CHAPTER 4
Marine Sediments

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Chapter Overview

• Marine sediments contain a record of Earth history.
• Marine sediments provide a variety of important resources.
• Marine sediments have a variety of origins.

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Marine Sediments

• Eroded rock particles and fragments
  – Transported to ocean
• Deposit by settling through water column
• Oceanographers decipher Earth history through studying sediments.

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Paleoceanography and Marine Sediments

• Paleoceanography – study of how ocean, atmosphere, and land interactions have produced changes in ocean chemistry, circulation, biology, and climate
  – Marine sediments provide clues to past changes.

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Marine Sediment Classification

• Classified by origin
• Lithogenous – derived from land
• Biogenous – derived from organisms
• Hydrogenous or Authigenic – derived from water
• Cosmogenous – derived from outer space

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Lithogenous Sediments

- Eroded rock fragments from land
- Also called terrigenous
- Reflect composition of rock from which derived
- Produced by weathering
  - Breaking of rocks into smaller pieces

Small particles eroded and transported
- Carried to ocean
  - Streams
  - Wind
  - Glaciers
  - Gravity
- Greatest quantity around continental margins

Lithogenous Quartz and Wind Transport

Grain Size

- Proportional to energy of transportation and deposition
**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)

**Pelagic Deposits**

- Fine-grained material
- Accumulates slowly on deep ocean floor
- Pelagic lithogenous sediment from:
  - Volcanic ash (volcanic eruptions)
  - Wind-blown dust
  - Fine-grained material transported by deep ocean currents

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**Sediment Distribution**

- **Neritic**
  - Shallow-water deposits
  - Close to land
  - Dominantly lithogenous
  - Typically deposited quickly
- **Pelagic**
  - Deeper-water deposits
  - Finer-grained sediments
  - Deposited slowly

**Pelagic Deposits**

- **Abyssal Clay**
  - At least 70% clay sized particles from continents
  - Red from oxidized iron (Fe)
  - Abundant if other sediments absent

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**Neritic Lithogenous Sediments**

- **Beach deposits**
  - Mainly wave-deposited quartz-rich sands
- **Continental shelf deposits**
  - Relict sediments
- **Turbidite deposits**
  - Graded bedding
- **Glacial deposits**
  - High latitude continental shelf
  - Currently forming by ice rafting

**Biogenous Sediment**

- Hard remains of once-living organisms
- Two major types:
  - **Macroscopic**
    - Visible to naked eye
    - Shells, bones, teeth
  - **Microscopic**
    - Tiny shells or tests
    - Biogenic ooze
- Mainly algae and protozoans
Biogenous Sediment Composition

- Two most common chemical compounds:
  - Calcium carbonate (CaCO₃)
  - Silica (SiO₂ or SiO₂·nH₂O)

Silica in Biogenous Sediments

- Diatoms
  - Photosynthetic algae
  - Diatomaceous earth
- Radiolarians
  - Protozoans
  - Use external food

Calcium Carbonate in Biogenic Sediments

- Coccolithophores
  - Also called nanoplankton
  - Photosynthetic algae
  - Coccoliths – individual plates from dead organism
  - Rock chalk
    - Lithified coccolith-rich ooze

Silica in Biogenous Sediments

- Tests from diatoms and radiolarians generate siliceous ooze.
- Siliceous ooze lithifies into diatomaceous earth.

Calcium Carbonate in Biogenic Sediments

- Foraminifera
  - Protozoans
  - Use external food
  - Calcereous ooze

Distribution of Biogenous Sediments

- Depends on three processes:
  - Productivity
  - Destruction
  - Dilution
Neritic Deposits

- Dominated by lithogenous sediment, may contain biogenous sediment
- **Carbonate Deposits**
  - Carbonate minerals containing CO$_3$
  - Marine carbonates primarily limestone – CaCO$_3$
  - Most limestones contain fossil shells
    - Suggests biogenous origin
  - Ancient marine carbonates constitute 25% of all sedimentary rocks on Earth.

Carbonate Deposits

- **Stromatolites**
  - Fine layers of carbonate
  - Warm, shallow-ocean, high salinity
  - Cyanobacteria

Calcareous Ooze and the CCD

- Scarce calcareous ooze below 5000 meters (16,400 feet) in modern ocean
- Ancient calcareous oozes at greater depths if moved by sea floor spreading

Calcareous Ooze and the CCD

- **CCD** – Calcite compensation depth
  - Depth where CaCO$_3$ readily dissolves
  - Rate of supply = rate at which the shells dissolve
- Warm, shallow ocean saturated with calcium carbonate
- Cool, deep ocean undersaturated with calcium carbonate
  - Lysocline – depth at which a significant amount of CaCO$_3$ begins to dissolve rapidly
Hydrogenous Marine Sediments

- Minerals precipitate directly from seawater
  - Manganese nodules
  - Phosphates
  - Carbonates
  - Metal sulfides
- Small proportion of marine sediments
- Distributed in diverse environments

Phosphates and Carbonates

- Phosphates
  - Phosphorus-bearing
  - Occur beneath areas in surface ocean of very high biological productivity
  - Economically useful as fertilizer
- Carbonates
  - Aragonite and calcite
  - Oolites

Manganese Nodules

- Fist-sized lumps of manganese, iron, and other metals
- Very slow accumulation rates
- Many commercial uses
- Unsure why they are not buried by seafloor sediments

Metal Sulfides

- Metal sulfides
  - Contain:
    - Iron
    - Nickel
    - Copper
    - Zinc
    - Silver
    - Other metals
  - Associated with hydrothermal vents

Evaporites

- Evaporites
  - Minerals that form when seawater evaporates
  - Restricted open ocean circulation
  - High evaporation rates
  - Halite (common table salt) and gypsum
Cosmogenous Marine Sediments

- Macroscopic meteor debris
- Microscopic iron-nickel and silicate spherules (small globular masses)
  - Tektites
  - Space dust
- Overall, insignificant proportion of marine sediments

Pelagic and Neritic Sediment Distribution

- Distribution controlled by
  - Proximity to sources of lithogenous sediments
  - Productivity of microscopic marine organisms
  - Depth of water
  - Sea floor features

Marine Sediment Mixtures

- Usually mixture of different sediment types
- Typically one sediment type dominates in different areas of the sea floor.

Pelagic Sediment Types

Pelagic and Neritic Sediment Distribution

- Neritic sediments cover about ¼ of the sea floor.
- Pelagic sediments cover about ¾ of the sea floor.

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)
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

End of CHAPTER 4
Marine Sediments