APES Chapter 14

Nonrenewable Mineral Resources

**Core Case Study: The Crucial Importance of Rare-Earth Metals**

* Crucial to the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ that support today’s lifestyles and economies
  + Used to make LCDs, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, fiber optics, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and digital cameras
* Without \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ supplies of rare earth elements, we could not develop cleaner technologies

**14-1 What Are the Earth’s Major Geological Processes/Mineral Resources?**

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ processes within the earth and on its surface produce the mineral resources on which we depend
* Mineral resources are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Produced and renewed over \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of years mostly by the earth’s rock cycle

The Earth Is a Dynamic Planet

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Study of dynamic processes taking place on earth’s surface and in earth’s interior
* Three major \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ zones of the earth
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, including the asthenosphere
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Continental crust
    - Oceanic crust: 71% of crust

What Are Minerals and Rocks?

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Naturally occurring compound that exists as a crystalline solid
* Mineral \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Concentration that we can extract and process into raw materials
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Solid combination of one or more minerals
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ rock
  + Made of sediments
    - Dead plant and animal remains
    - Tiny particles of weathered and eroded rocks
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ rock
  + Intense heat and pressure
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ rock
  + Existing rock subjected to high temperatures, pressures, fluids, or a combination

Earth’s Rocks Are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Very Slowly

* Rock \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Rocks are recycled over \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of years
  + Erosion, melting, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of earth’s cycle processes

We Depend on a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of Nonrenewable Mineral Resources

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Contains profitable concentration of a mineral
  + High-grade ore
  + Low-grade ore
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mineral resources
  + Aluminum
  + Iron for steel
  + Copper
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mineral resources
  + Sand, gravel, and limestone
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Estimated supply of a mineral resource

**14-2 How Long Might Supplies of Nonrenewable Mineral Resources Last?**

* Nonrenewable mineral resources exist in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ amounts
  + Can become economically \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ when it costs more than it is worth to find, extract, and process the remaining deposits
* There are several ways to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ supplies of mineral resources
  + But each of these is limited by \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ factors

Supplies of Nonrenewable Mineral Resources Can Be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Depleted

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Identified deposits from which we can extract the mineral profitably
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ time
  + Time to use a certain portion of reserves
* When a resource becomes economically depleted:
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ existing supplies
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ less
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ less
  + Find a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Do \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Global and U.S. Rare-Earth Supplies

* Rare-earth elements aren’t really \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ produces 97% of the world’s rare-earth metals and oxides
* The U.S. produces \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Prices Affect \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of Nonrenewable Minerals

* Subsidies and tax breaks to mining companies keep mineral prices \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ low
* Scarce investment capital \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the development of new supplies of mineral resources

Can We Expand Reserves by Mining \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Ores?

* Factors that \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the mining of lower-grade ores
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ cost of mining and processing larger volumes of ore
  + Availability of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ impact
* Improve mining technology
  + Using microorganisms – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ process

Can We Get More Minerals from the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_?

* Mineral resources \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in the ocean
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ concentrations
* Deposits of minerals in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ along the shallow continental shelf and near shorelines
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ore deposits
  + Hot water vents in the ocean floor
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ from the ocean floor
  + Manganese nodules
* What is the effect of mining on aquatic life?

**14-3 What Are the Environmental Effects From Using Nonrenewable Minerals?**

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ minerals from the earth’s crust and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ them into useful products can:
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the land
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ soils
  + Produce large amounts of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ waste
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the air, water, and soil

Mineral Use Creates Environmental Impacts

* Metal product life cycle
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Environmental impacts
  + Determined by an ore’s \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of metal content

Removing Mineral Deposits Has Harmful Environmental Effects

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mining
  + Removes \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ deposits
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ deposited into spoils – waste material
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mining
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mining
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ strip mining
* Mountaintop \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ mining
  + Deep deposits
* Potential problems
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Acid mine \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Case Study: The Real Cost of Gold**

* At about \_\_\_\_\_\_ of the world’s gold mines
  + Mineral extracted with \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ salts
  + Cyanide is extremely \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Mining companies declare \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Allows them to avoid environmental \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Removing \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ from Ores Has Harmful Environmental Effects

* Ore extracted by mining
  + Ore \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ – waste material
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ using heat or chemicals causes:
    - Air pollution
    - Water pollution

**14-4 How Can We Use Mineral Resources More Sustainability?**

* We can:
  + Try to find \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ for scarce resources
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ resource waste
  + Recycle and reuse \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

We Can Find Substitutes for Some Scarce Mineral Resources

* Materials \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ replacing some metals for common uses
* New technologies:
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, ceramics, and high-strength plastics
* Substitution doesn’t always work
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ – industrial catalyst

We Can Use Mineral Resources More Sustainably

* Recycling and reuse
  + Lower environmental \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ than mining and processing metals from ores
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ supplies of rare-earth elements in the short-term
  + Substitutes for rare-earth elements

Solutions: Sustainable Use of Nonrenewable Minerals

**14-5 What Are the Earth’s Major Geologic Hazards?**

* Dynamic processes move matter within the earth and on its surface and can cause \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, erosion, and landslides

The Earth Beneath Your Feet Is Moving

* The earth’s crust is broken into \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ plates
  + “Float” on the asthenosphere
* Much geological activity takes place at the plate \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Release Molten Rock from the Earth’s Interior

* Volcano
  + Magma rising through the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ reaches the earth’s surface through a crack
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ – release of lava, hot ash, and gases into the environment
  + What are the benefits and hazards of volcanoes?

Earthquakes Are Geological Rock-and-Roll Events

* Earthquake
  + Breakage and shifting of rocks
    - At a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_waves
    - Vibrations in the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ – origin of earthquake
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ – severity of earthquake
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ – size of the seismic waves
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ scale
  + Insignificant: <4.0
  + Minor: 4.0–4.9
  + Damaging: 5.0–5.9
  + Destructive: 6.0–6.9
  + Major: 7.0–7.9
  + Great: >8.0
* Largest recorded: \_\_\_\_\_\_ in Chile, 1960

Earthquakes on the Ocean Floor Can Cause Huge Waves Called Tsunamis

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Series of huge waves generated when ocean floor suddenly rises or drops
  + Travels several hundred miles per hour
* December 2004 – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ tsunami
  + Magnitude 9.15 and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ waves at shore
* 2011 – Japan tsunami
  + Damaged \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* Detection of tsunamis
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in open ocean

**Three Big Ideas**

* Dynamic forces that move matter within the earth:
  + Recycle the earth’s rocks
  + Form deposits of mineral resources
  + Cause volcanic eruptions, earthquakes, and tsunamis
* The available supply of a mineral resource depends on:
  + How much of it is in the earth’s crust
  + How fast we use it
  + The mining technology used to obtain it
  + Market prices
  + Harmful environmental effects of removing and using it
* We can use mineral resources more sustainably by:
  + Trying to find substitutes for scarce resources
  + Reducing resource waste
  + Reusing and recycling nonrenewable minerals

**Tying It All Together: Rare-Earth Metals and Sustainability**

* Rare-earth elements are important for a variety of modern technologies
* New technological developments can help extend mineral supplies
  + Nanotechnology
  + Biomining
  + Graphene