1 **Sedimentary Rocks**

Earth 12th Edition, Chapter 7

2 ***Chapter 7 – Sedimentary Rocks***

3 **The Importance of Sedimentary Rocks**

- Sediments and sedimentary rocks cover approximately 75% of land and virtually ALL of the ocean basins
- However, those only comprise about 5 percent (by volume) of Earth's outer 10 miles
- Those contain evidence of past environments
- Those contain important economic resources
  - Coal, oil, and other fossil fuels
  - Uranium, iron, aluminum, manganese, phosphate
  - Groundwater resources

4 **Origins of Sedimentary Rock**

- Sedimentary rocks are products of mechanical and chemical weathering
  - Sediments and soluble constituents are typically transported downslope by gravity (*mass wasting*)
  - The sediments are then deposited and subsequently buried
  - As deposition continues, the sediments are lithified into sedimentary rocks
- There are three types of sedimentary rocks:
  - Detrital, chemical, and organic sedimentary rocks

5 **Origins of Sedimentary Rock**

6 **Detrital Sedimentary Rocks**

- Detrital sedimentary rocks form from sediments that have been weathered and transported
  - Chief constituents of detrital rocks include clay minerals, quartz, feldspars, and micas
  - Particle size is used to distinguish among the various rock types
    - It also presents important information about the environment of deposition
  - Common detrital sedimentary rocks include
    - Shale, sandstone, conglomerate, and breccia

7 **Particle Size Categories**

8 **Detrital Sedimentary Rocks**

- Shale
  - Silt- and clay-sized (fine-grained) particles
  - Form from gradual settling of sediments in quiet, non-turbulent environments (e.g., lakes, floodplains, deep ocean basins)
  - Sediments form in thin layers that are called laminae
  - Has fissility (meaning the rock can be split into thin layers)
  - Crumbles easily and tends to form gentle slopes
  - Most abundant sedimentary rock

9 **Shale**

10 **Shale**

11 ***Del Mar formation (below) / Torrey sandstone (above)***

12 ***Del Mar Formation. (shale)***

13 ***Mudstone***

14 ***Mudstone***

15 **Detrital Sedimentary Rocks**

- Sandstone
  - Sand-sized particles
  - Forms in a variety of environments
  - Second most abundant sedimentary rock
  - Quartz is the most abundant mineral
    - Quartz sandstone is predominately composed of quartz

- Arkose sandstone contains appreciable quantities of feldspar
- Graywacke contains rock fragments and matrix, in addition to quartz and sandstone

16 **Quartz Sandstone**

17 ***Torrey Sandstone***

18 ***Esplanade Sandstone***

19 ***Esplanade Sandstone***

20 ***Esplanade Sandstone***

21 **Detrital Sedimentary Rocks**

- Sandstone (continued)
  - Particles are classified by sorting and shape
    - Sorting is the degree of similarity in particle size
      - If all the grains in a rock are of similar size, the rock is well sorted
      - If the grains in a rock are different sizes (both large and small grains), the rock is poorly sorted
      - Sorting can help decipher the depositional environment of the rock
    - Particle shape varies from rounded to angular
      - The degree of rounding is indicative of how far the sediments have been transported
      - Rounded sediments are typically transported to great distances
      - Angular sediments are only transported a short distance
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22 **Quartz Sandstone**

23 **Quartz Sandstone**

24 **Detrital Sedimentary Rocks**

- Conglomerate and Breccia
  - Conglomerate consists of rounded, gravel-sized sediments
  - Breccia consists of angular, gravel-sized sediments
  - Both types of rocks are usually poorly sorted

25 **Conglomerate and Breccia**

26 ***conglomerate***

27 ***conglomerate***

28 ***Breccia in ABDSP***

29 ***Breccia in GCNP***

30 **Chemical Sedimentary Rocks**

- Chemical sedimentary rocks form from precipitated material that was once in solution
  - Precipitation of material occurs by:
    - Inorganic processes: evaporation or chemical activity
    - Organic processes from water-dwelling organisms form biochemical sedimentary rocks
  - Chemical sedimentary rocks include:
    - Limestone, chert, rock salt

31 **Chemical Sedimentary Rocks**

- Limestone
  - Most abundant chemical sedimentary rock
  - Mainly composed of the mineral calcite
  - Can form from inorganic and biochemical origins
  - Has economic value

32 ***Redwall Limestone, Grand Canyon***

33 ***Redwall Limestone, Grand Canyon***

34 ***Vasey's Paradise***

35 ***Tyndall Limestone (Manitoba)***

36 ***Fossils in Tyndall Limestone***

37 **Chemical Sedimentary Rocks**

- Limestone (continued)
  - Biochemical limestone originates from the shells of marine organisms
    - Large quantities of marine limestone are formed from corals
      - Corals secrete a calcium carbonate skeleton and create reefs
        - »Australia's Great Barrier Reef is the largest coral reef on Earth
    - *Coquina* is composed of cemented fragments of shell material
    - *Chalk* is composed of the hard parts of microscopic marine organisms

38 **Biochemical Limestone**
39 ***coquina***
40 ***coquina-to-be (St. Pete Beach, Florida)***
41 **Biochemical Limestone**
42 **Biochemical Limestone**
43 ***Chalk – Dover, England***
44 **Chemical Sedimentary Rocks**

- Inorganic Limestone
  - Inorganic limestone forms when chemical changes increase the calcium carbonate content of the water until it precipitates
    - *Travertine* is a type of limestone found in caves
      - Is precipitated when the water in the cave loses carbon dioxide
    - *Oolitic limestone* is composed of small spherical grains called ooids
      - *Ooids* form as tiny "seeds" roll in shallow marine water supersaturated with calcium carbonate

45 **Inorganic Limestone**
46 ***Travertine – malachite and rhodochrosite***
47 ***Travertine in Arroyo Zamora, near El Marmol***
48 ***Travertine in Elves' Chasm, GCNP***
49 ***Travertine in Elves' Chasm, GCNP***
50 **Inorganic Limestone**
51 **Chemical Sedimentary Rocks**

- Dolostone
  - Similar to limestone but contains magnesium
  - Origin of dolostone is unclear
    - Significant quantities of dolostone are created when magnesium-rich waters circulate through limestone
- Chert
  - Composed of microcrystalline quartz
  - Forms when dissolved silica precipitates
    - Flint, jasper, and agate are varieties of chert

52 ***dolostone***
53 **Chert**
54 ***Chert Nodules in Limestone***
55 ***Chert Nodules in Limestone***
56 ***Chert (agate)***
57
58 ***Chert ("coprolite")***
59 **Chemical Sedimentary Rocks**

- Evaporites
  - Form when restricted seaways become over-saturated and salt deposition starts
  - *Rock salt* and *rock gypsum* are two common evaporites
  - Occasionally, evaporites form on salt flats when dissolved materials are precipitated as a white crust on the ground

60 **Salt Flats**

61 **Salt Flats**
62 ***Rock salt (halite)***
63 ***Halite "soda straws***" in the Grand Canyon***
64 ***Gypsum***
65 ***Gypsum***
66 ***Fish Creek Gypsum Mine***
67 **Coal: An Organic Sedimentary Rocks**
- Coal is different from other sedimentary rocks
- Organic sedimentary rocks form from the carbon-rich remains of organisms
- Occasionally, plant structures (leaves, bark, and wood) are identifiable in coal

68 **Coal: An Organic Sedimentary Rocks**
- Four stages of Coal Formation
  1. Accumulation of plant remains
  2. Formation of peat and lignite
  3. Formation of bituminous coal
  4. Formation of anthracite coal

69 **From Plants to Coal**
70 ***Coal depositional environment ?***
71 ***Coal depositional environment ?***
72 ***Coal depositional environment ?***
73 ***Coal depositional environment ?***
74 **Turning Sediments into Sedimentary Rock: Diagenesis and Lithification**
- Many changes occur to sediment after it is deposited
  - Diagenesis—chemical, physical, and biological changes that take place after sediments are deposited
    - Occurs within the upper few kilometers of Earth's crust
    - Examples:
      - *Recrystallization* of more stable minerals from lass stable ones (e.g., aragonite to calcite)
      - Formation of coal

75 **Turning Sediments into Sedimentary Rock: Diagenesis and Lithification**
- Many changes occur to sediment after it is deposited
  - Lithification—unconsolidated sediments are transformed into solid sedimentary rocks
    - Compaction—as sediments are buried, the weight of the overlying material compresses the deeper sediments
    - Cementation—involves the crystallization of minerals among the individual sediment grains

76 **Turning Sediments into Sedimentary Rock: Diagenesis and Lithification**
77 **Classification of Sedimentary Rocks**
- Sedimentary rocks are classified according to the type and texture of material
  - Two major groups:
    - Detrital
      - Has clastic texture
      - Composed of discrete fragments cemented together
    - Chemical/organic
      - Has nonclastic or crystalline texture
      - The minerals form patterns of interlocked crystals

78 **Classification of Sedimentary Rocks**
79 **Classification of Sedimentary Rocks**
80
- An environment of deposition or a sedimentary environment is a geographic setting where

sediment is accumulating
  - Sites are characterized by particular combinations of geologic processes and environmental conditions
- Determines the nature of the sediments that accumulate (grain size, grain shape, etc.)
  - Three broad categories of sedimentary environments
    - Continental
    - Marine
    - Transitional

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- Continental Environments
  - Dominated by stream erosion and deposition
    - Streams are the dominant agent of landscape alteration
  - Glacial
    - Deposits are typically unsorted mixtures of sediments that range from clay to boulder-sized
  - Wind (eolian)
    - Well-sorted, fine sediments

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- Marine Environments
  - *Shallow marine* (to about 200 m)
    - Borders the world's continents
    - Receives huge quantities of terrestrial sediments
    - Warm seas with minimal terrestrial sediments have carbonate-rich muds and debris from coral reefs
  - *Deep marine* (seaward of continental shelves)
    - Primarily fine sediments that accumulate on the ocean floor
    - Turbidity currents—submarine landslides—are the exception

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- Transitional Environments
  - The shoreline is the transition zone between marine and continental environments
    - Examples include:
      - *Beaches*
      - *Tidal flats*
      - *Spits, bars, and barrier islands*
      - *Lagoons*
      - *Deltas*

84 **Sedimentary Environments**

85

- Sedimentary Facies
  - Different sediments often accumulate in adjacent environments
    - For example, when sand is depositing on a beach, mud is being deposited offshore
  - Changes in past environments can be seen when a single layer of sedimentary rock is traced laterally
    - Each unit (facies) possesses a distinctive set of characteristics reflecting the conditions of a particular environment
    - Transitions between different facies are gradual

86 **Sedimentary Facies**

87 **Sedimentary Structures**

- When present, they provide additional information for interpreting Earth's history
- Types of sedimentary structures
  - The layers of the sedimentary rocks are called strata or beds
    - Single most common and characteristic feature of sedimentary rocks

  - Bedding planes separate strata
  - Cross-bedding occurs when the layers in the sedimentary rocks are inclined
    - Characteristic of sand dunes, deltas, and some stream deposits

88 **Sedimentary Strata**

89 ***Strata, or beds***

90 **Sedimentary Strata**

91 ***Cross-bedding***

92 ***Cross-bedding***

93 **Sedimentary Structures**

- Graded beds are a unique situation where the sediments in a strata gradually change from coarse at the bottom to fine at the top
  - Often associated with turbidity currents

94 ***Graded bedding***

95 **Sedimentary Structures**

- Ripple marks are small waves that are lithified in the sedimentary rocks
- Mud cracks indicate sediments form in an alternatively wet and dry environment
- Fossils are the remains of prehistoric life
  -

96 ***Ripple marks***

97 ***Mud cracks (modern)***

98 ***Mud cracks (ancient)***

99 ***Natural casts of shelled invertebrates***

100 ***Natural casts of shelled invertebrates***

101 ***Dinosaur footprint in limestone***

102 ***Dinosaur footprint in limestone***

103 ***More trace fossils***

104 **The Carbon Cycle and Sedimentary Rocks**

- CO_2 moving from the atmosphere to the biosphere and back again is one of the most active parts of the carbon cycle
  - Plants absorb CO_2 through photosynthesis
  - When plants die, some CO_2 is deposited in sediments
    - *Over geologic time*, a small amount of CO_2 is deposited as sediment—but considerable amounts of plant biomass is converted into fossil fuels
    - When fossil fuels are burned, the CO_2 is released back into the atmosphere
    - Volcanoes also release CO_2
  - Limestone is Earth's largest repository of carbon

105 **The Carbon Cycle and Sedimentary Rocks**

106 ***End of Chapter 7***