



1 2  **Renewable and Nonrenewable Resources**


- Resources can be divided into renewable and nonrenewable resources.
 - *Renewable resources* can be replenished over relatively short time spans.
 - Plants and animals for food
 - Fiber for clothing
 - Trees for lumber and paper
 - Energy from the Sun, wind, and flowing water
 - *Nonrenewable resources* are deposits that take millions of years to form.
 - Fossil fuels
 - Metals
 - Groundwater

3  **How much do each of us use?**4  **Energy Resources – Traditional Fossil Fuels**


- Coal, petroleum, and natural gas are the primary fossil fuels in society.
 - 81 percent of energy consumed in the U.S. comes from fossil fuels.
 - *Fossil fuels* use energy from the Sun stored by plants and animals millions of years ago.
 - Reserves are declining and future energy needs will have to be met with alternative energy sources.

5  **U.S. Energy Consumption, 2014**6  **Energy Resources – Traditional Fossil Fuels**

- Coal
 - Today, accounts for ~18 percent of the nation's energy needs
 - The major fuel used in power plants to generate electricity.
 - Though the percentage of energy used that is derived from coal is decreasing, the energy demand continues to increase—so this does not mean we are using less coal!
 - Problems with coal use include environmental damage from mining and air pollution from burning it.

7  **Surface Coal Mine**8  **Energy Resources – Traditional Fossil Fuels**

- Oil and Natural Gas
 - Combined, provide more than 60 percent of the energy consumed in the United States
 - In 2011, natural gas production exceeded coal production for the first time in 30 years
 - Petroleum formation
 - Both oil and natural gas consist of hydrocarbon compounds and are found in similar environments
 - Formation begins with the burial of large quantities of organic material
 - Organic material is transformed to liquid and gaseous hydrocarbons through chemical reactions with increasing burial over millions of years
 - Liquids and gases migrate into permeable beds

9  **Drilling for Oil**10  **Energy Resources – Traditional Fossil Fuels**

- Oil and Natural Gas
 - Traps for oil and gas
 - An *oil trap* is an environment that allows for economically significant amounts of oil and gas to accumulate underground.
 - All traps have two basic conditions.
 - » A *reservoir rock*—A porous, permeable unit.
 - » A *cap rock*—An impermeable unit.
 - Common traps:
 - Anticline.
 - Fault trap.

- Salt dome.
- Stratigraphic (pinchout) trap.

11  **Common Oil Traps**


12  **Seismic Search for Oil and Gas**

13  **Oil Sands, Oil Shale, and Gas Hydrates**

- Oil Sands
 - Mixtures of clay and sand combined with water and bitumen (a viscous tar)
 - Oil in oil sands is much more viscous and cannot be pumped out
 - Several substantial deposits around the world
 - Largest reserve in Alberta, Canada
 - Obtaining oil from tar sands requires large amounts of energy and has significant environmental drawbacks

14  **Oil Sands**

15  **Oil Sands**

16  **Energy Resources – Traditional Fossil Fuels**

- Hydraulic Fracturing
 - In some regions, significant amounts of natural gas are *trapped in shale* with low permeability.
 - Shale is shattered (“fracking”) to release the gas.
 - Concerns for groundwater contamination and induced seismicity.
 - Still a controversial practice

17  **Hydraulic Fracturing**


18  **Nuclear Energy**

- Nuclear energy is an important part of U.S. energy needs
 - Fuel comes from energy released by *nuclear fission* (splitting atoms)
 - Resulting controlled chain reaction releases heat used to drive steam turbines
 - U²³⁵ is the only naturally occurring isotope that is readily fissionable
 - Primarily fuel used in nuclear power plants
 - Rare element in Earth’s crust

19  **Nuclear Energy**

- Obstacles to Development
 - Plant safety
 - Skyrocketing costs for safety features
 - Plants cannot explode like bombs, however the escape of radioactive debris during a meltdown is a major hazard.
 - Example: Fukushima nuclear power plant, 2011.

20  **Tsunami Destroys Nuclear Power Plant**

21  **Renewable Energy**

- Renewable energy sources regenerate and can be *sustained indefinitely*
 - The use of renewable energy is not new
 - 150 years ago, wood supplied most of our energy needs.
 - 13 percent of U.S. electricity is generated from renewable resources.

22  **Renewable Energy**

23  **Renewable Energy**

- Solar Energy
 - Direct use of the Sun’s rays to supply energy.
 - Passive solar collectors
 - South-facing windows.
 - Active solar collectors
 - Solar hot water.
 - Trough solar collectors.
 - Photovoltaic (solar) cells convert the Sun’s energy directly to electricity.

–Stirling dish converts thermal energy to electricity.

24  **Parabolic Troughs**

25  **Photovoltaic Cells**

26  **Renewable Energy**

- Wind Energy
 - Converting the kinetic energy of a moving air mass (wind) into other forms of energy to perform work.
 - Increase in the number of wind turbines installed.
 - Wind turbines supply 3 percent of world electricity.
 - Wind speed is crucial in determining suitability of installing a wind-energy facility.

27  **Global Installed Wind Capacity**

28  **Wind Energy Potential for the United States**

29  **Renewable Energy**

- Hydroelectric Power
 - *Hydroelectric power* is power generated by falling water used to drive turbines to produce electricity.
 - Most energy is produced at large dams.
 - Dams have finite lifetimes.
 - Limited sites to construct dams.
 - Recently a different type of hydro power has come into use: *pumped water-storage system*.
 - Water is pumped to a higher storage reservoir during periods of low demand.


30  **Grand Coulee Dam**

31  **Renewable Energy**

- Geothermal Energy
 - *Geothermal energy* is power generated by tapping into underground steam and hot water.
 - Used for heating and to generate electricity
 - Three factors determine if a geothermal reservoir has commercial value.
 - A potent source of heat
 - Large and porous reservoirs
 - A cap of low-permeability rocks

32  **Geothermal Development in Iceland**

33  **The Geysers**


34  **Renewable Energy**

- Biomass—Renewable Energy from Plants and Animals
 - *Biomass* is organic material made from plants and animals.
 - Wood
 - Crops
 - Biofuels
 - Manure
 - Garbage
 - Biogas

35  **Renewable Energy**

- Tidal Power
 - Ocean's energy potential remains largely untapped
 - Tidal power is harnessed by constructing a dam across the mouth of a bay or estuary in a coastal area.
 - The narrow opening between the bay and the open ocean magnifies the variations in water level that occur as the tides rise and fall.

36  **Tidal Power**

37  **Mineral Resources**

- *Mineral resources* are the endowment of useful minerals ultimately available commercially.

- Mineral resources include:
 - *Reserves*—already identified deposits from which minerals can be extracted profitably.
 - An *ore* is a useful metallic mineral that can be mined for profit.
- 98 percent of the continental crust is composed of only eight elements
 - A deposit is valuable if the element is concentrated above the level of its average crustal abundance.
 - Known deposits that are not economically or technologically recoverable may become profitable if the demand changes.

38

39

Bingham Canyon Mine

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Igneous and Metamorphic Processes

- Magmatic Differentiation
 - Separation of heavy minerals that crystallize early or enrichment of rare elements in the residual melt
 - Especially in the late stages of a melt
 - Sometimes crystals form in a fluid-rich environment
 - As fluids don't solidify, the crystals grow unusually large
 - *Pegmatites* are rocks with unusually large crystals.
 - Often contain some of the least abundant elements.
 - Some pegmatites include semiprecious gems such as beryl, topaz, and tourmaline.

41

Pegmatites

42

Igneous and Metamorphic Processes

- Hydrothermal Solutions
 - Hydrothermal (hot water) solutions are the best known and most important ore deposits.
 - *Vein deposits*
 - Hot, metal-rich fluids migrate through cracks in the rock before eventually depositing the metals.
 - Many of the most productive deposits of gold, silver, and mercury occur as hydrothermal vein deposits.

43

Pegmatites and Hydrothermal Deposits

44

Igneous and Metamorphic Processes

- Hydrothermal Solutions
 - *Disseminated deposits*
 - Instead of being concentrated in narrow veins, disseminated deposits are distributed as small masses throughout the entire rock
 - Example: Copper, Bingham Canyon mine.
 - *Hydrothermal activity at oceanic ridges*
 - Black smokers are a source of metal-rich sulfide deposits.

45

Native Copper

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Sulfide Deposits along a mid-ocean ridge

47

Igneous and Metamorphic Processes

- Diamonds
 - Best known as gems but commonly used as abrasives
 - Originate at great depths (200 kilometers!)
 - Carried upward through pipe-shaped conduits that increase in diameter toward the surface
 - Crystals are disseminated in ultramafic rock called *kimberlite*.

48

Igneous and Metamorphic Processes

- Metamorphic Processes
 - Many important ores are created by *contact metamorphism*.
 - Most common minerals associated with contact metamorphism
 - Sphalerite (zinc).

- Galena (lead).
- Chalcopyrite (copper).
- Magnetite (iron).
- Bornite (copper).

49 

- *Weathering* creates deposits by concentrating metals into economically valuable concentrations (*secondary enrichment*).
- Bauxite
 - Principal ore of aluminum.
 - Forms in rainy tropical climates from chemical weathering and the removal of undesirable elements by leaching.

50 **Bauxite**51 

- Other Deposits
 - Weathering processes concentrate metals that are deposited through low-grade primary ore.
 - Examples: copper and silver.
 - Typically occurs in deposits containing pyrite.
 - Pyrite is important because when it chemically weathers, sulfuric acid forms.
 - Enables percolating waters to dissolve the ore metals.
 - Metals gradually migrate downward through the primary ore body until they are precipitated.

52 

- Placer Deposits
 - *Placers* are deposits formed when heavy metals are mechanically concentrated by currents.
 - Involve heavy and durable minerals.
 - Examples include:
 - Gold.
 - Diamonds.
 - Tin.

53 **Placers**54 **Nonmetallic Mineral Resources**

- Use of the word “mineral” is very broad
 - Materials not used for fuels or processed for metals are called *nonmetallic mineral resources*.
- Two common groups
 - Building materials.
 - Industrial minerals.


55 **Nonmetallic Mineral Resources**


- Building Materials
 - Natural aggregate
 - Crushed stone, sand, and gravel.
 - Gypsum
 - Plaster and wallboard.
 - Clay
 - Tile, bricks, and cement.

56 **Limestone Quarry**57 **Nonmetallic Mineral Resources**

- Industrial Minerals
 - Fertilizers
 - Nitrate, phosphate, and potassium compounds are important to agriculture.

- Sulfur
 - Used to produce sulfuric acid.
- Salt
 - Used to "soften" water, keep streets ice-free, and as a nutrient.

58  **Potash Mine**

59  End of Chapter 23