
  - Generally minimal impact
  - More planning and care needed for sensitive areas (arid, wetlands, and permafrost areas)

19 **Impact of Mineral Extraction and Processing (1)**

General impact

- Direct impact on land, water, air, and biological environment
-
- Indirect impact on the environment: Topographic effect, transportation of materials, etc.
-
- Impact on social environment: Increased demands for housing and services

20 **Impact of Mineral Extraction and Processing (2)**

Impact from mining operations

- Land disturbances from access, surface mining (more economical but more direct environmental effects)
- Waste from mines: 40 percent of the mining area for waste disposal, mining waste 40 percent of all solid wastes
- Special mining (e.g., chemical leaching from gold mining)
- Mining acid drainage, during mining and post mining
- Water pollution, such as smelting emissions of SO_2
- Biological environment

21 **Impact of Mineral Extraction and Processing (3)**

Figure 15.16

22 **Impact of Mineral Extraction and Processing (4)**

Water pollution

- Trace elements leaching out into water, such as Cd, Co, Cu, Pb, Mo, Zn
-
- Flooding of abandoned mine

-
- Acid mine drainage from tailings
-
- Acidic and toxic mining wastewater

23 **Impact of Mineral Extraction and Processing (5)**

Other pollution

- Air pollution: Both extraction and processing operations have adverse effects on air quality; smelting has released enormous quantities of pollutants; toxic gases from abandoned mines
- Pollution to overall biological environment: Physical and chemical changes in the land, soil, water, and air associated with mining directly and indirectly affect the biological environment

24 **Mining and Toxicity**

- Itai-Itai Disease: Chronical and painful (*itai-itai* means “ouch, ouch”), attacks bones.
- The bones and tissues of victims were examined and found to contain large concentrations of zinc, lead, and cadmium
- Mercury and gold mining: Gold particles cling to the liquid metal, mercury making recovery of the gold easier.
- Estimated 4,500 metric tons of mercury was lost into the environment, from 1850s–1880s in CA

25 **Minimizing the Impact of Mining**

- Knowledge and technology transfer: Developed countries to developing countries
- Environmental regulations: forbid bad mining practices, Clean Air Act, and on- and offsite treatment of wastes
- Land reclamation: About 50 percent of land used in mining industry reclaimed
- Use of new biotechnology in mining: Bio-oxidation, bioleaching, biosorption, genetic engineering
- Practicing the three Rs of waste management

26 **Minimizing the Impact**

Figure 15.19

27 **Recycling Mineral Resources (1)**

Why recycle? Consider the impact of the wastes

- Toxic to humans
-
- Dangerous to natural ecosystem
-
- Degradation of air, water, and soil
-
- Use of land for disposal
-
- Aesthetically undesirable

28 **Recycling Mineral Resources**

Figure 15.21

29 **Recycling Mineral Resources (2)**

- Waste contains recyclable materials
-
- Saves energy, money, land, raw mineral resources from more mining
-
- Saves energy and money when recycling instead of refining raw ore materials
-
- Recycling has been proven to be profitable and workable

Recycling Mineral Resources (3)

- Most-recycled metals: iron and steel, 90 percent by weight
- One third as much energy needed to produce steel from recycled scrap as from original ore
- In 2006, the total value of recycled steel in the United States was about $18.5 billion, recycling of iron and steel amounted to approximately 50 percent
- Lead (73 percent, $1.96 billion), aluminum (43 percent, $9.38 billion), copper (32 percent, $6.72 billion), nickel (43 percent, $2.62 billion), and titanium (47 percent, $0.25 billion)

Minerals and Sustainability

- Sustainability: Long term strategy for consuming the resources
- Find an alternative materials for the metal (e.g., glass fiber cable for copper wires)
- Use raw materials more efficiently. The time available for finding a solution to the depletion of a nonrenewable mineral is the R/C ratio, where R is the known reserve and C is the rate of consumption
- More R&D on innovative substitutes or ways to keep the R/C ratio, a solution to the depletion of nonrenewable resources

Critical Thinking

- Considering the fact that mineral resources are nonrenewable, do you believe that technology will eventually help meet the growing demand for mineral resources? If yes, explain.
- Biotechnology shows the potential for cleaner minerals extraction and waste disposal. Will biotechnology bring about any environmental problems?
- What types of environmental impact would there be if we increasingly extract more mineral resources from seafloor?

Chapter 15 figures follow…

End of Chapter