1 ***Energy and Mineral Resources***

Earth 12th Edition – Chapter 23

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 **Copper mine, Morenci, Arizona**

6 **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.

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

8 **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.

9 **Surface Coal Mine**

10 **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

11 **Drilling for Oil**

12 **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.

13 **Common Oil Traps**
14 **Seismic Search for Oil and Gas**
15 **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

16 **Oil Sands**
17 **Oil Sands**
18 ***Oil shale in the United States***
19 ***Oil shale in the Green River Formation***
20 **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

21 **Hydraulic Fracturing**
22 **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 isotope in Earth’s crust

23 **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.

24 **Tsunami Destroys Nuclear Power Plant**
25 ***Alternate energy sources - nuclear***
26 ***Diablo Canyon (near S.L.O.)***
27 **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.

28 **Renewable Energy**
29 **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.

30 **Parabolic Troughs**

31 **Photovoltaic Cells**

32 ***Alternate energy sources - solar***

33 ***Solar One (near Barstow)***

34 ***near Sacramento***

35 **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.

36 **Global Installed Wind Capacity**

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

38 ***Still Pumping...***

39 ***Alternate energy sources - wind***

40 **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.

41 **Grand Coulee Dam**

42 ***Alternate energy sources - hydroelectric***

43 ***Alternate energy sources - hydroelectric***

44 **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

45 **Geothermal Development in Iceland**

46 **The Geysers**

47 **Alternate energy sources - geothermal**

48 ***Alternate energy sources - geothermal***

49 **Renewable Energy**

- Biomass—Renewable Energy from Plants and Animals

- *Biomass* is organic material made from plants and animals.
  - Wood
  - Crops
    - Biofuels
  - Manure
  - Garbage
    - Biogas

50 **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.

51 **Tidal Power**

52 ***Alternate energy sources - tidal***

53 ***Tidal Power***

54 ***Annapolis Royal, Nova Scotia***

55 **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.

56

57 ***Bingham Canyon, Utah***

58

59 **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.

60 **Pegmatites**

61 ***Pegmatite in the Black Hills, South Dakota***

62 ***Pegmatite near Warner Springs Cryo-Genie Mine***

63 **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.

64 **Pegmatites and Hydrothermal Deposits**

65 **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.

66 ***Native Copper***
Keweenaw Peninsula, Michigan

67 ***Diablo Lake Overlook***
North Cascades National Park

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

69 ***Black smoker,***
East Pacific Rise

70 **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*.

71 **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).

72 ***Talc Exploration***
Dillon, Montana, 1979

73

- *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.

74 **Bauxite**

75

- 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.

76 ***Uranium Exploration***
Lingle, Wyoming, 1977

77

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

78 **Placers**

79 ***"sourdough" in 1850***
(how old do you think he is???)

80 ***Gold Dredge near Nome, Alaska***

81 ***Gold Dredging in Colorado***

82 **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.

83 **Nonmetallic Mineral Resources**

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

84 **Limestone Quarry**

85 ***Aggregate in action***

86 **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.

87 **Potash Mine**

88 ***Phosphate Mining in Florida***

89 ***End of Chapter***