












































- 1  **CHAPTER 4: Marine Sediments**
- 2  **Marine sediments**
  - Eroded rock particles and fragments
  - Transported to ocean
  - Deposit by settling through water column
  - Oceanographers decipher Earth history through studying sediments
- 3  **Classification of marine sediments**
  - Classified by origin
  - Lithogenous (derived from land)
  - Biogenous (derived from organisms)
  - Hydrogenous (derived from water)
    - Also known as *Authigenic*
  - Cosmogenous (derived from outer space)
- 4  **Lithogenous sediments**
  - Eroded rock fragments from land
  - Reflect composition of rock from which derived
  - Transported from land by
    - Water (e.g., river-transported sediment)
    - Wind (e.g., windblown dust) - *aeolian transport*
    - Ice (e.g., ice-rafted rocks)
    - Gravity (e.g., turbidity currents)
    -
- 5  **Classification of Marine Sediments**
- 6  **Classification of Marine Sediments**
- 7  **Lithogenous sediments**
- 8  **Lithogenous sediments**
  - Most lithogenous sediments at continental margins
  - Coarser sediments closer to shore
  - Finer sediments farther from shore
  - Mainly mineral quartz ( $\text{SiO}_2$ )
- 9  **Figure 4.1**
- 10  **Figure 4.2**
- 11  **Figure 4.3**
- 12  **Figure 4.4a**
- 13  **Relationship of fine-grained quartz and prevailing winds**
- 14  **Figure 4.4b**
- 15  **Sediment texture**
  - Grain size
    - Proportional to energy of transportation and deposition
- 16  **Sediment texture**
  - Grain size sorting
    - Indication of selectivity of transportation and deposition processes
  - Textural maturity
    - Increasing maturity if
      - Clay content decreases
      - Sorting increases
      - Non-quartz minerals decrease
      - Grains are more rounded (abraded)
- 17  **Distribution of sediments**

- Neritic
  - Shallow water deposits
  - Close to land
  - Dominantly lithogenous
  - Typically deposited quickly
- Pelagic
  - Deeper water deposits
  - Finer-grained sediments
  - Deposited slowly
- 18  **Neritic lithogenous sediments**
  - Beach deposits
    - Mainly wave-deposited quartz-rich sands
  - Continental shelf deposits
    - Relict sediments
  - Turbidite deposits
  - Glacial deposits
    - High latitude continental shelf
- 19  **Figure 4.4c**
- 20  **Figure 4.4d**
- 21  **Pelagic lithogenous sediments**
  - Sources of fine material:
    - Volcanic ash (volcanic eruptions)
    - Wind-blown dust
    - Fine-grained material transported by deep ocean currents
  - Abyssal clay (red clay)
    - Oxidized iron
    - Abundant if other sediments absent
- 22  **Figure 4.6 (top)**
- 23  **Biogenous marine sediments**
  - Hard remains of once-living organisms
    - Shells, bones, teeth
    - Macroscopic (large remains)
    - Microscopic (small remains)
      - Tiny shells or tests settle through water column
      - Biogenic ooze (30% or more tests)
      - Mainly algae and protozoans
- 24  **Biogenous marine sediments**
  - Commonly either calcium carbonate ( $\text{CaCO}_3$ ) or silica ( $\text{SiO}_2$  or  $\text{SiO}_2 \cdot n\text{H}_2\text{O}$ )
  - Usually planktonic (free-floating)
- 25  **Silica in biogenous sediments**
  - Diatoms (algae)
    - Photosynthetic
    - Diatomaceous earth
  - Radiolarians (protozoans)
    - Use external food
  - Siliceous ooze
- 26  **Siliceous ooze**
  - Seawater undersaturated with silica
  - Siliceous ooze commonly associated with high biologic productivity in surface ocean
- 27  **Calcium carbonate in biogenous sediments**
  - Coccolithophores (algae)

- Photosynthetic
- Coccoliths (nano-plankton)
- Rock chalk
- 28  **Calcium carbonate in biogenous sediments**
  - Foraminifera (protozoans)
    - Use external food
    - Calcareous ooze
- 29  **Distribution of biogenous sediments**
  - Most common as pelagic deposits
  - Factors controlling distribution
    - Productivity
    - Destruction (dissolution)
    - Dilution
- 30  **Carbonate deposits**
  - Stromatolites
    - Warm, shallow-ocean, high salinity
    - Cyanobacteria
- 31  **Figure 4.10a (left)**
- 32  **Figure 4.10b**
- 33  **Calcareous ooze and the CCD**
  - Warm, shallow ocean saturated with calcium carbonate
  - Cool, deep ocean undersaturated with calcium carbonate
    - Lysocline--depth at which *a significant amount of*  $\text{CaCO}_3$  begins to dissolve rapidly
    - Calcite compensation depth CCD--depth where  $\text{CaCO}_3$  readily dissolves
      - *Rate of supply = rate at which the shells dissolve*
- 34  **Calcareous ooze and the CCD**
  - Scarce calcareous ooze below 5000 m in modern ocean
  - Ancient calcareous oozes at greater depths if moved by sea floor spreading
  -
- 35  **Calcareous Ooze and the Calcite Compensation Depth**
- 36  **Distribution of calcareous oozes in surface sediments of modern sea floor**
- 37  **Hydrogenous marine sediments**
  - Minerals precipitate directly from seawater
    - Manganese nodules
    - Phosphates
    - Carbonates
    - Metal sulfides
  - Small proportion of marine sediments
  - Distributed in diverse environments
- 38  **Iron-manganese nodules**
  - Fist-sized lumps of manganese, iron, and other metals
  - Very slow accumulation rates
  - Why are they on surface sea floor?
- 39  **Figure 4.15a (left)**
- 40  **Figure 4.15a (right)**
- 41  **Figure 4.15b**
- 42  **Hydrogenous marine sediments**
  - Phosphates
    - Phosphorus-bearing
    - Occur beneath areas in surface ocean of very high biological productivity

- Economically useful: fertilizer
  - Carbonates
    - Aragonite and calcite
    - Oolites
- 43  **Hydrogenous marine sediments**
  - Metal sulfides
    - Contain iron, nickel, copper, zinc, silver, and other metals
    - Associated with hydrothermal vents
  - Evaporites
    - Minerals that form when seawater evaporates
    - Restricted open ocean circulation
    - High evaporation rates
    - Halite (common table salt) and gypsum
- 44  **Figure 4.16**
- 45  **Cosmogenous marine sediments**
  - Macroscopic meteor debris
  - Microscopic iron-nickel and silicate spherules
    - Tektites
    - Space dust
  - Overall, insignificant proportion of marine sediments
- 46  **Figure 4.C**
- 47  **Figure 4.D**
- 48  **Figure 4.17**
- 49  **Mixtures of marine sediments**
  - Usually mixture of different sediment types
    - For example, biogenic oozes can contain up to 70% non-biogenic components
  - Typically one sediment type dominates in different areas of the sea floor
- 50  **Distribution of neritic and pelagic marine sediments**
  - Neritic sediments cover about  $\frac{1}{4}$  of sea floor
  - Pelagic sediments cover about  $\frac{3}{4}$
  - Distribution controlled by
    - Proximity to sources of lithogenous sediments
    - Productivity of microscopic marine organisms
    - Depth of water
    - Sea floor features
  -
- 51  **Figure 4.18**
- 52  **Distribution of neritic and pelagic marine sediments**
- 53  **How sea floor sediments represent surface ocean conditions**
  - Microscopic tests sink slowly from surface ocean to sea floor (10-50 years)
  - Tests could be moved horizontally
  - Most biogenous tests clump together in fecal pellets
    - Fecal pellets large enough to sink quickly (10-15 days)
- 54  **Figure 4.20**
- 55  **Figure 4.21**
- 56  **Figure 4.21 (left)**
- 57  **Figure 4.21 (right)**
- 58  **Marine sediments often represent ocean surface conditions**
  - Temperature
  - Nutrient supply
  - Abundance of marine life

- Atmospheric winds
- Ocean current patterns
- Volcanic eruptions
- Major extinction events
- Changes in climate
- Movement of tectonic plates

59  **Figure 4.22**

60  **Retrieving sediments**

1 ■ Dredge

■ Gravity corer


■ Rotary drilling

2 ■ Deep Sea Drilling Program

■ Ocean Drilling Program

■ Integrated Ocean Drilling Program

61  **Figure 4.E**

62  **Figure 4.F**

63  **Figure 4.23**

64  **Resources from marine sediments**

■ Energy resources

■ Petroleum

■ Mainly from continental shelves

■ Gas hydrates

■ Sand and gravel (including tin, gold, and so on)


■ Evaporative salts

■ Phosphorite

■ Manganese nodules and crusts

■

65  **Figure 4.24a**

66  **Figure 4.24b**

67  **Figure 4.25**

68 

69  **Manganese nodules**

70  **Figure 4.28**

71  **End of CHAPTER 4**

**Marine Sediments**