Marine Sediments

Introductory Oceanography

Ray Rector: Instructor

Ocean Basins are Vast Sinks for Huge Amounts of Sediment from Numerous Different Sources

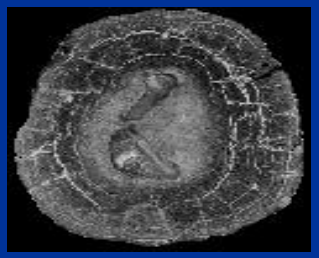
Four Major Types of Seafloor Sediments

1. Lithogenous

- **Sources:** Erosion of land; volcanic eruptions; wind-blown dust
- **Material:** Gravels, Sands, Silts, and Clays

2. Biogenous

- **Sources:** Organic; accumulation of plant and animal hard parts
- **Material:** Calcareous and Siliceous Oozes



3. Hydrogenous

- **Sources:** Precipitation of minerals from solution
- **Material:** Carbonates, Metal Oxides and Sulfides

4. Cosmogenous

- **Sources:** Extraterrestrial dust and meteorites
- **Material:** Tektite particles, Glassy spheres, Silicate dust

Marine Depositional Environments

Four Major Depositional Settings

1) Littoral (shallow)

2) Shelf (shallow)

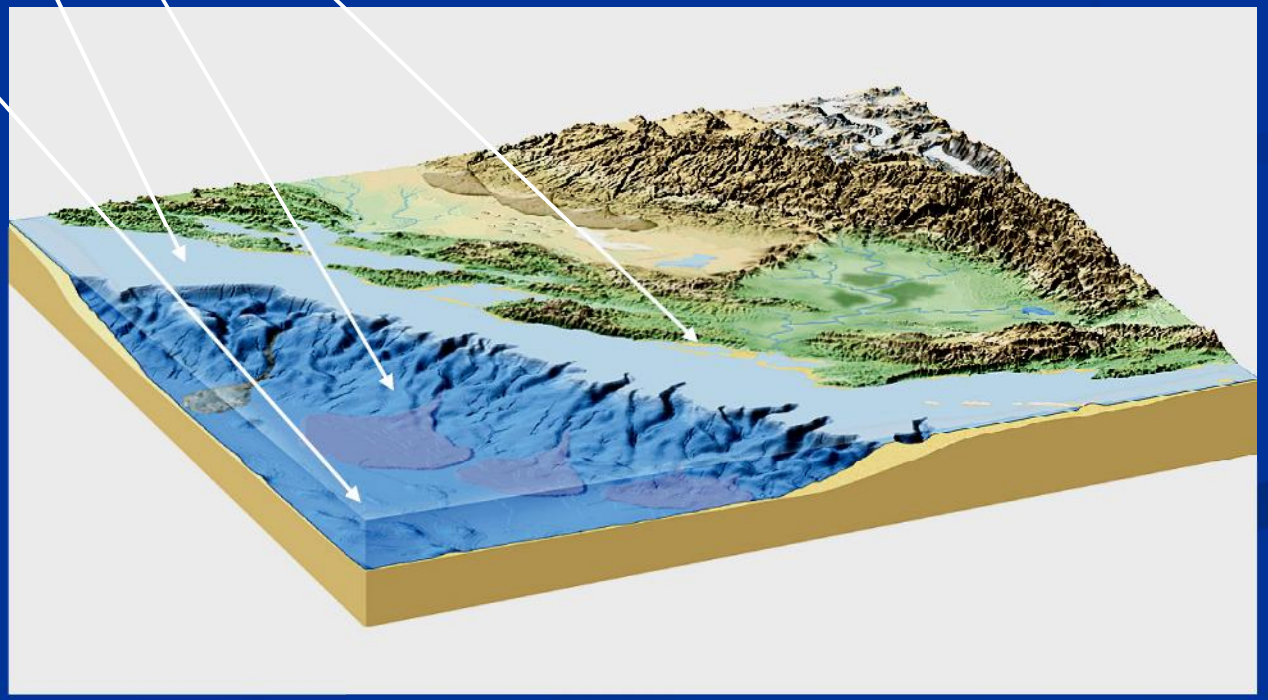
3) Slope/Rise (transitional deep)

4) Abyssal (deep)

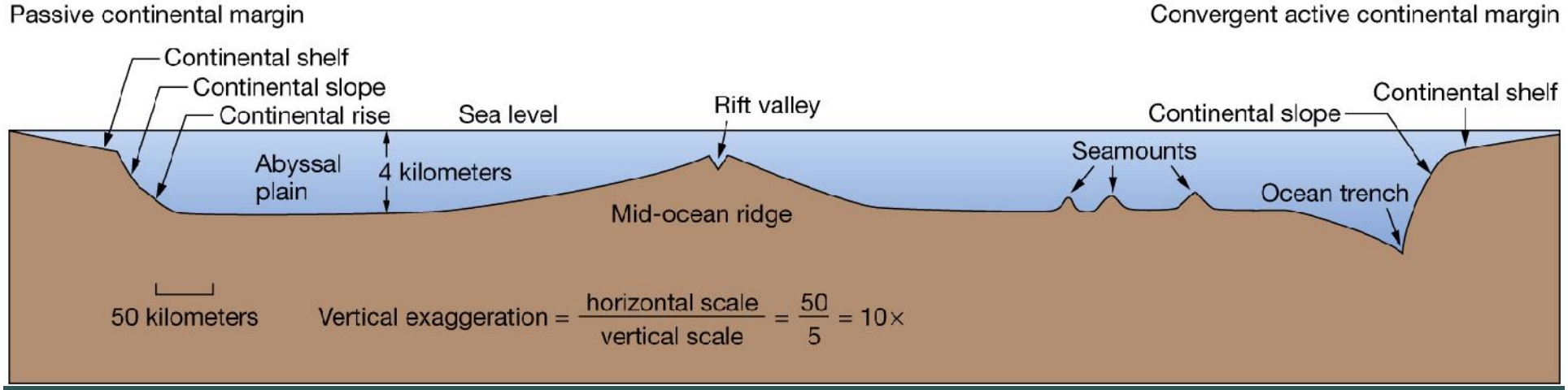
Very Shallow (shoreline) = "Littoral"

Shallow (over shelf) = "Neritic"

Deep (the abyss) = "Oceanic"



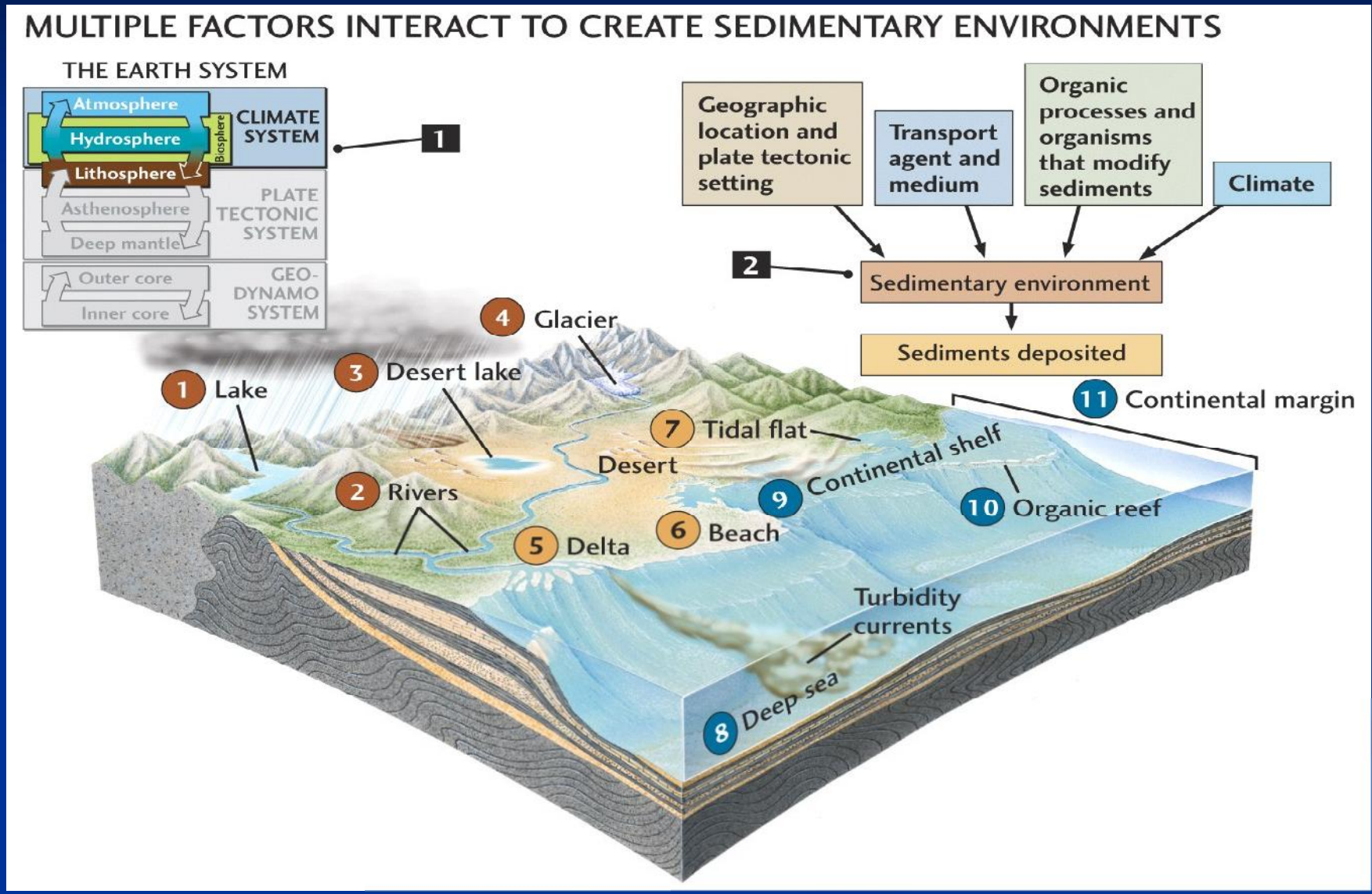
Seafloor Sediment Provinces



Cross-Section Profile of an Ocean Basin

- ✓ Continental shoreline = Littoral Province
- ✓ Continental shelf = Neritic Province
- ✓ Continental slope to rise = Transitional
- ✓ All deep sea regions = Oceanic or Pelagic

Sedimentary Environments are Where Sediments Deposit and Sedimentary Rocks Form



Predominant Sediment Grain Sizes at Specific Depositional Settings

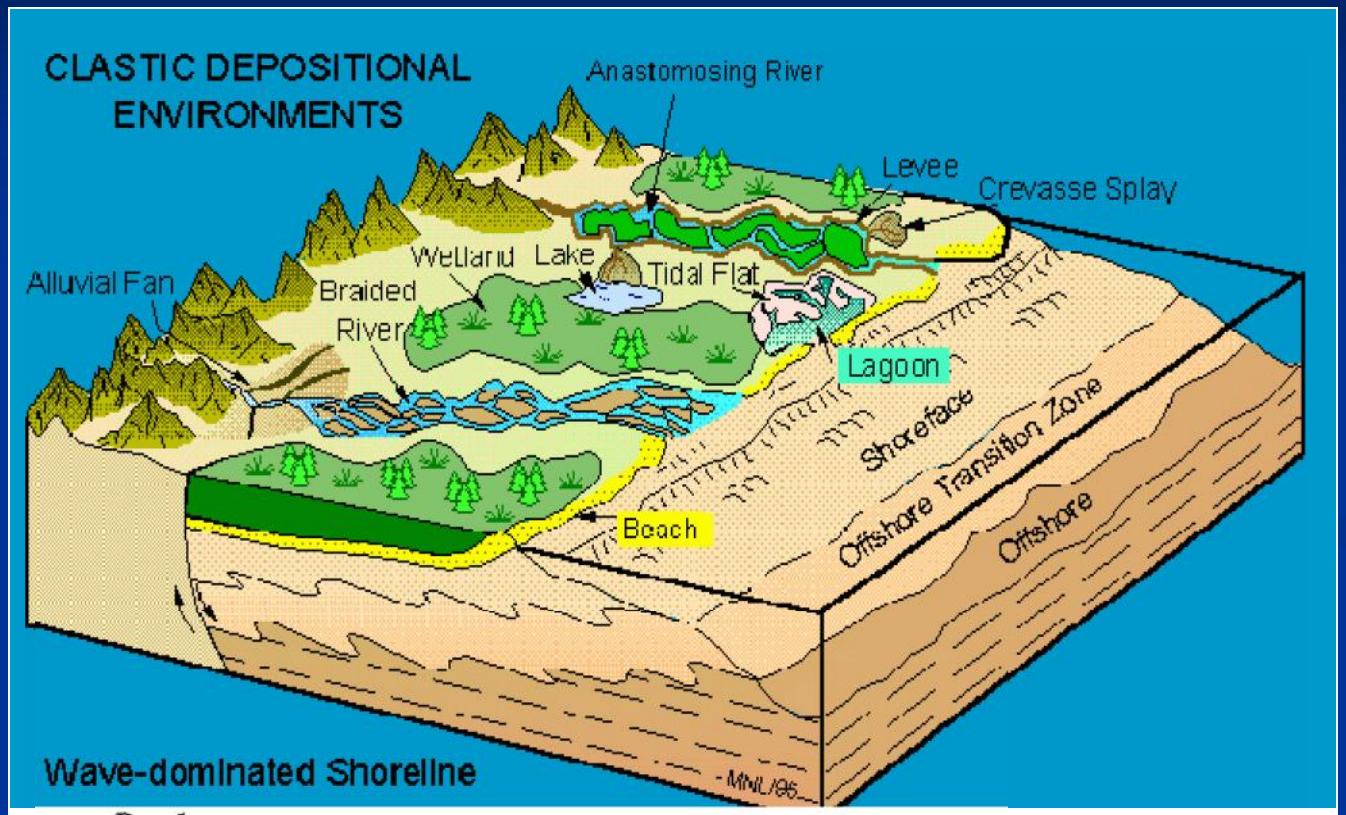
Gravel-size

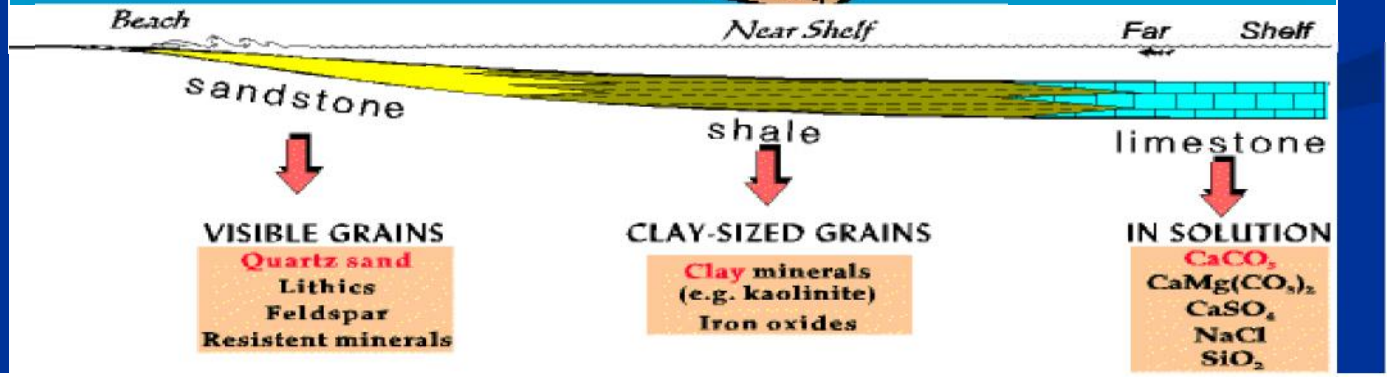
Sand-size

Silt-size

Clay-size

Clast Size





Origin of Lithogenous Sediments

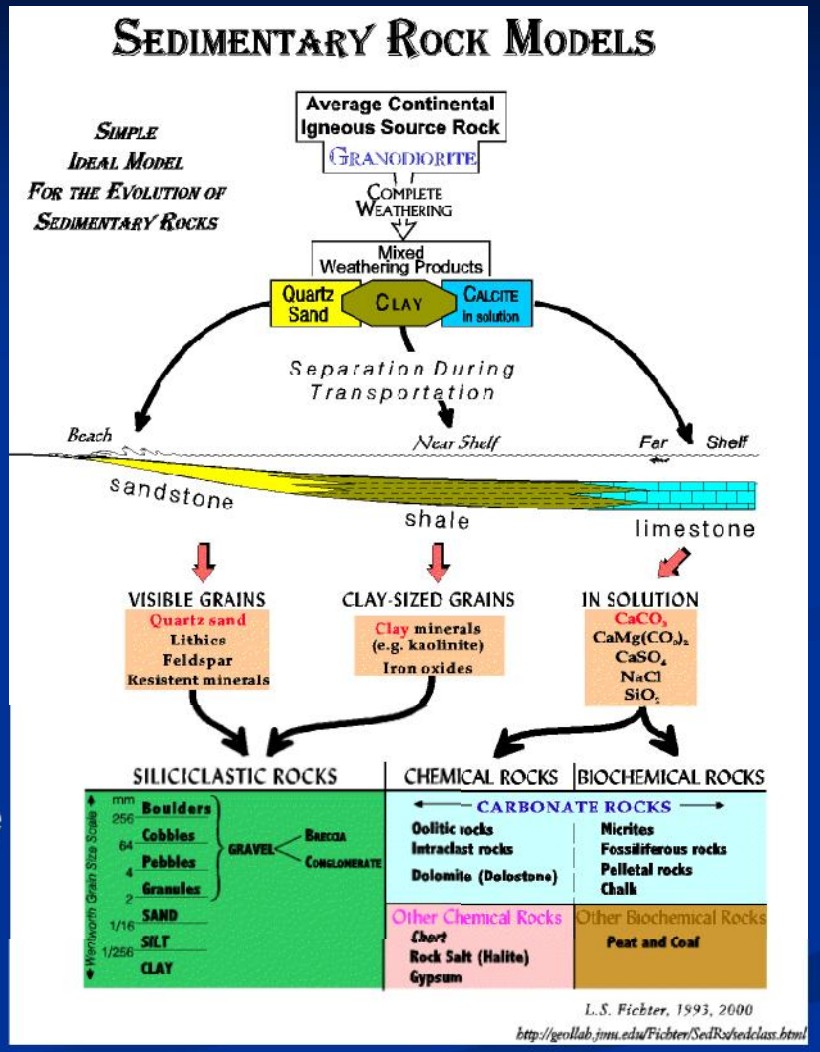
Key Points

1) Primary source is continental rocks
   - Granodiorite most common rock

2) Granodiorite is mechanically broken down into smaller and smaller pieces
   - From boulder size to silt size
   - Courser near source, finer farther away

3) Granodiorite is chemically altered where most original minerals turn in clays
   - Feldspars, micas, amphiboles and olivine get altered to clays
   - Quartz is mineral is not altered

4) Weathered rock is then eroded away (removed and transported from source region to region of deposition.



Sediment Clast/Grain Types

Clast Size

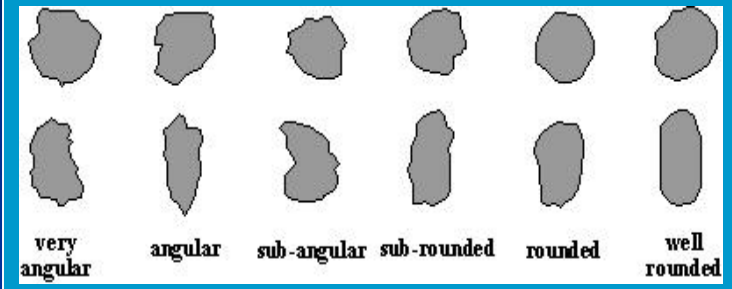
Gravel-size

Sand-size

Silt-size

Clay-size

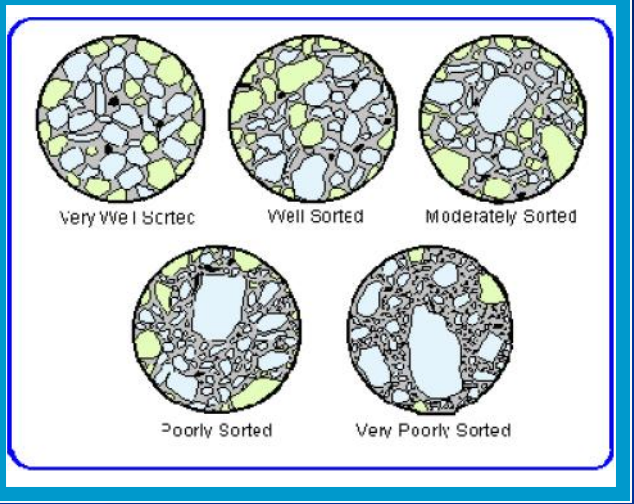
Clast Shape



Near-to-source

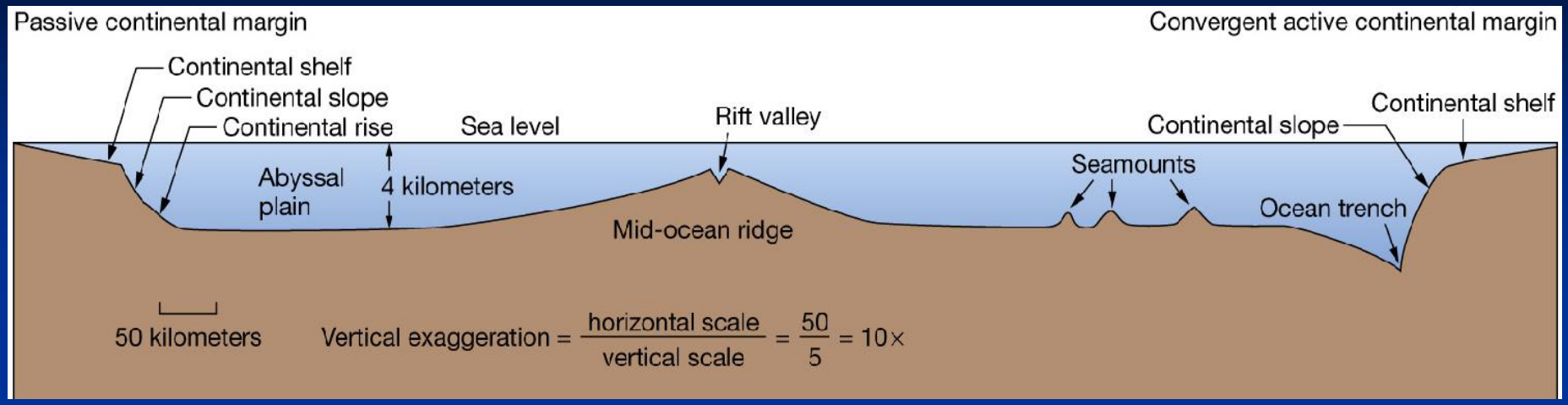
Far-from-source

Clast Sorting



1) **Clast size** is a function of transport time and medium
   - ✓ An indicator of depositional environment
2) **Clast shape** is a function of transport distance and time
   - ✓ An indicator of sediment "maturity"
3) **Clast sorting** is a function of transport medium
   - ✓ An indicator of depositional environment

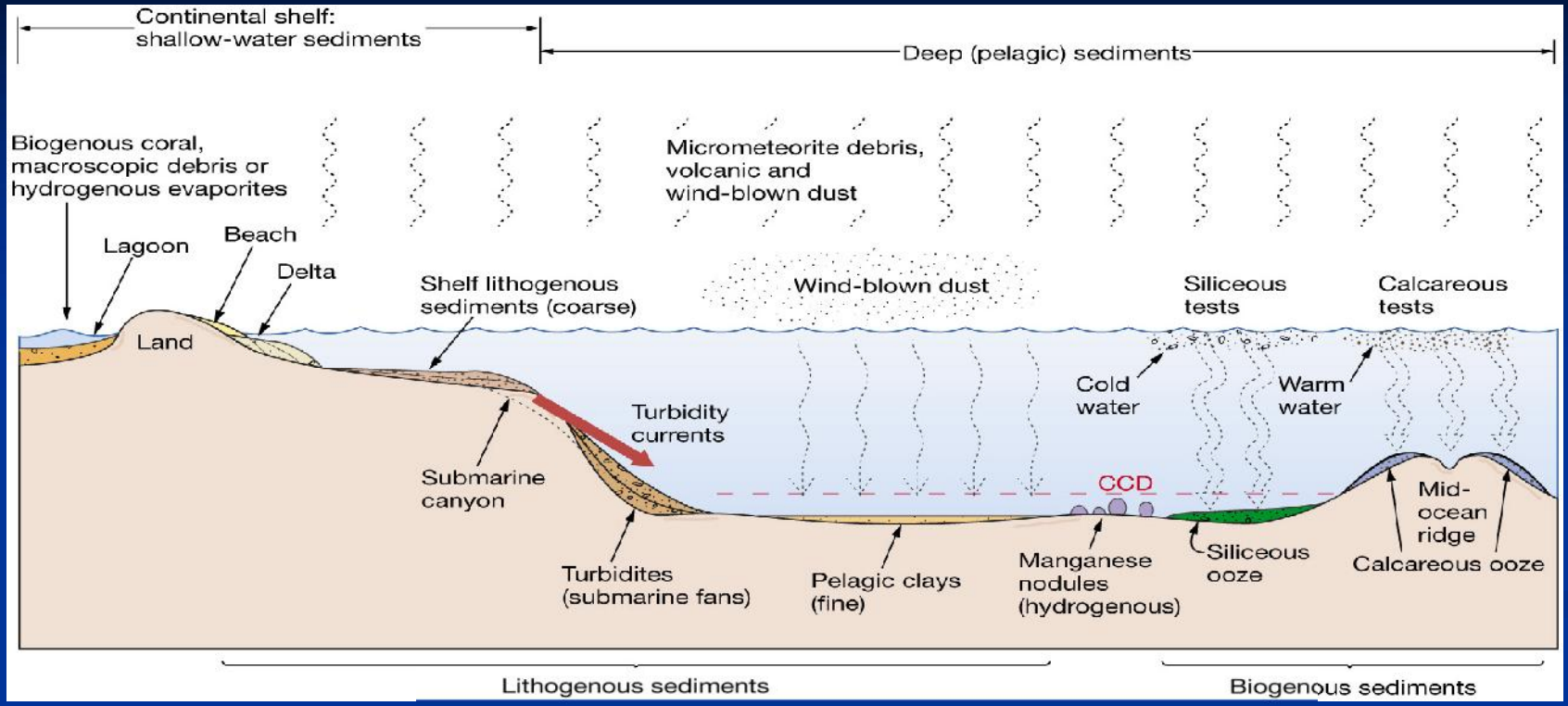
Cross-Section Profile of an Ocean Basin



Ocean Bottom Features

- ✓ Continental shelf, slope, and rise
- ✓ Abyssal plains and hills
- ✓ Mid-ocean ridge and rift valley
- ✓ Oceanic islands, seamounts, and guyots
- ✓ Ocean trench

Type and Locality of Marine Sediments



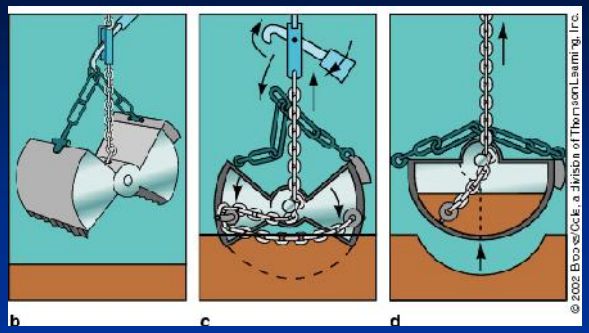
Types

1) Lithogenous
2) Biogenous
3) Hydrogenous
4) Cosmogenous

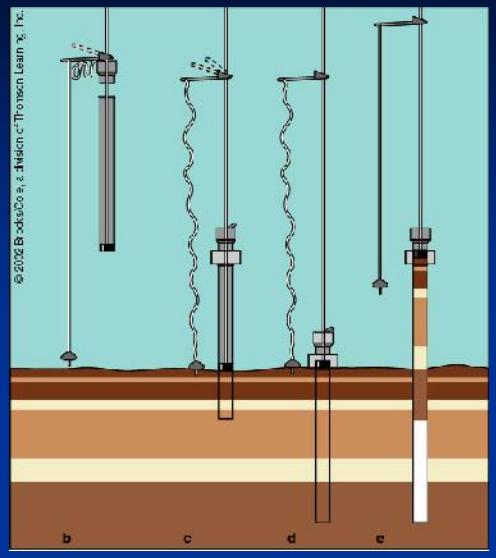
Localities

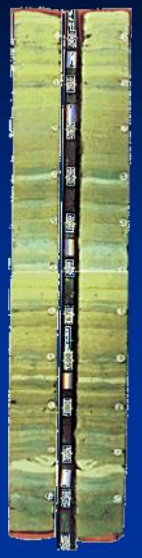
1) Littoral
2) Shelf
3) Slope/Rise
4) Pelagic

Marine Sediment Sampling Methods



1) Bucket-Scooping





2) Piston Coring

4) Submersible

3) Drilling

Marine Sediment Sampling Tools

Camel Grab

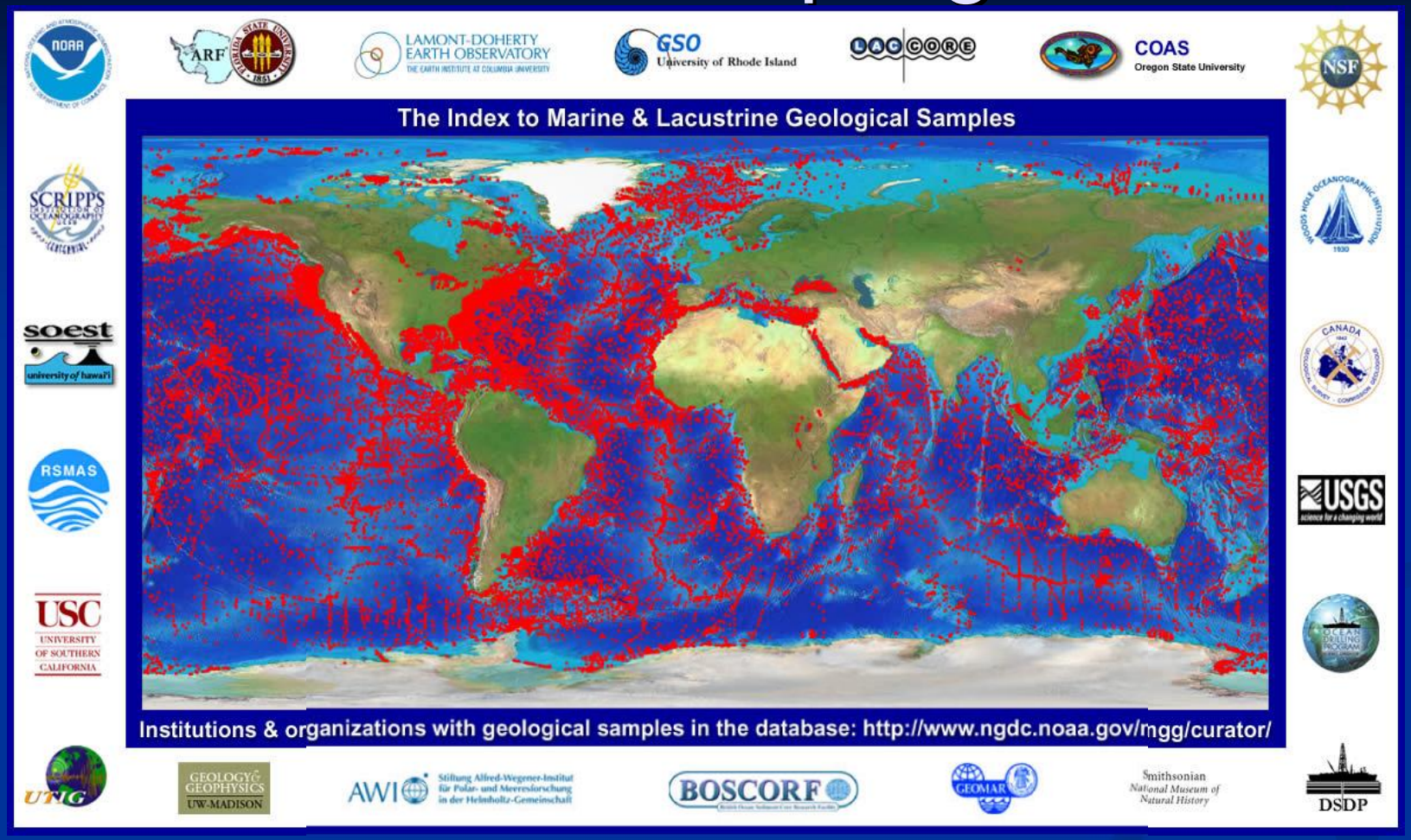
Box Core

Drill Core

Piston Core

Core Sample Processing and Analysis

Marine Sediment Sampling Locations



Primary Sampling Institutions:

1) Governments Agencies
2) Academic Institutions
3) Oil Companies

Continental Margins of the World

1) Seafloor that includes shorelines and continental shelves

2) Submerged continental margins are colored pale orange

3) Average width of continental margins is 80 km

4) Depths of continental margins typically down to 150 meters

5) Continental margin seafloor bedrock mostly granitic rock

Shallow Marine Sediments

Key Points

1) Shallow marine sediments that deposit along shorelines and offshore shelf are termed ***neritic***

2) Coast and shelf sediments are of two types:

- ✓ Land-derived inorganic rock and mineral fragments of gravel, sand, silt, and clay
- ✓ Organic carbonate materials of marine life skeletons and seawater precipitates

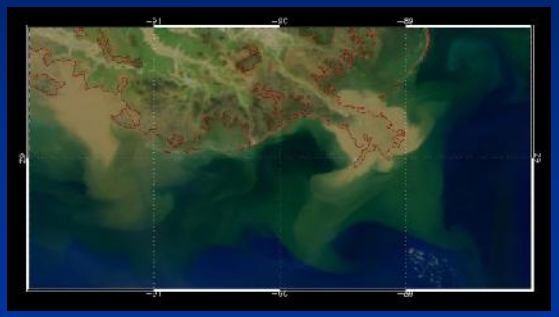
3) Shelf sediments mostly arrive via rivers

4) Coastal sediments may reach deep waters via turbidity currents moving down submarine canyons

Lithogenous Sediments Sources

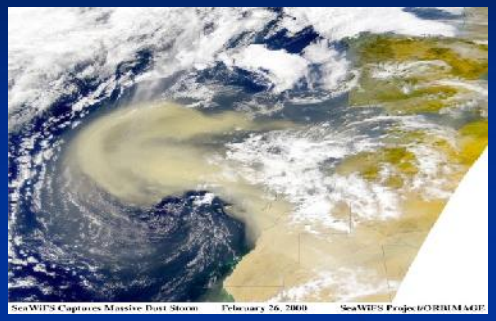
Sources: Rivers; Glaciers; Wind-blown dust; Coastal Erosion; Volcanic eruption

Materials: Gravel, Sands, Silts, and Clays



1) Rivers

2) Glaciers



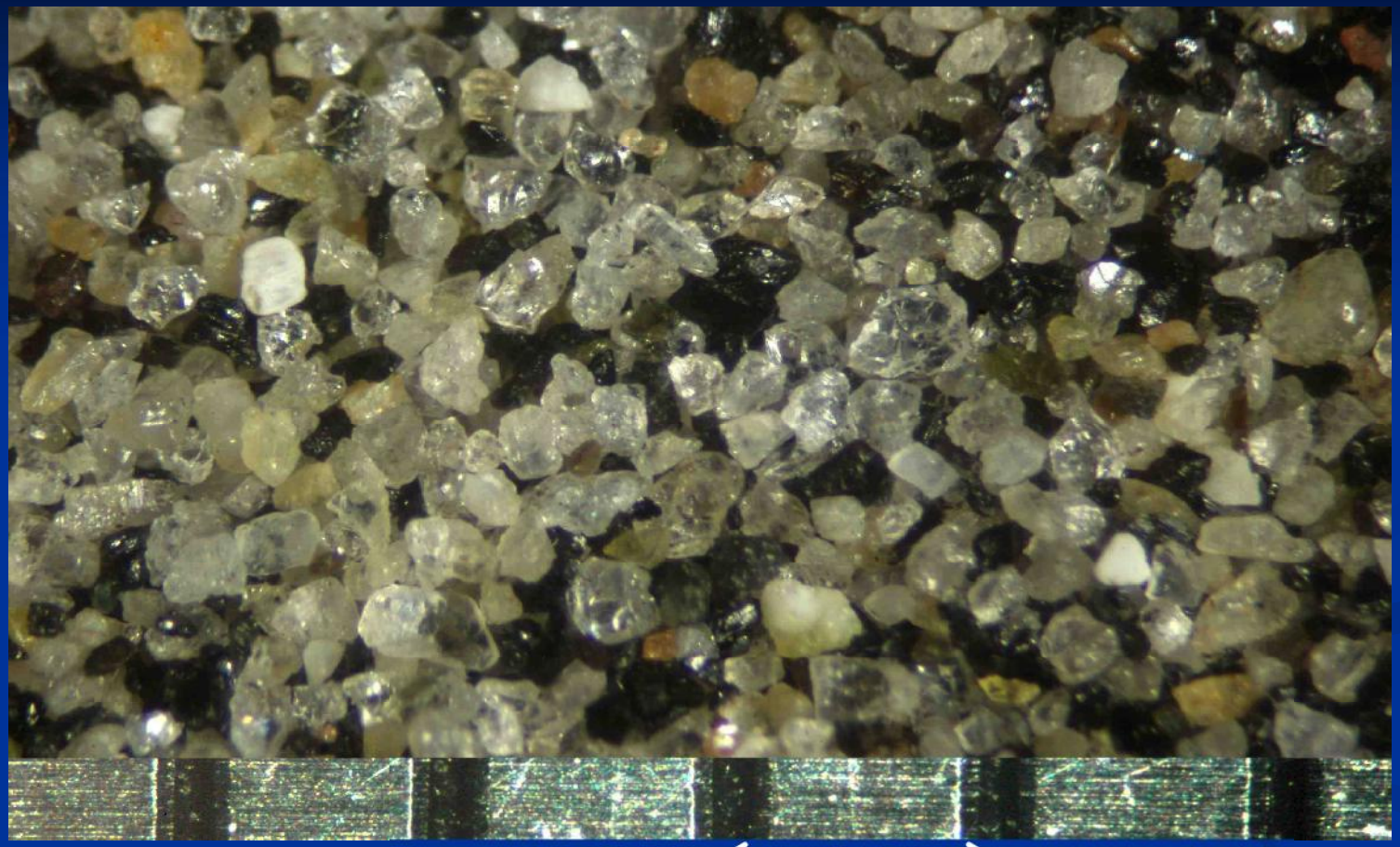
3) Wind-blown dust

Major Sediment Input to the Oceans	
Source	**Estimated Amount (10^9 tons/yr)**
Rivers	18.3
Glaciers	2.0
Wind blown dust	0.6
Coastal erosion	0.25
Volcanic debris	0.15
Groundwater	<0.48

4) Coastal erosion

5) Ash from volcanic eruptions

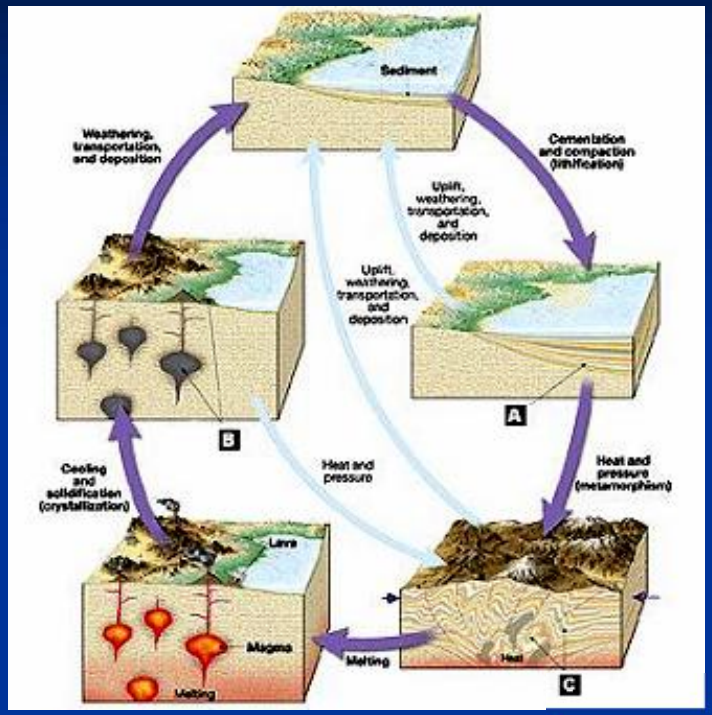
San Diego Beach Sand



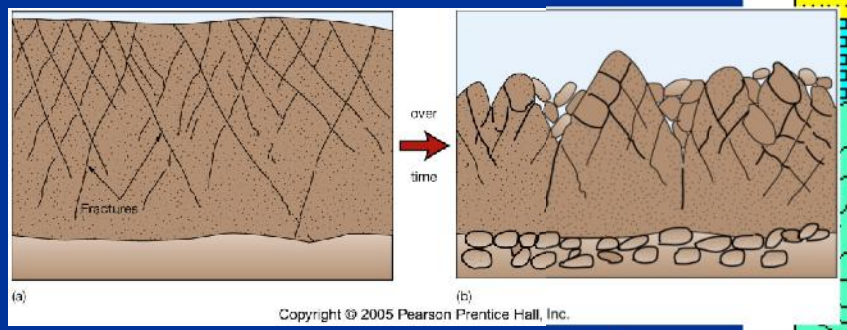
1) Quartz 2) Feldspar 3) Hornblende 4) Biotite

5) Pyroxene 6) Muscovite 7) Garnet 8) Magnetite

Sediments and the Rock Cycle

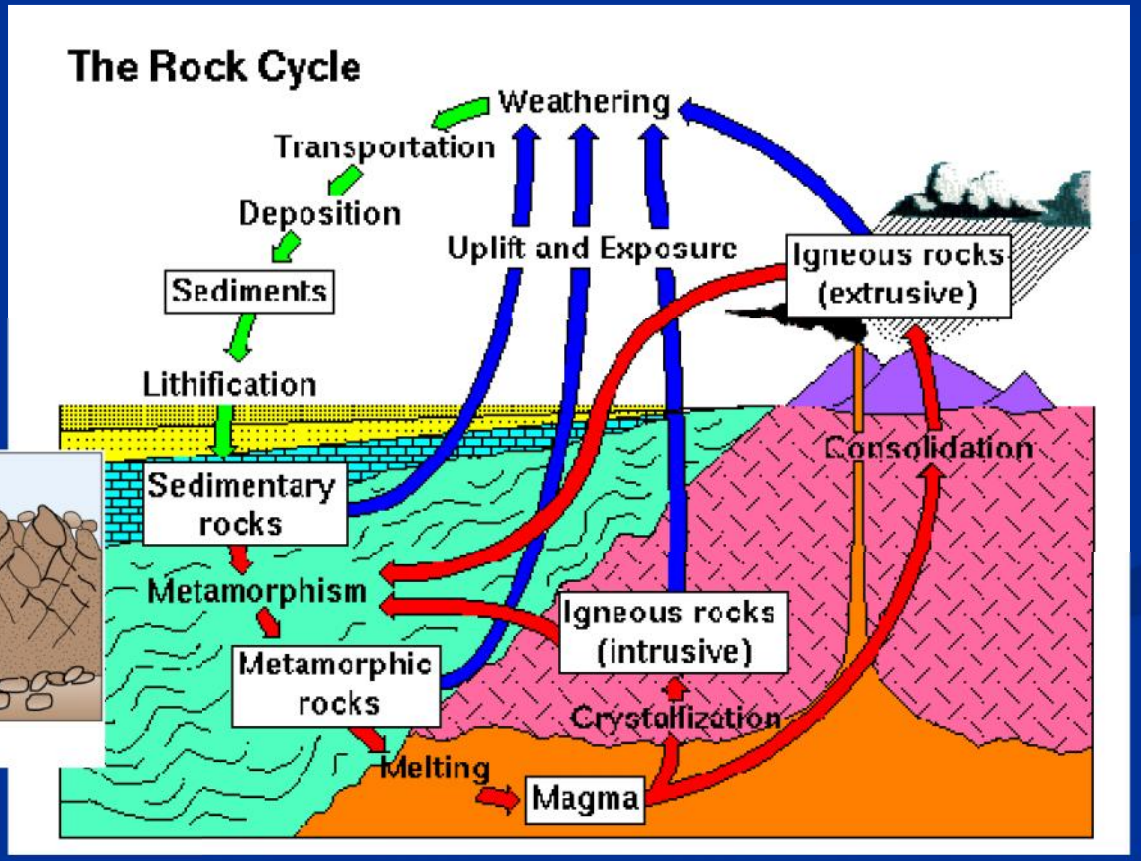


The Rock Cycle



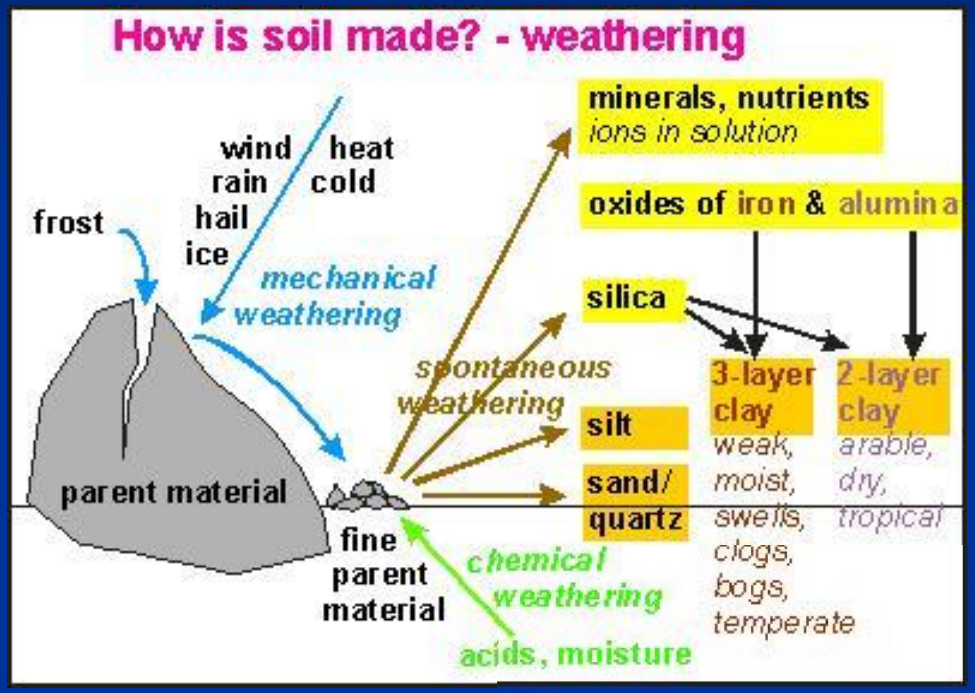
Breakdown and Removal

- **Weathering** = Breakdown of Rock
- **Erosion** = Removal and Transport
- **Deposition** = Settling of Material



SEDIMENTARY PROCESSES

The Chemical/Physical Breakdown and Removal of Rock



Formation of Terrigenous Sediments

- **Weathered Products**
  - ✓ Clays
  - ✓ Quartz
  - ✓ Dissolved Ions
- **Erosion Methods**
  - ✓ Running water
  - ✓ Moving ice
  - ✓ Blowing wind
  - ✓ Turbidity currents

Deep Ocean Basins

1) Deep seafloors from continental slope to mid-ocean ridge

3) Deep ocean bottom is shown in blue color (except for lakes)

4) Average depth of abyssal seafloor is 4000 meters

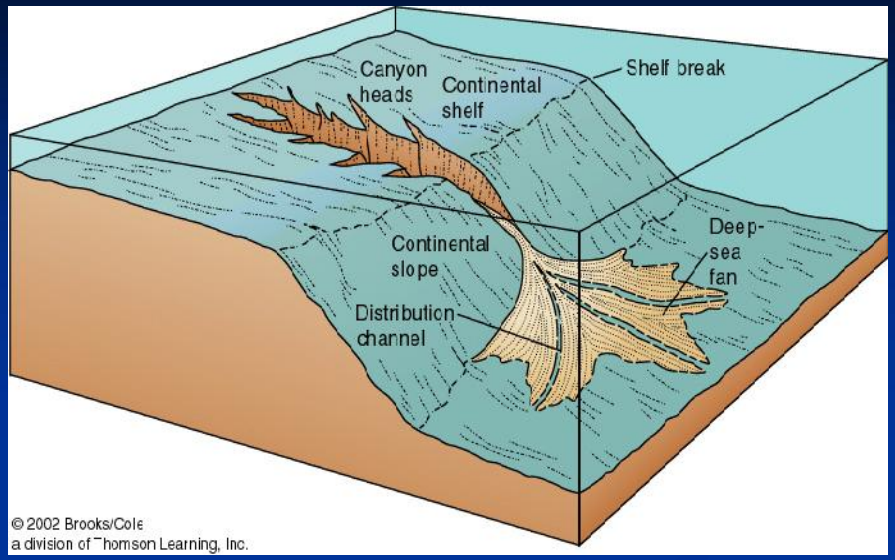
5) Deepest seafloor down to 11,000 meters

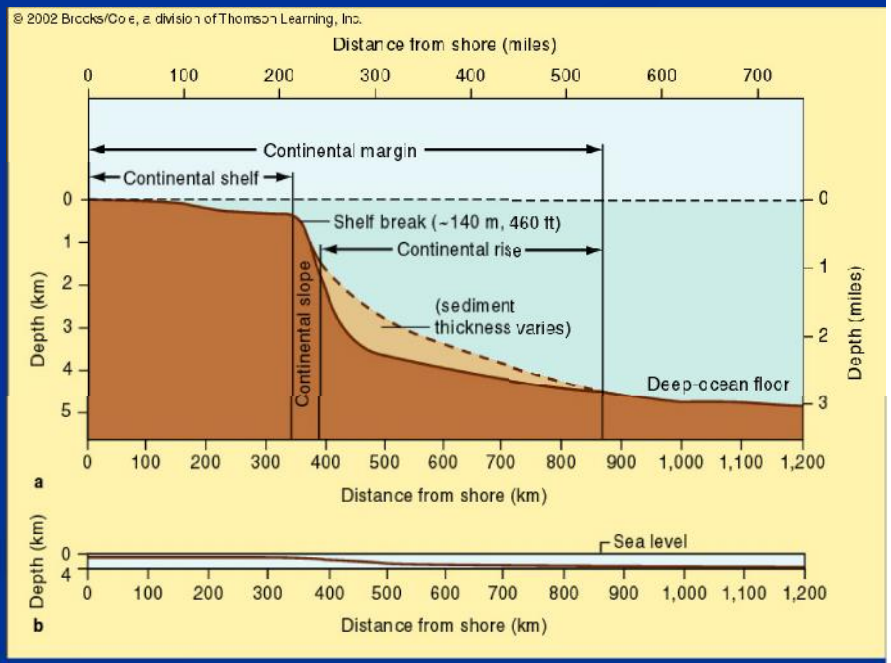
6) Deep seafloor bedrock consists of basaltic volcanic rock

Continental Slope and Rise Sediments

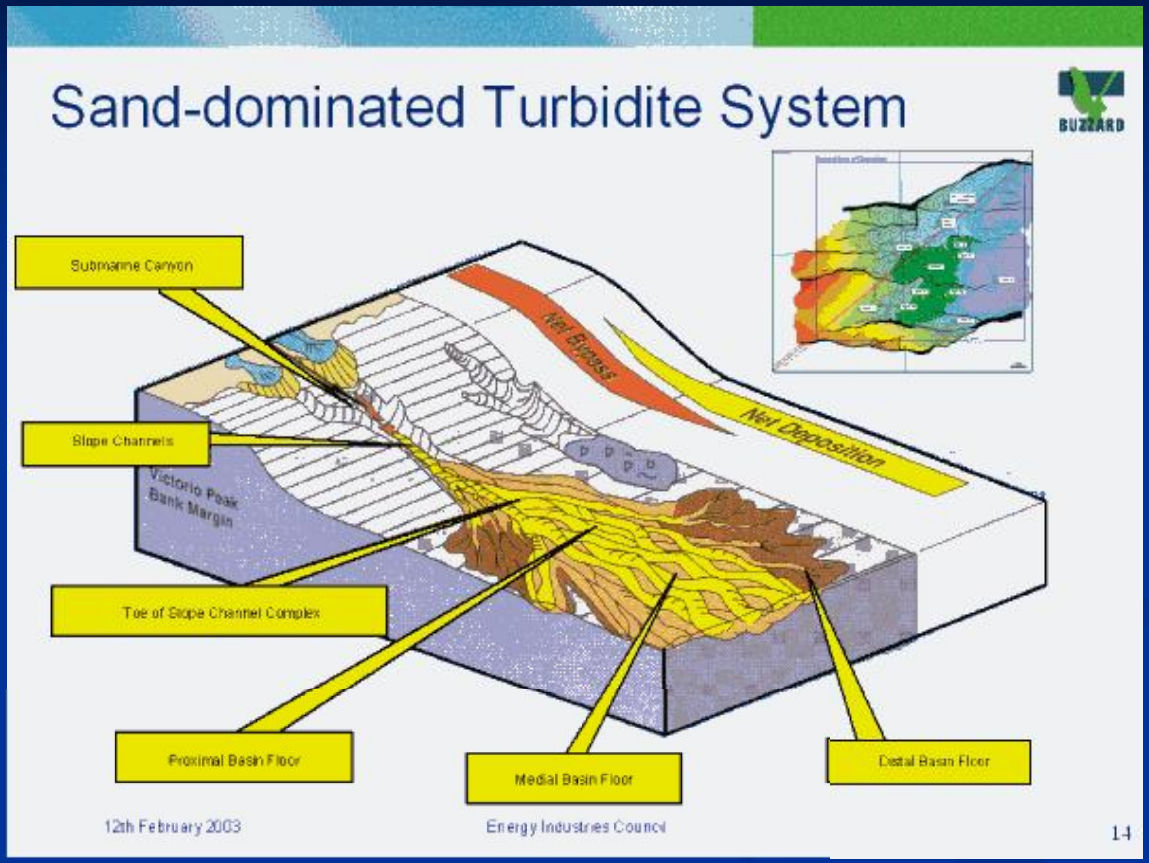
Key Points

- Thickest ocean sediment piles
  - ✓ Up to 20 km thick!
- Thickest sections found at base of submarine canyons in the form of fan-shape sediment wedges
- Mainly consists of sand, silt and clay within graded bedding
- Continentally derived, but classified as transitional-deep sediment
- Primarily transported and deposited by turbidity current processes

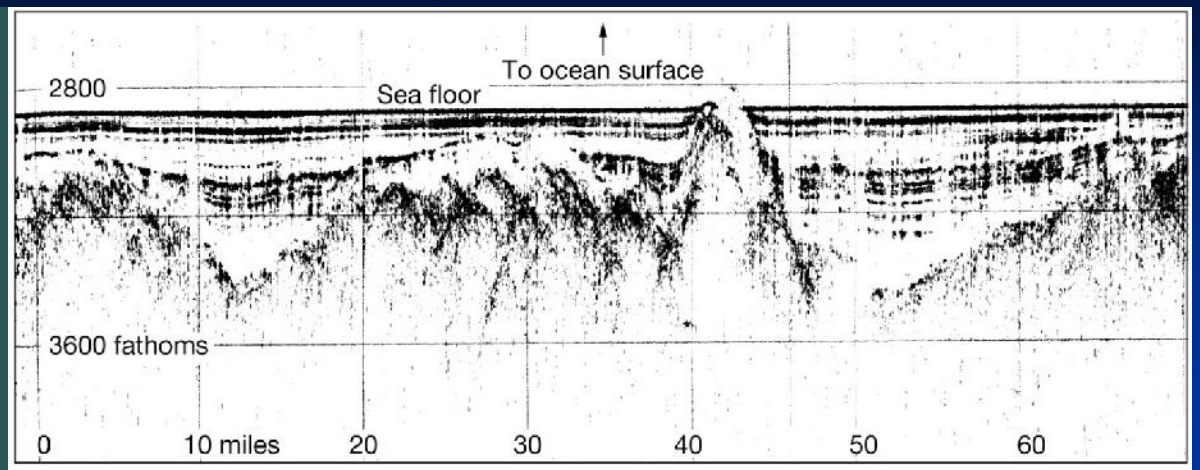


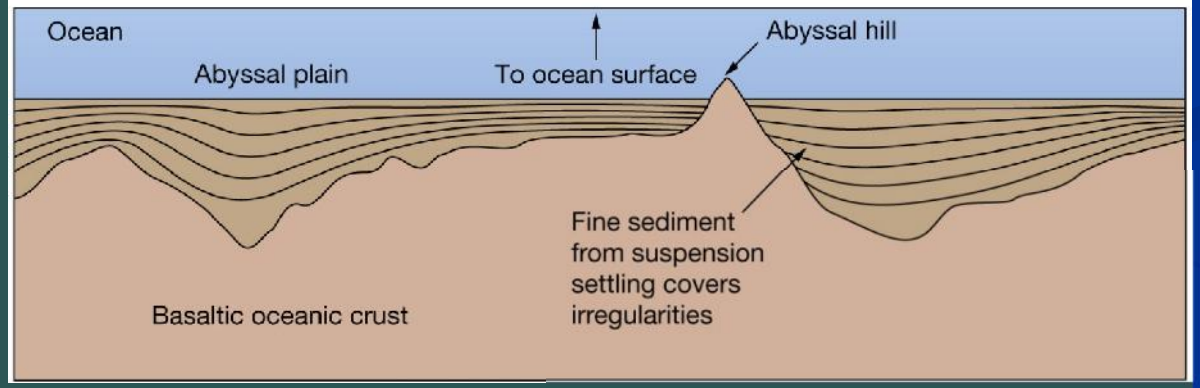


Slope and Rise Turbidity Sedimentation



Abyssal Plains and Hills





Key Points

- Thick pelagic sediment covers a rugged subsurface bedrock of basalt
- Abyssal plains are the flattest, most featureless provinces on Earth
- Abyssal hills are tops of seamounts sticking out
- Abyssal plains and hills cover the most extensive tracts of ocean seafloor

- Subsurface imaging of abyssal plains and hills from seismic reflection studies and deep sea drilling

Deep Marine Sediments

Key Points

1) Deep ocean sediments are termed "***pelagic***"

2) Pelagic sediments are predominately very fine-grained

3) Two types of pelagic sediments
   - ✓ Inorganic clays
   - ✓ Biogenic oozes

4) Two types of biogenic oozes
   - ✓ Calcareous
   - ✓ Siliceous

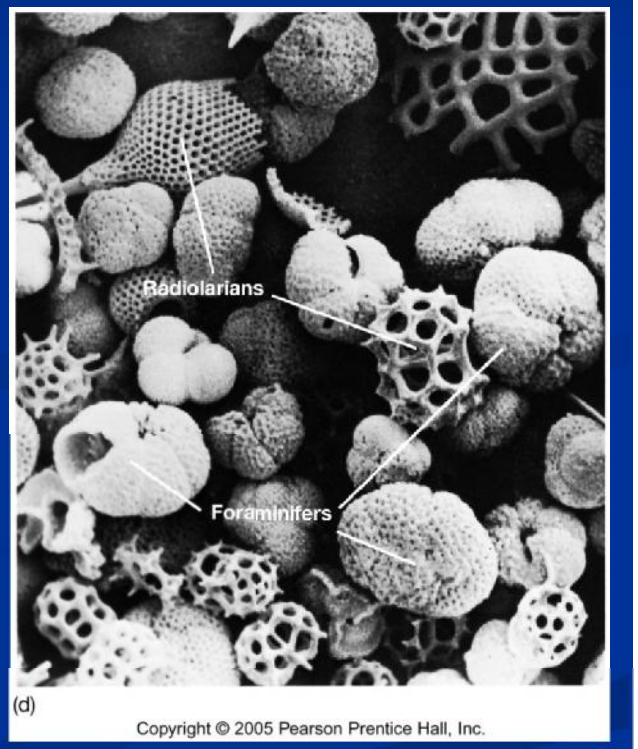
5) Abundant benthic organisms crawl over and burrow through the sediment = ***Bioturbation***

Biogenous Sediment Sources

Sources: Organic; accumulation of plant and animal hard parts

Material: Calcareous and Siliceous Oozes and Detritus

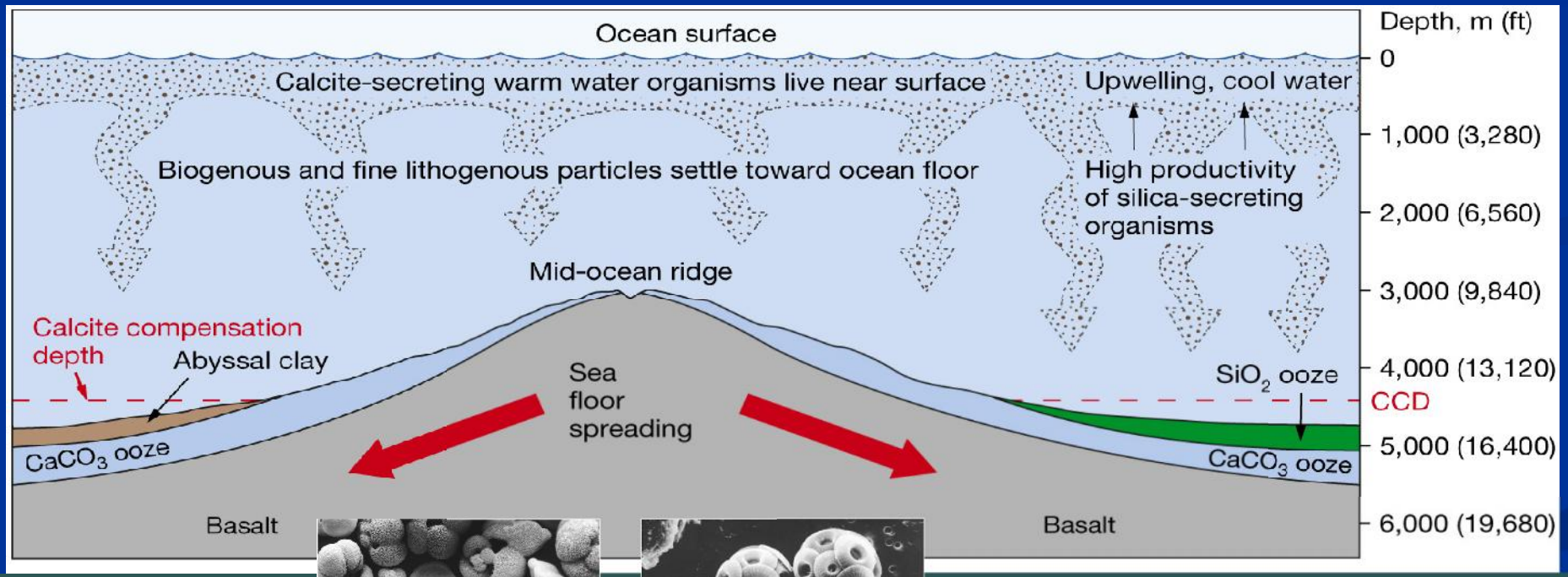
Deep Ocean Seafloor



Plankton Tests

Calcareous Ooze Sediments

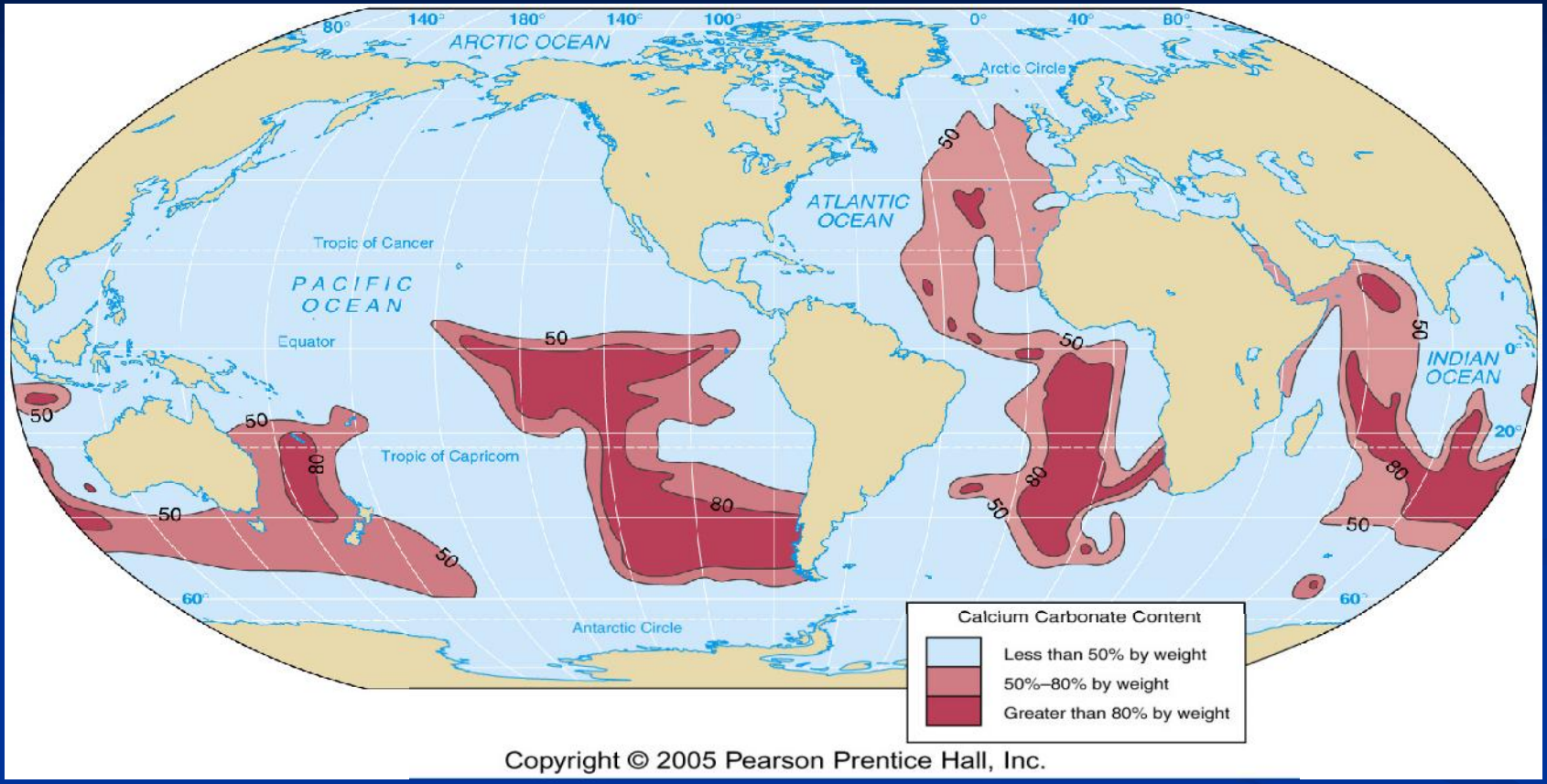
- ✓ Accumulation of calcium carbonate hard parts from dead microscopic plankton
- ✓ Mainly consists of cocolithophores and foraminifera tests
- ✓ Calcite-shelled plankton abundant in warmer surface waters
- ✓ Accumulate above the Carbonate Compensation Depth (CCD)



foraminifera

cocolithophores

Distribution of Calcareous Ooze Sediments

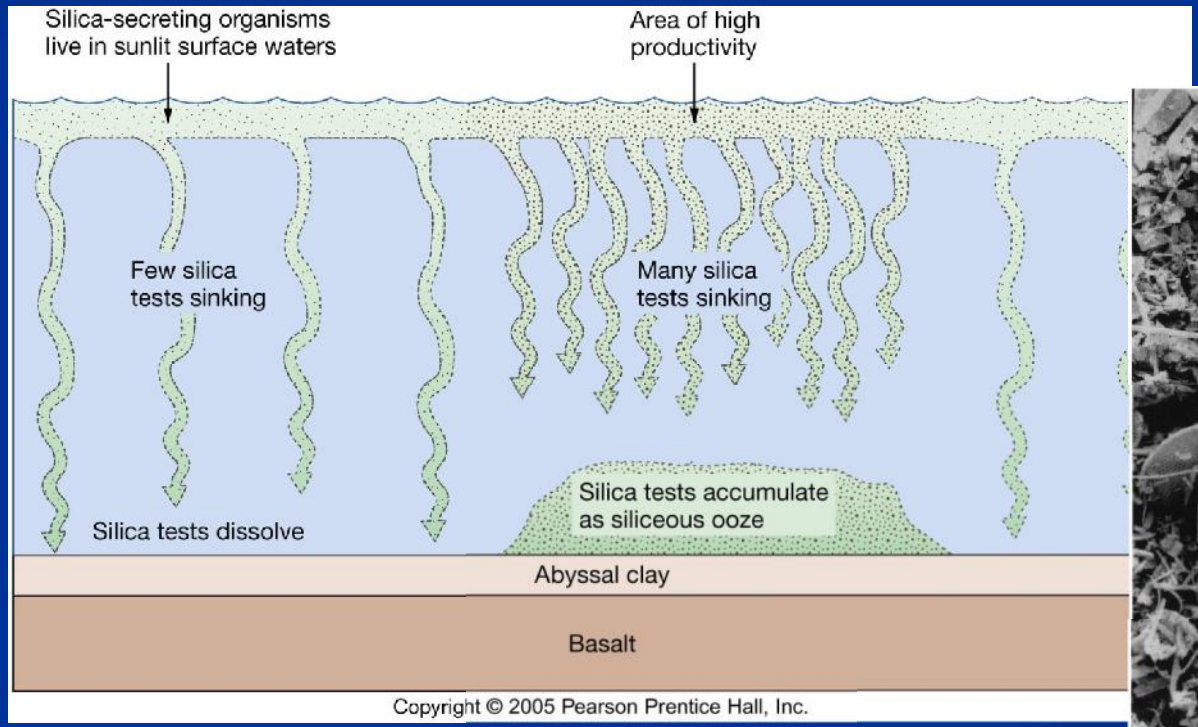


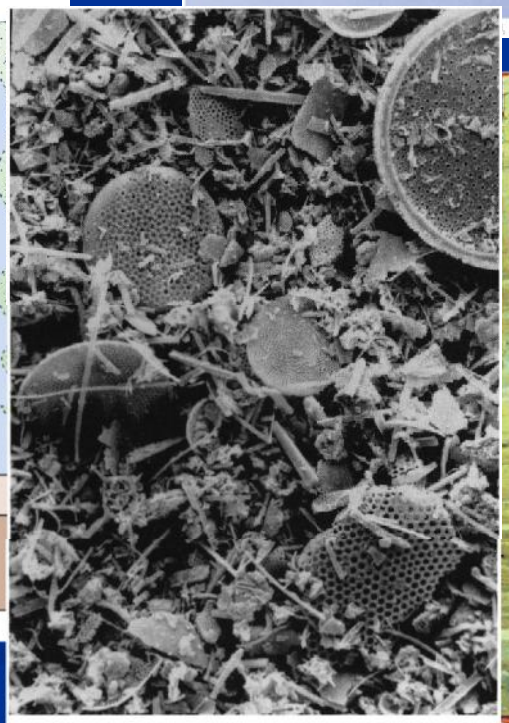
1) Calcareous oozes principally deposit in relatively shallow, low- to mid-latitude regions of deep ocean

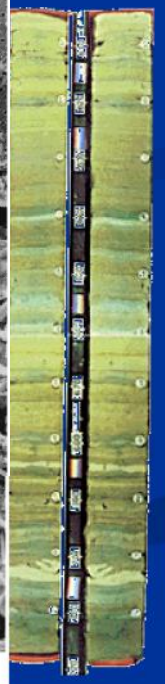
2) Concentrated on tops and flanks of mid ocean ridges

Silica Ooze Sediments

- ✓ Accumulation of silica hard parts from dead plankton
- ✓ Mainly consists of diatoms and radiolarian tests
- ✓ Abundant in deeper, cooler surface waters – high latitude

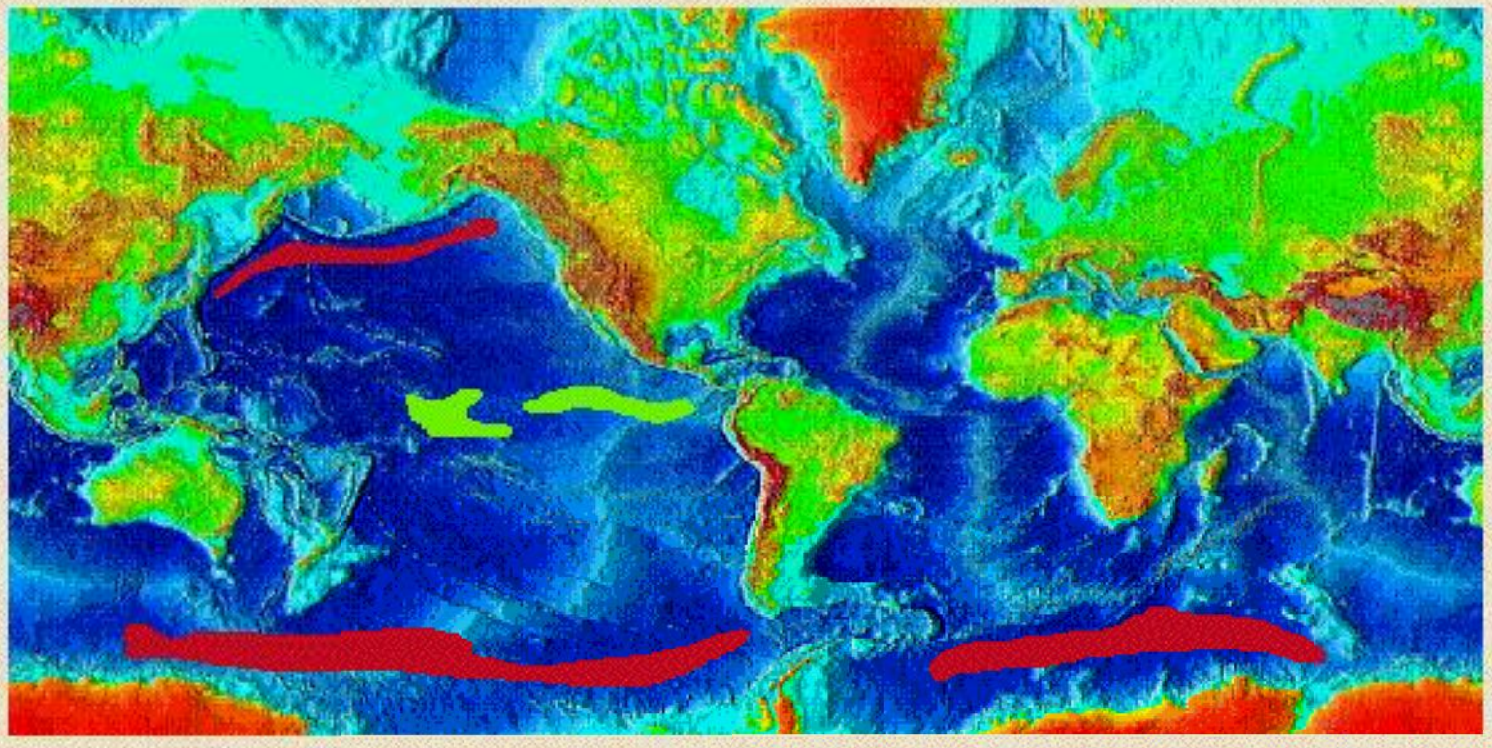






Siliceous Oozes:

- Areas of high nutrients, cold waters
  - two types: diatomaceous oozes, radiolarian oozes



siliceous oozes

diatomaceous

radiolarian

Comparing Silica and Carbonate Oozes

Table 4.3 Comparison of environments interpreted from deposits of siliceous and calcareous ooze in surface sediments

	Siliceous ooze	*Calcareous ooze*
Surface water temperature above sea floor deposits	Cool	Warm
Main location found	Sea floor beneath cool surface water in high latitudes	Sea floor beneath warm surface water in low latitudes
Other factors	Upwelling brings deep, cold, nutrient-rich water to the surface	Calcareous ooze dissolves below the CCD
Other locations found	Sea floor beneath areas of upwelling, including along the equator	Sea floor beneath warm surface water in low latitudes along the mid-ocean ridge

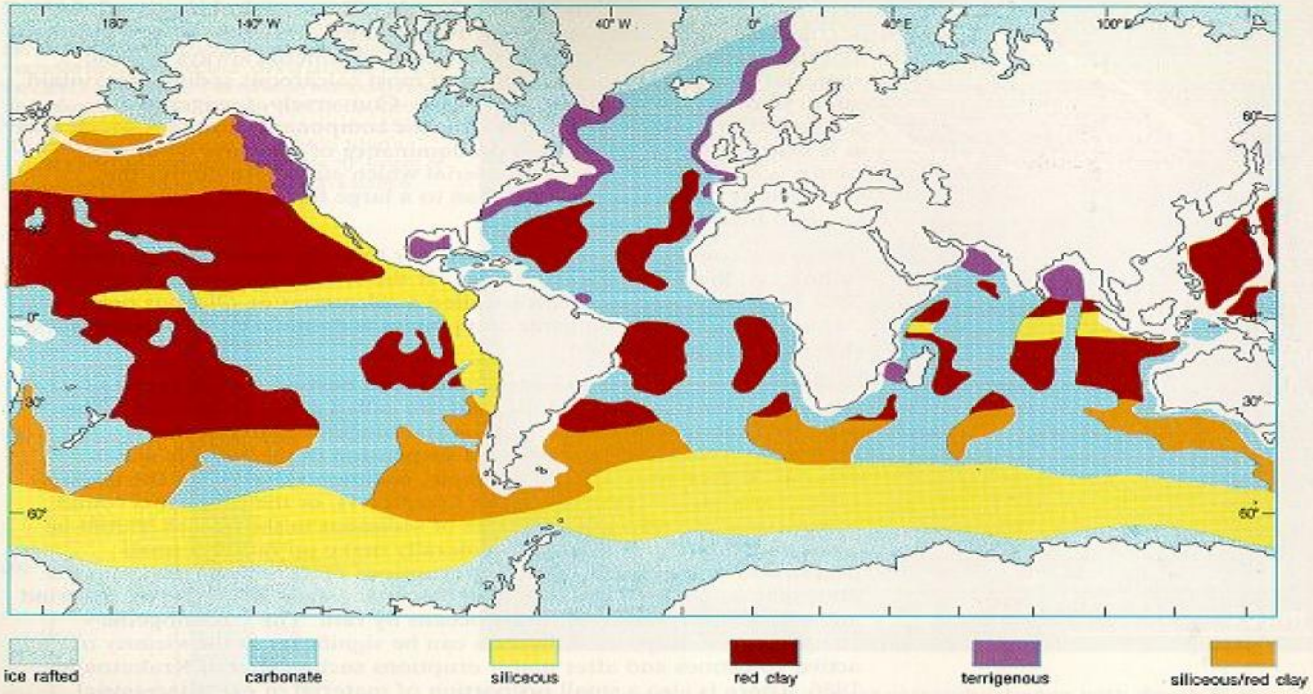
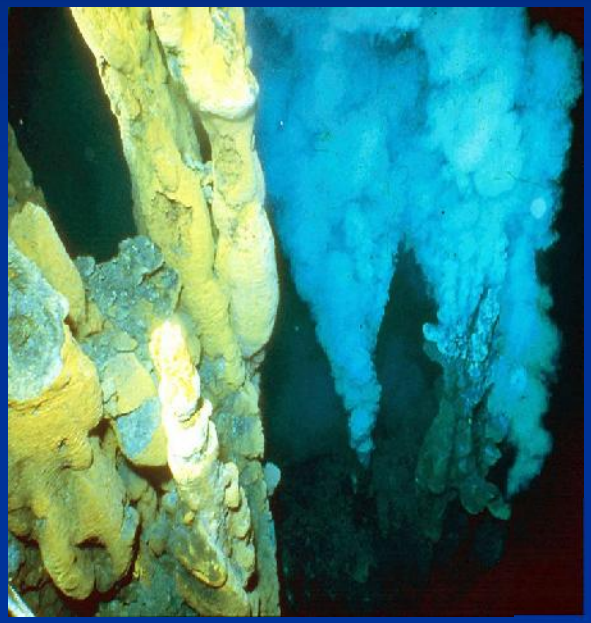


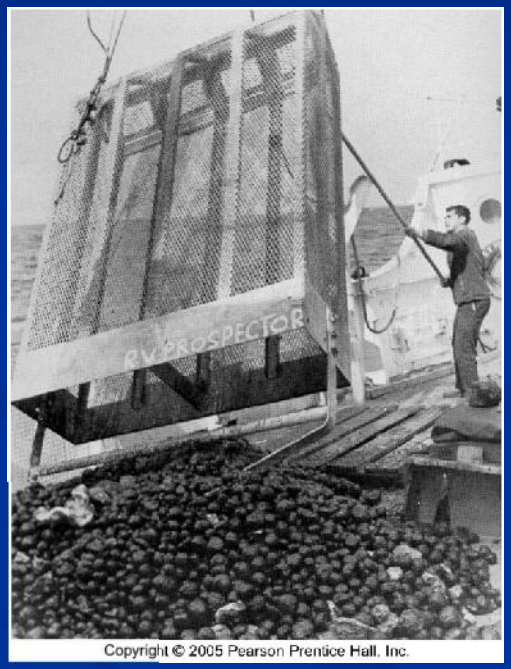
Figure 1.4 Distribution of dominant sediment types on the floor of the present-day oceans. Note that red clays are also terrigenous sediments.

Types of Hydrogenous Sediment

- **Sources:** Precipitation of minerals from solution
- **Minerals:** Carbonates, Phosphates, Metal Oxides and Sulfides



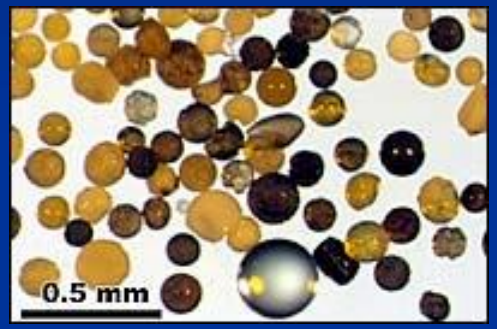
Black Smoker Chimneys Sulfides



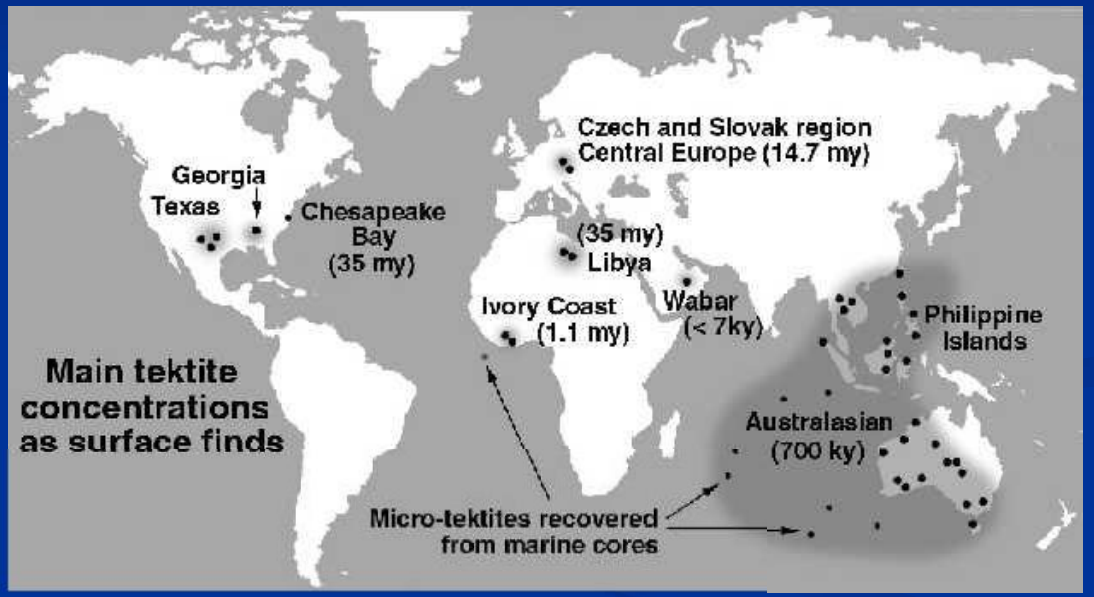
Manganese Nodules

Types of Cosmogenous Sediment

- **Sources:** Extraterrestrial rock, dust ,and debris
- **Materials:** Silicates, glass, and metals



Microtektites



Tektite Strewn Fields

Type and Distribution of Marine Sediments

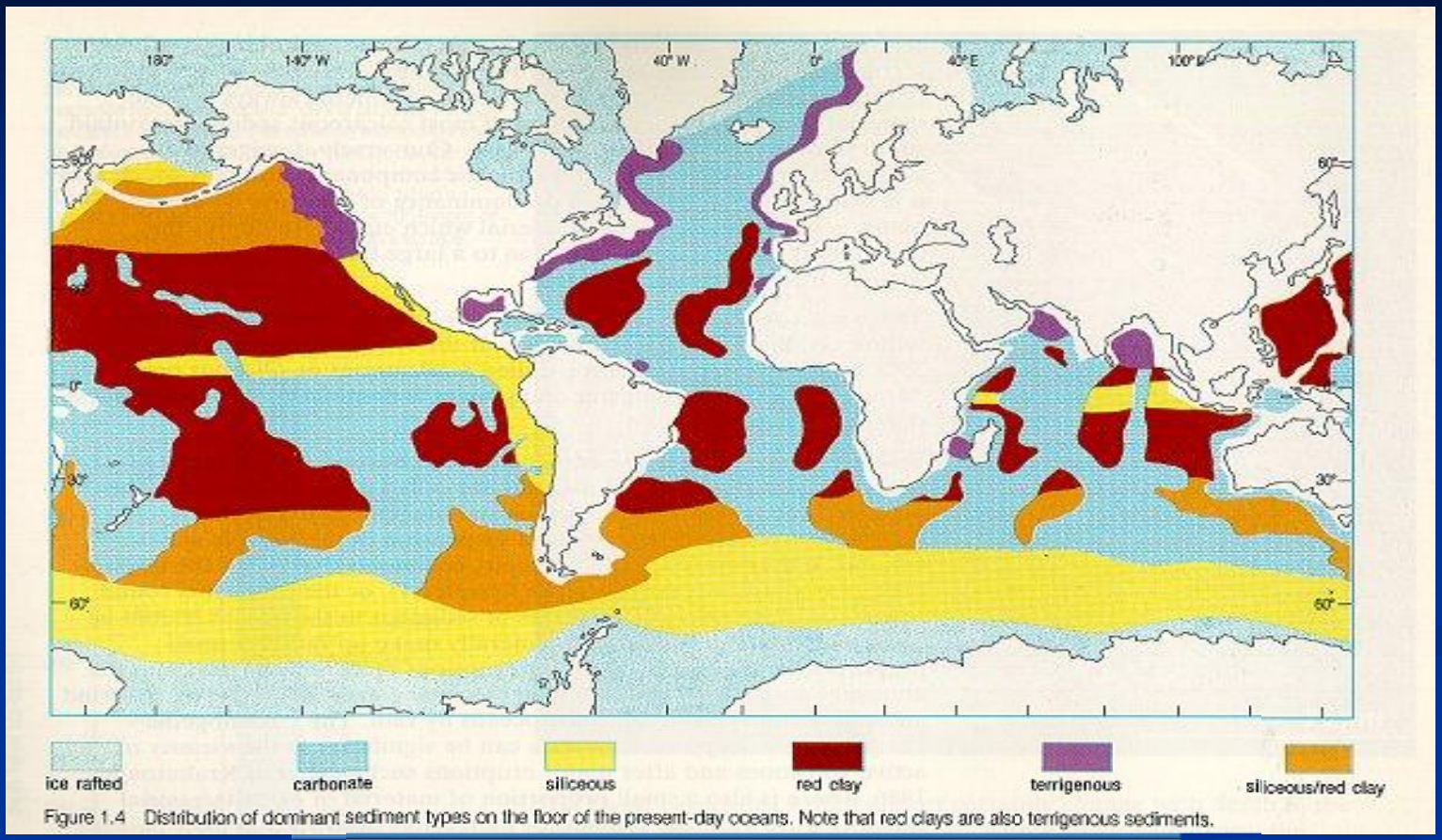
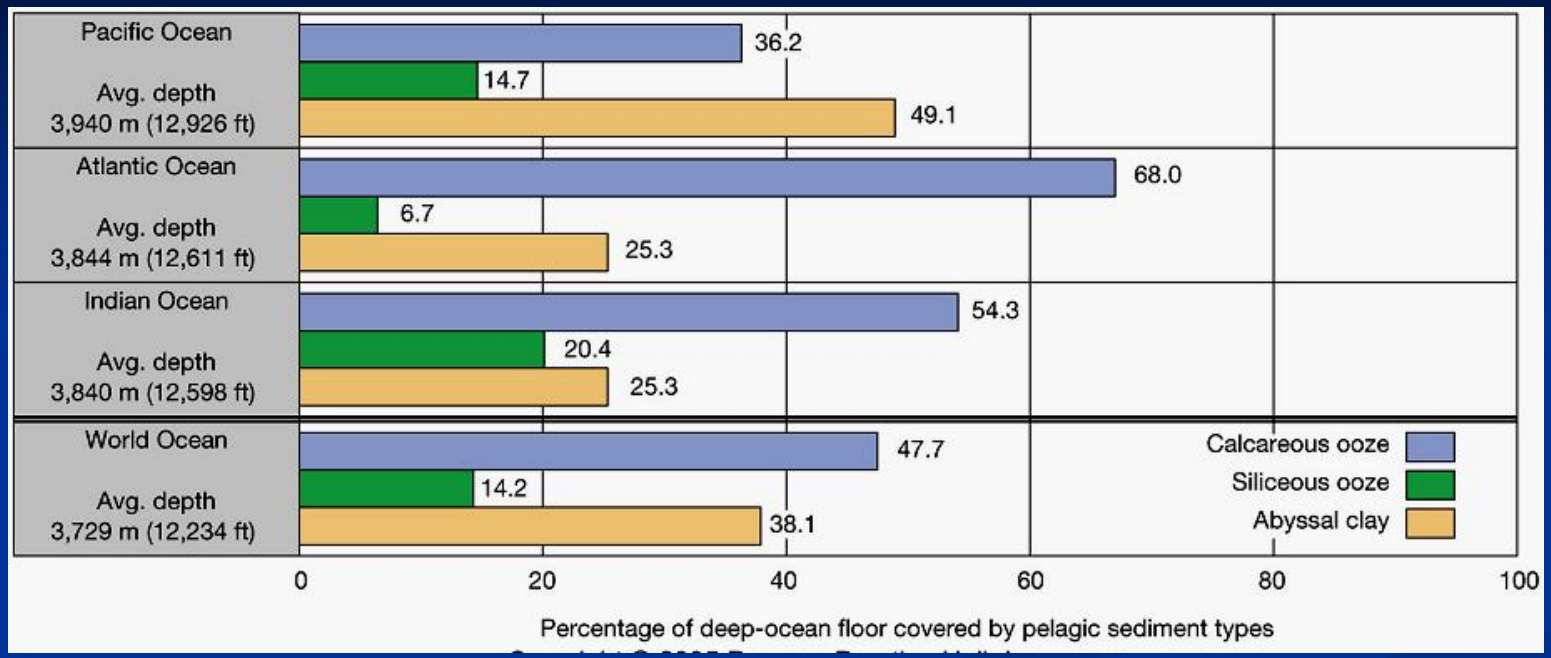


Figure 1.4 Distribution of dominant sediment types on the floor of the present-day oceans. Note that red clays are also terrigenous sediments.

Region	Percent of Ocean Area	Percent of Total Volume of Marine Sediments	Average Thickness
Continental shelves	9%	15%	2.5 km (1.6 mi)
Continental slopes	6%	41%	9 km (5.6 mi)
Continental rises	6%	31%	8 km (5 mi)
Deep-ocean *floor*	78%	13%	0.6 km (0.4 mi)

Percentage Distribution of Pelagic Sediments



1) **Calcareous Oozes** = covers **48%** of deep seafloor

2) **Siliceous Oozes** = covers **15%** of deep seafloor

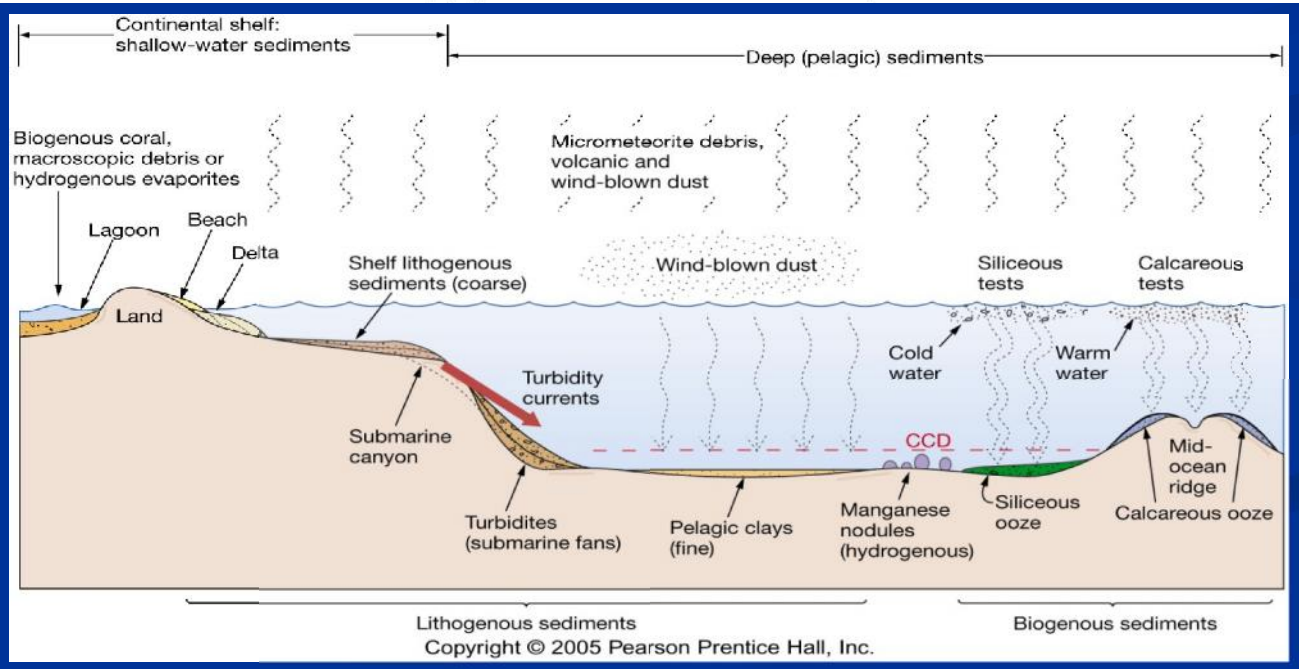
3) **Abyssal Clays** = covers **38%** of deep seafloor

Note the variation in the proportions of the three pelagic sediment types from one ocean basin to another

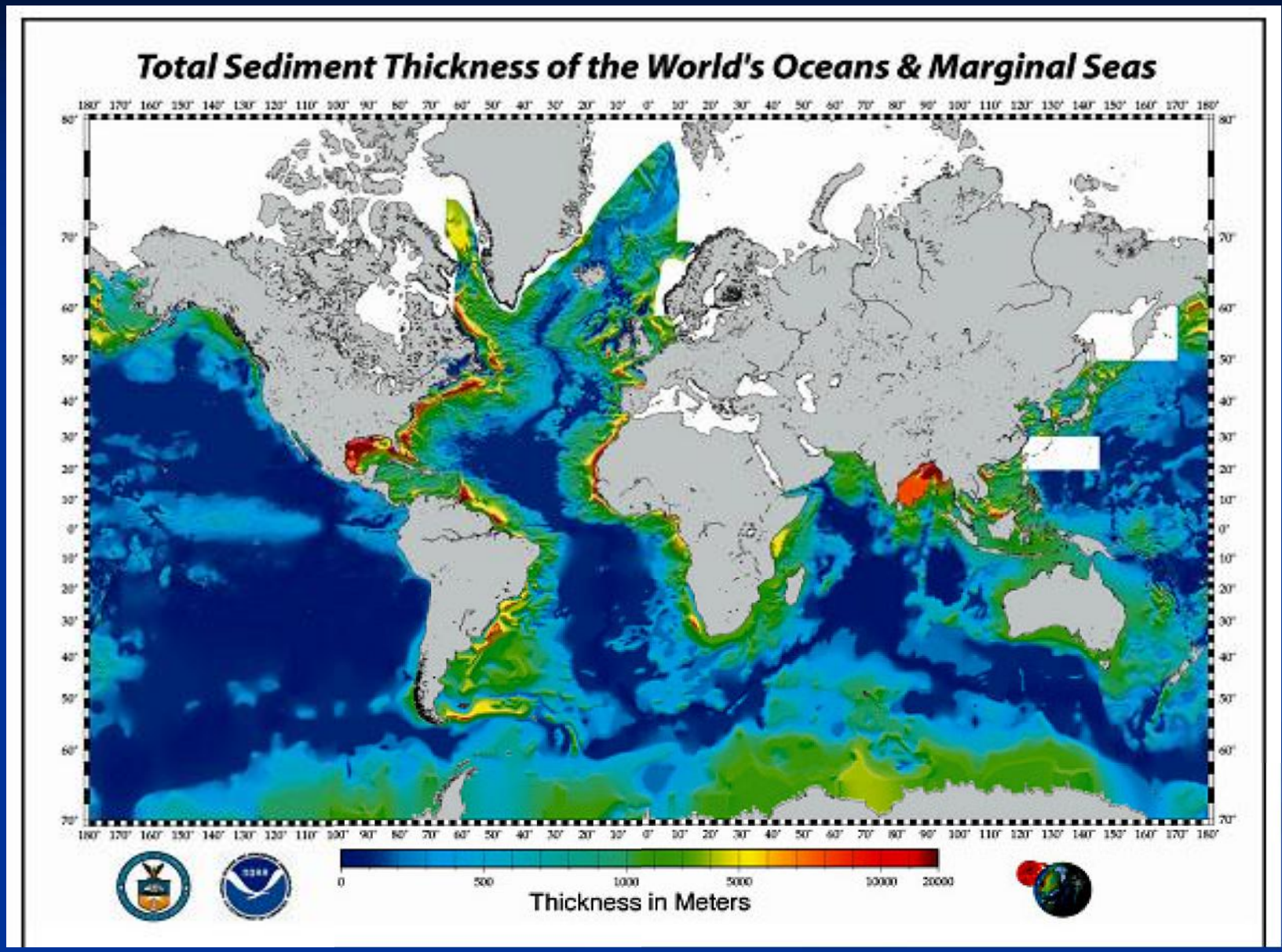
Rates of Deposition of Marine Sediments

Table 4.4 Average rates of deposition of selected marine sediments.

Type of sediment/deposit	*Average rate of deposition (per 1000 years)*	*Thickness of deposit after 1000 years equivalent to . . .*
Coarse lithogenous sediment, neritic deposit	1 meter (3.3 feet)	A meter stick
Biogenous ooze, pelagic deposit	1 centimeter (0.4 inch)	The diameter of a dime
Abyssal clay, pelagic deposit	1 millimeter (0.04 inch)	The thickness of a dime
Manganese nodule, pelagic deposit	0.001 millimeter (0.00004 inch)	A microscopic dust particle



Sediment Pile Thickness on Ocean Bottoms



MARINE SEDIMENTS

Discussion