

Marine Sediments



Fig. CO-4

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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

Classification of marine sediments

- Classified by origin
- **Lithogenic** (derived from land)
- **Biogenic** (derived from organisms)
- **Hydrogenic** (derived from water)
 - Also known as *Authigenic*
- **Cosmogenic** (derived from outer space)

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)

Lithogenous sediments

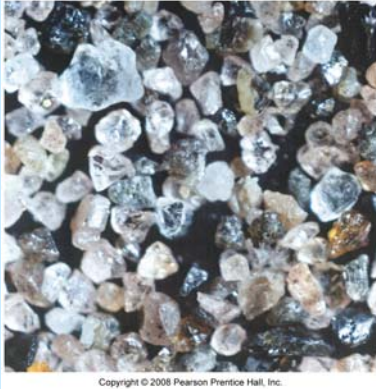


Fig. 4.5

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Lithogenous sediments

- Most lithogenous sediments at continental margins
- Coarser (larger) sediments closer to shore
- Finer (smaller) sediments farther from shore
- Mainly mineral quartz (SiO_2) and aluminum-iron silicate (clays)

Relationship of fine-grained quartz and prevailing winds

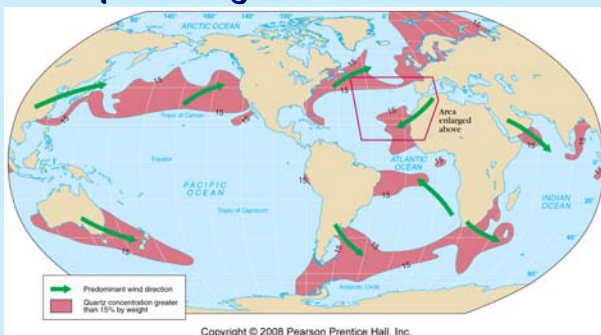


Fig. 4.6b

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Sediment texture

- Grain size
 - Proportional to energy of transportation and deposition

TABLE 4.2 Wentworth scale of grain size for sediments				
Size range (millimeters)	Particle name	Grain size	Example	Energy of the depositional environment
Above 256	Boulder	Coarse-grained	Coarse material found in streambeds near the source areas of rivers	High energy
64 to 256	Cobble			
4 to 64	Pebble	Grained		
2 to 4	Gravels			
$\frac{1}{16}$ to 2	Sand	Fine-grained	Beach sand	Low energy
$\frac{1}{256}$ to $\frac{1}{16}$	Silt		Feels gritty in teeth	
$\frac{1}{625}$ to $\frac{1}{256}$	Clay		Microscopic; feels sticky	

Scale in millimeters

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Table 4.2

Distribution of sediments

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

Neritic lithogenous sediments

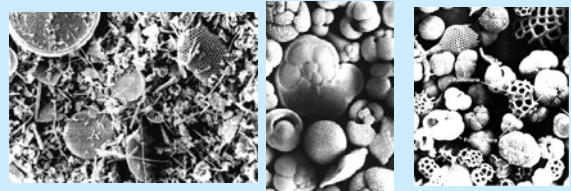
- Beach deposits
 - Mainly wave-deposited quartz-rich sands
- Continental shelf deposits
 - Relict sediments
- Turbidite deposits
- Glacial deposits
 - High latitude continental shelf

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

Biogenous marine sediments

shells or skeletons of organisms that sink to the sea floor after the organisms death; made of silicate or carbonate



Sediments of Diatoms (left), foraminifera (center) and radiolaria (right)

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

Biogenous marine sediments

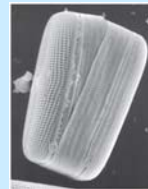
- Commonly either calcium carbonate (CaCO_3) or silica (SiO_2 or $\text{SiO}_2 \cdot n\text{H}_2\text{O}$)
- Usually planktonic (free-floating)

Distribution of biogenous sediments

- Most common as pelagic deposits
- Factors controlling distribution
 - Productivity
 - Destruction (dissolution)
 - Dilution

Silica in biogenic sediments

- Diatoms (algae)
 - Photosynthetic
 - Diatomaceous earth
- Radiolarians (protozoans)
 - Use external food
- They form Siliceous ooze (high amounts of Si)



Siliceous ooze

- Seawater undersaturated with silica
- Siliceous ooze commonly associated with high biologic productivity in surface ocean

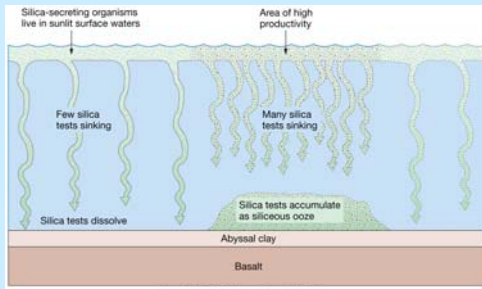


Fig. 4.11

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Calcium carbonate in biogenous sediments

- Coccolithophores (algae)
 - Photosynthetic
 - **Coccoliths** (nano-plankton)
 - Rock chalk



Fig. 4.8a



White Cliffs of Dover, England

Calcium carbonate in biogenous sediments

- **Foraminifera** (protozoans)
 - Use external food
 - Calcareous ooze



Fig. 4.8c

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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 CaCO_3 begins to dissolve rapidly
 - **Calcite compensation depth CCD**--depth where CaCO_3 readily dissolves
 - *Rate of supply = rate at which the shells dissolve*

Calcareous ooze and the CCD

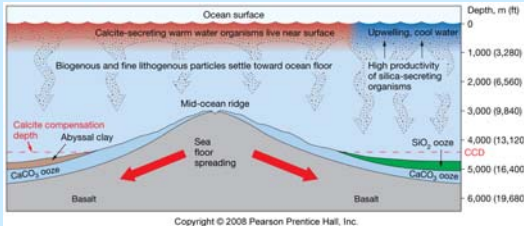


Fig. 4.13

- Scarce calcareous ooze below 5000 m in modern ocean
- Ancient calcareous oozes at greater depths if moved by sea floor spreading

Hydrogenous marine sediments

- Minerals precipitate directly from seawater
 - Manganese nodules
 - Phosphates
 - Carbonates
 - Metal sulfides
 - Sea Salt Deposits (Sodium Chloride...)
- Small proportion of marine sediments
- Distributed in diverse environments

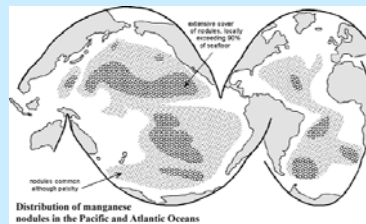
Iron-manganese nodules

- Fist-sized lumps of manganese, iron, and other metals
- Very slow accumulation rates
- Why are they on surface sea floor?



Fig. 4.15a

Manganese nodules



Metal	Composition
Mn (%)	25%
Fe (%)	5%
Ni (%)	1%
Cu (%)	1.5%
Plus many other metals	

Growth Rate = 1-5 mm per million years



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Cosmogenous marine sediments

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

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

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)

Distribution of neritic and pelagic marine sediments

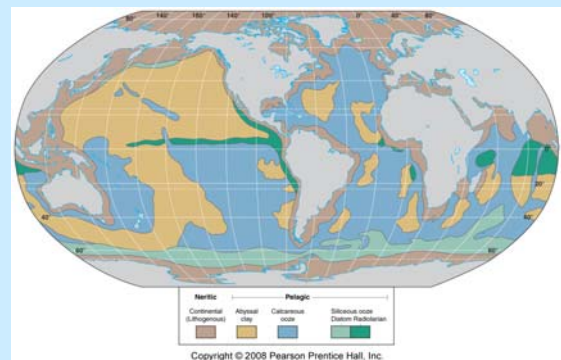


Fig. 4.19

Sampling of Marine Sediments



Sampling of Marine Sediments

Many different methods available:
dependent on what question you are trying
to answer and importantly, what
environment you are sampling

- Marsh (not under water)
- Shallow water (sub-tidal)
- Deeper water (ocean bottom)

- Depth of Core (10 cm versus 10s meters)

- Surface Sediment (bioactive zone)

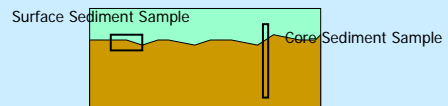
Sediments often represent Environmental Conditions

- Temperature
- Nutrient supply
- Abundance of marine life
- Atmospheric winds
- Ocean current patterns
- Volcanic eruptions
- Major extinction events
- Changes in climate
- Movement of tectonic plates
- Chemical Pollution

Retrieving sediments

Surface Samples or Core Samples

- | | |
|----------|-----------------|
| ■ Dredge | ■ Gravity corer |
| ■ Ponar | ■ Box corer |
| ■ Shipex | ■ Piston corer |
| ■ Ekman | ■ Drill Ship |



Retrieving sediments: Samplers



Ponar



Ekman Dredge



Shipex



Hand Held Piston Corer

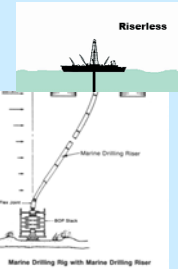
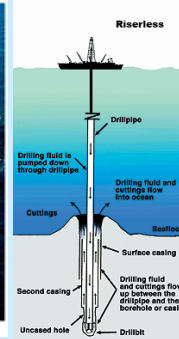


Gravity Corer

Retrieving sediments: Samplers



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Drill Ship and how it works

Field Sampling, June 2003



Vibra Coring on the Anacostia River, DC

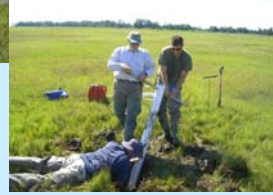
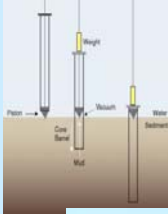
Retrieving sediments: Vibra Coring in Potomac River



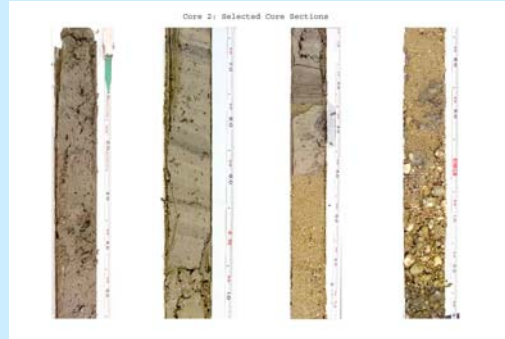
Cores can be taken by SCUBA Divers!



Piston Core: One of many methods for taking a marsh core



What a cores looks like:



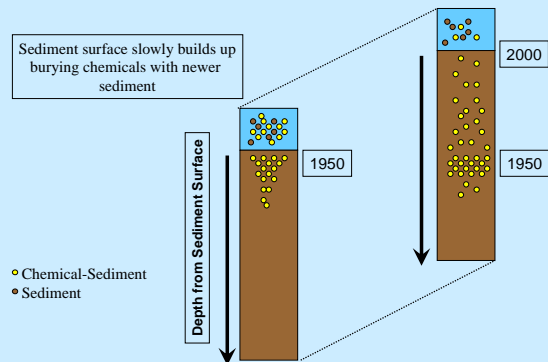
Cores 2

Key Geochemical and Health Test on All Cores Taken!



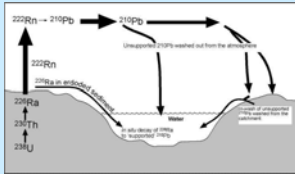
The Ashley Taste Test

Sediments: an ecosystem's memory



²¹⁰Pb, ¹³⁷Cs and other tracers for dating of sediments

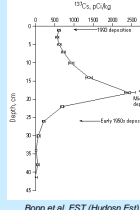
Pb dating is good for approx. 100 to 150 yrs
 Pb is very particle reactive so it is immobile mainly with sediments.



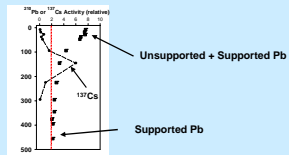
Sources of ²¹⁰Pb
 supported ²¹⁰Pb produced by radioactive decay within sediments
 unsupported ²¹⁰Pb transported to lake from watershed (atm to water and watershed)

Half Life = 22.5 yrs

¹³⁷Cs distribution in sediments

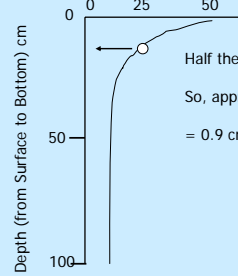


- ¹³⁷Cs produced by atomic weapons or power plants
- Particle reactive but can desorb in marine waters
- Peaks are used to mark a specific time
- Assume linear rates between dates



²¹⁰Pb for dating of sediments

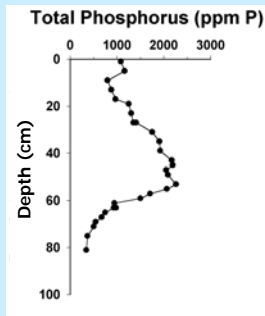
²¹⁰Pb (activity)



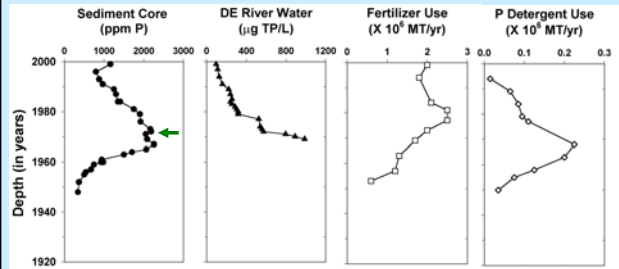
Half the amount of ²¹⁰Pb is at 20 cm
 So, approximate sedimentation rate = 20 cm/22.5 yr
 = 0.9 cm/yr

Half Life of ²¹⁰Pb = 22.5 yrs

Distribution of Phosphorus in Woodbury Marsh Core (New Jersey)



Why did Phosphorus levels decrease over the past 30 years?



← CWA - Clean Water Act

**End of
CHAPTER 4
Marine
Sediments**



Fig. 4E

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