1

2 ***Chapter 23 – Energy & Mineral Resources***

3 **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

4 **How much do each of us use?**

5 **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.

6 **U.S. Energy Consumption, 2014**

7 **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.

8 **Surface Coal Mine**

9 **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

10 **Drilling for Oil**

11 **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.

12 **Common Oil Traps**

13 **Seismic Search for Oil and Gas**

14 **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

15 **Oil Sands**

16 **Oil Sands**

17 **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

18 **Hydraulic Fracturing**

19 **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
    - U^{235} is the only naturally occurring isotope that is readily fissionable
      - –Primarily fuel used in nuclear power plants
      - –Rare element in Earth's crust

20 **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.

21 **Tsunami Destroys Nuclear Power Plant**

22 **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.

23 **Renewable Energy**

24 **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.

25 **Parabolic Troughs**

26 **Photovoltaic Cells**

27 **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.

28 **Global Installed Wind Capacity**

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

30 **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.

31 **Grand Coulee Dam**

32 **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

33 **Geothermal Development in Iceland**

34 **The Geysers**

35 **Renewable Energy**

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

36 **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.

37 **Tidal Power**

38 **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.

39

40 **Bingham Canyon Mine**

41 **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.

42 **Pegmatites**

43 **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.

44 **Pegmatites and Hydrothermal Deposits**

45 **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.

46 **Native Copper**

47 **Sulfide Deposits along a mid-ocean ridge**

48 **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*.

49 **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).

50

- *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.

51 **Bauxite**

52

- 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.

53

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

54 **Placers**

55 **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.

56 **Nonmetallic Mineral Resources**

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

57 **Limestone Quarry**

58 **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.

59 **Potash Mine**

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End of Chapter 23