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