OCN 201: Deep-Sea Sediments

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Where is the Sediment?

- Continental Margins: 87% (covers ~21% of ocean area)
- Deep-ocean floor: 13%

Table 5.3 The Distribution and Average Thickness of Marine Sediments

Region	Percent of Ocean Area		Percent of Total Volume of Marine Sediments		Average Thickness
Continental shelves	9	~21%	15	~87%	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)

Sources: Emery in Kennett, *Marine Geology*, 1982 (Table 11-1); Weihaupt, *Exploration of the Oceans*, 1979; Sverdrup, Johnson, and Fleming, *The Oceans: Their Physics, Chemistry, and General Biology*, 1942

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Sediment Deposition Rates
(time to deposit 1 cm on seafloor)

- Terrigenous Deposits
  - Ala Wai Canal 3-6 mo
  - Near large rivers 1-10 yr
  - Continental Shelf 30 yr
  - Continental Rise 100 yr
- Pelagic Deposits
  - Biogenic sediment 200-1000 yr
  - Abyssal Clay 2000-10000 yr
  - Mn nodules/crusts >1 M year

Sediment Classification Schemes

- Size
- Mode of formation (chemical vs detrital)
- Location (and source)
- Degree of lithification (hardness)

Classification by ***Size***

Table 5.1 Particle Sizes and Settling Rate in Sediment

Type of Particle	Diameter	Settling Velocity in Still Water	Time to Settle 4 km (2.5 mi)
Boulder	>256 mm (10 in.)	—	—
Cobble	64–256 mm (>2 $\frac{1}{2}$ in.)	—	—
Pebble	4–64 mm ($\frac{1}{6}$–2 $\frac{1}{2}$ in.)	—	—
Granule	2–4 mm ($\frac{1}{12}$–$\frac{1}{6}$ in.)	—	—
Sand	0.062–2 mm	2.5 cm/sec (1 in./sec)	1.8 days
Silt	0.004–0.062 mm	0.025 cm/sec ($\frac{1}{100}$ in./sec)	6 months
Clay	<0.004 mm	0.00025 cm/sec	50 years[a]

[a] Though the theoretical settling time for individual clay particles is usually very long, under certain conditions clay particles in the ocean can interact chemically with seawater, clump together, and fall at a faster rate. Small biogenous particles are often compressed by organisms into fecal pellets that can fall more rapidly than would otherwise be possible. A fecal pellet is shown in Figure 5.16.

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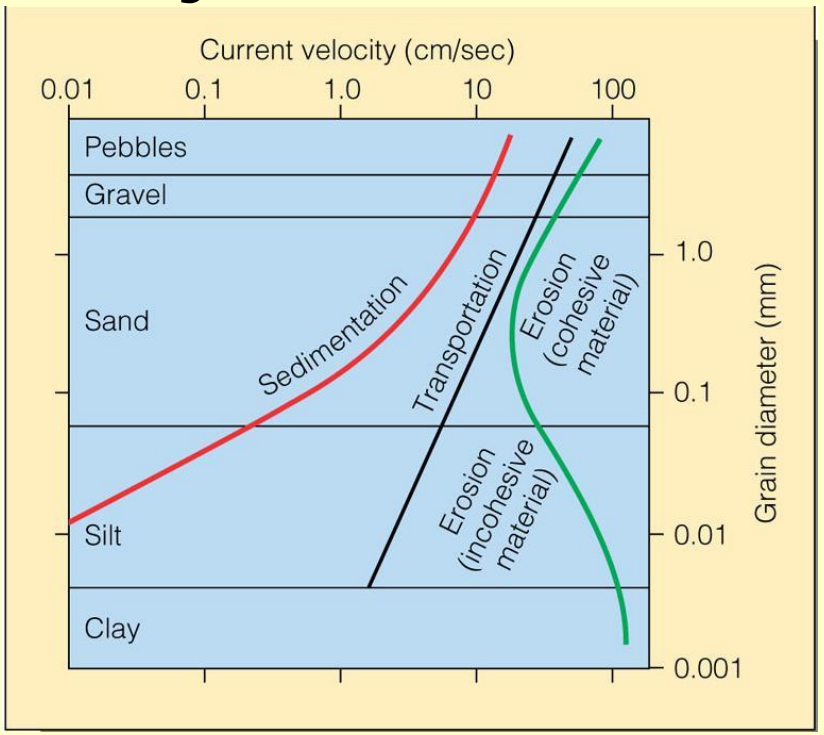


- Large particles settle fast, small particles settle slowly
- Weak currents move small particles, stronger currents are needed for larger particles
- Velocity of currents vs. erosion rate of sediments

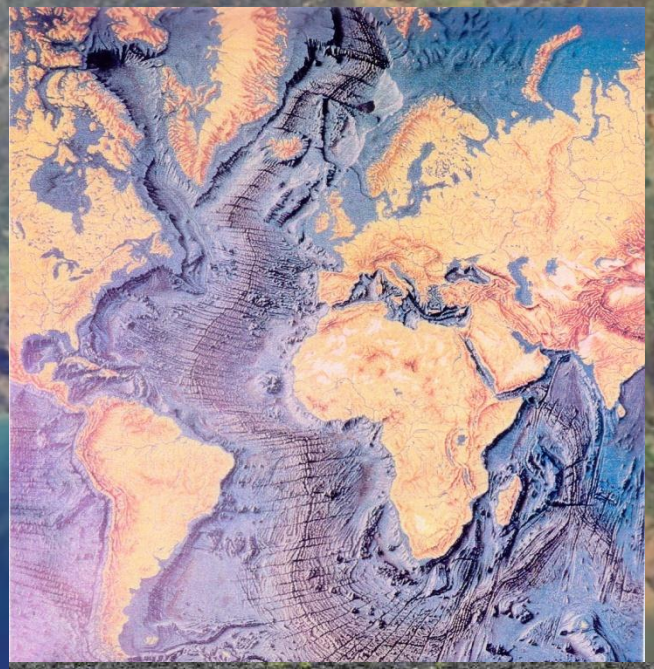
Types of ***Detrital*** Sediments

- Terrigenous: from land and transported by…
  - Rivers (to continental margins only, accumulated since last glacial period)
  - Turbidity currents (= mudslides, graded deposits)
  - Wind
  - Floating ice (“ice rafted”, poorly sorted)
- Biogenous
- Cosmogenous
- Hydrothermal

Sediment from Rivers

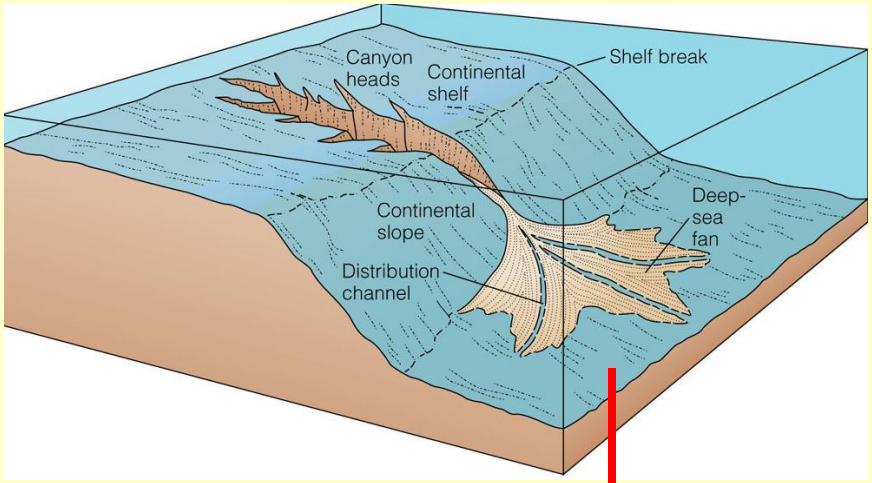
Three rivers account for most of sediment input to Atlantic Ocean

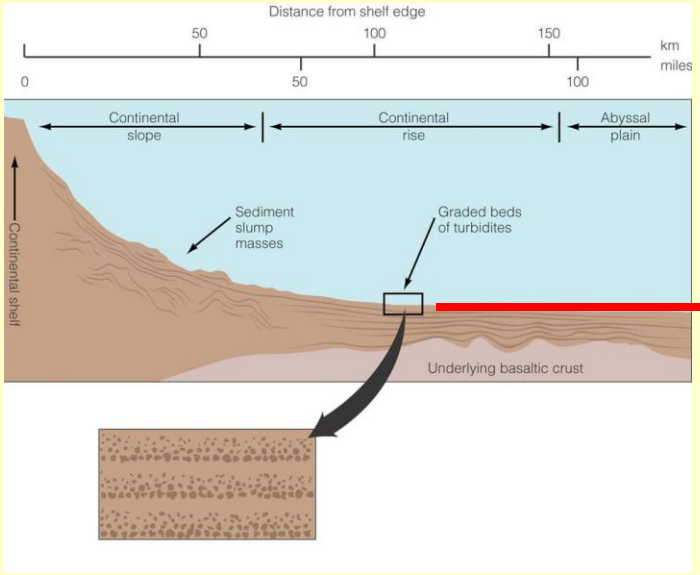
- Amazon, Congo, & Mississippi

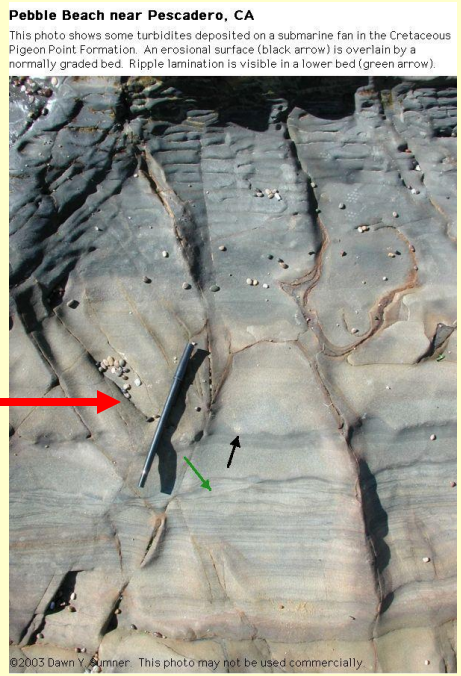


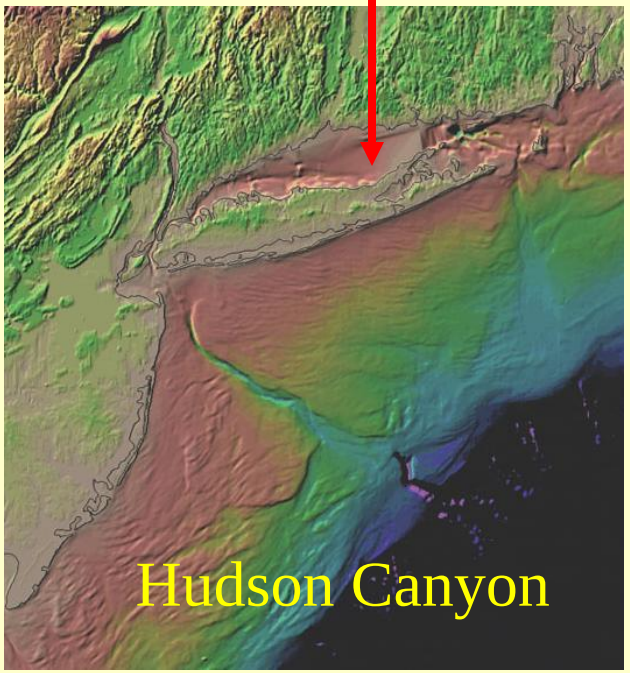
Turbidity Currents

- Density driven mudslides off continental shelf
- Triggered by earthquakes or other physical disturbance
- Fast moving (multiple 100 km/hr), extend long distances
- Produce submarine canyons, fans and graded deposits



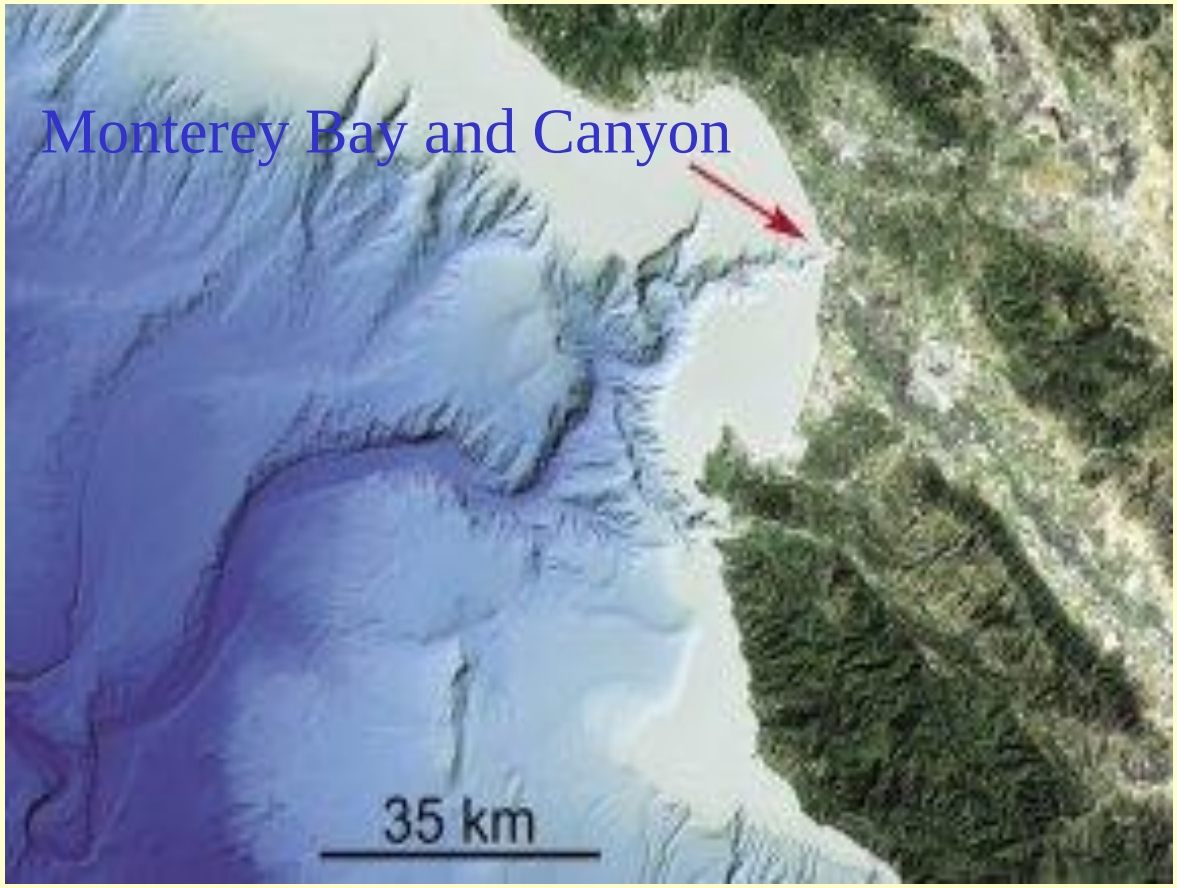




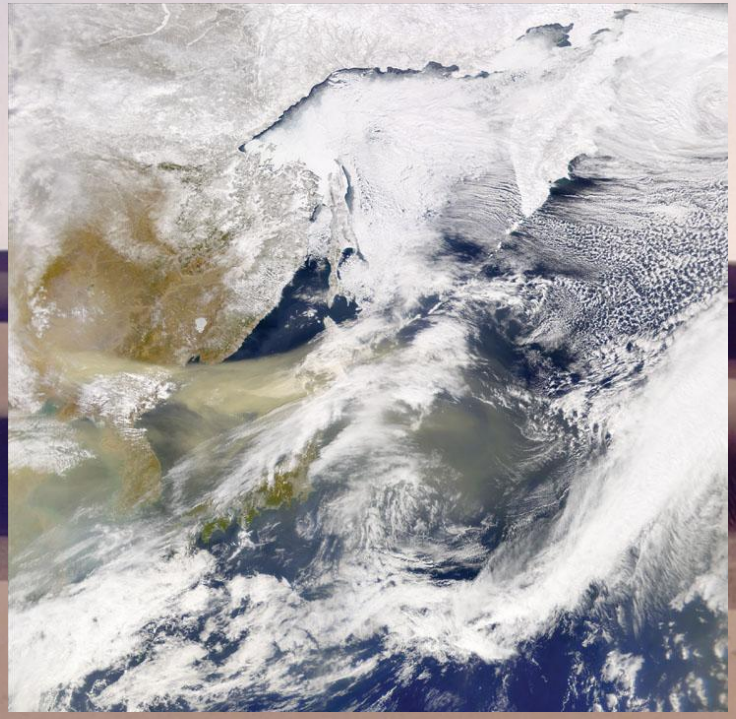


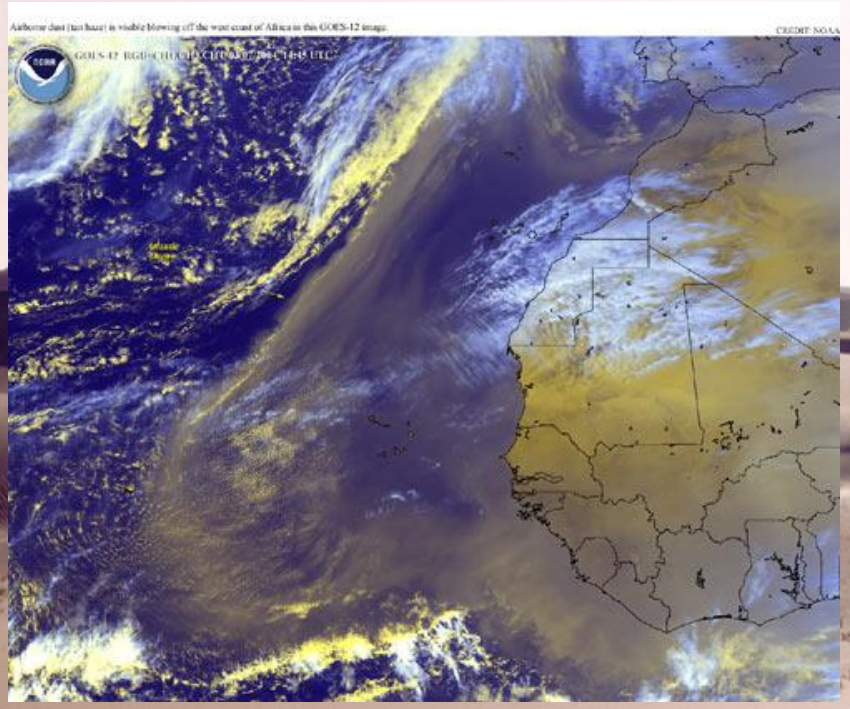
Hyperpycnal currents

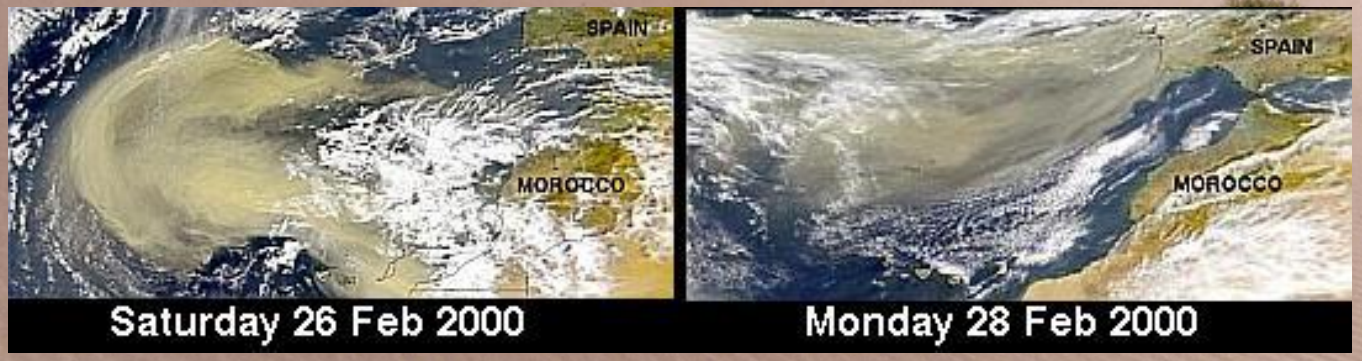
- Hyperpycnal currents: freshwater whose **density** is increased above saltwater by TSS load
- Are probably a major mechanism for transporting sediments from continents to the offshore seafloor



Sediment Carried by Wind



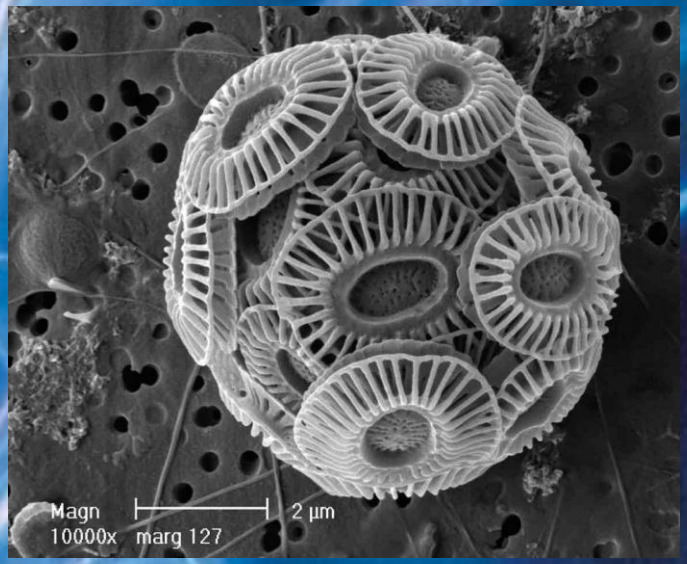


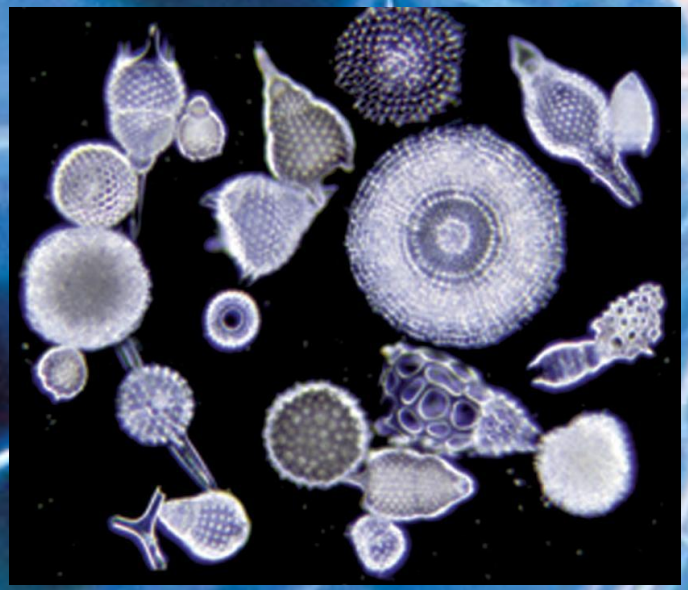


Ice Rafted Sediment

Biogenic Sediments

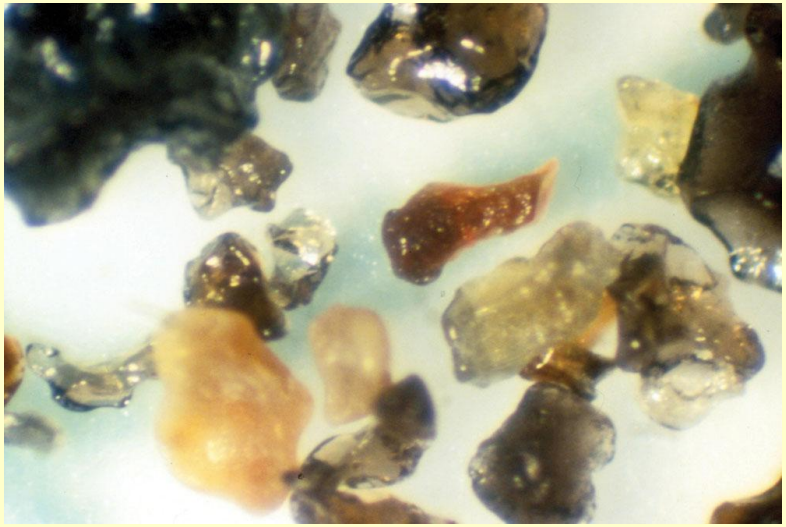
- From organisms: calcareous and siliceous





Other Detrital Sediments

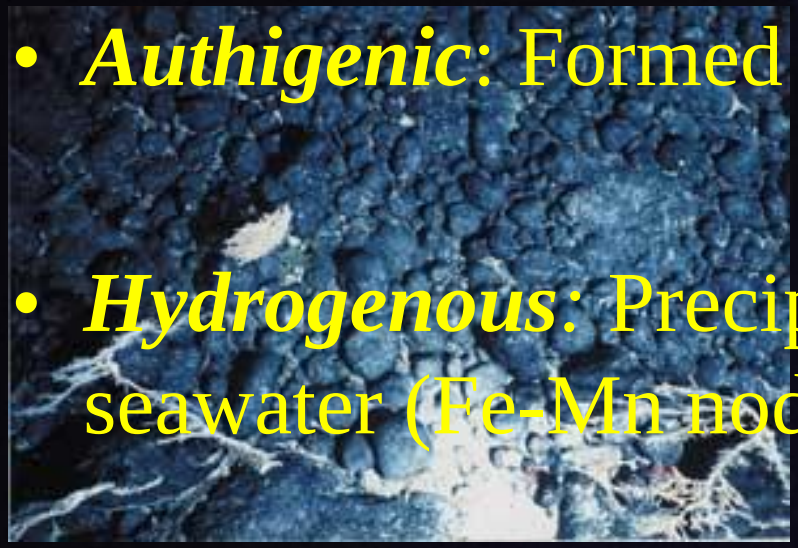
- **Cosmogenic:** From space (dust, tektites, Fe-Ni spherules)



- **Volcanogenic:** From volcanoes (note that these are also terrigenous)

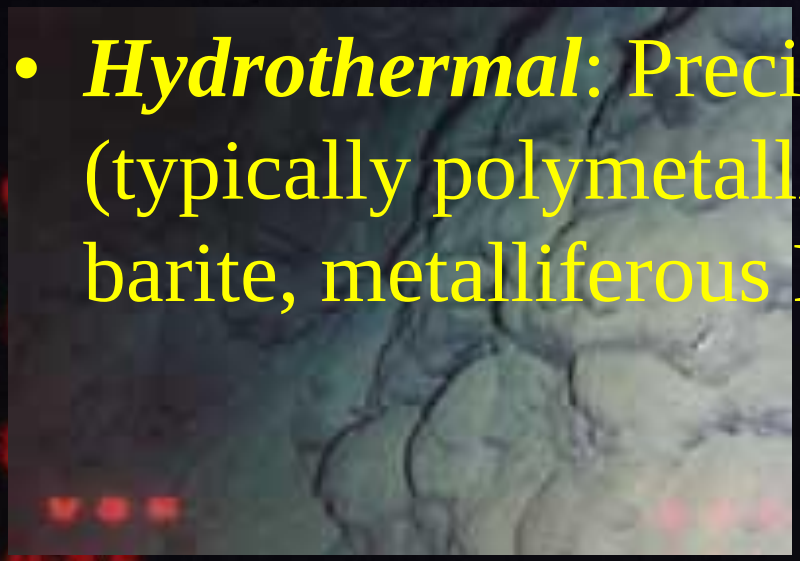
Pinatubo, Philippines

Chemically Derived Sediments



- ***Authigenic***: Formed in place, within sediment

- ***Hydrogenous:*** Precipitated directly from seawater (Fe-Mn nodules & crusts, Evaporites)



- ***Hydrothermal***: Precipitated from hot water (typically polymetallic sulfides, anhydrite, barite, metalliferous Fe-rich sediments)

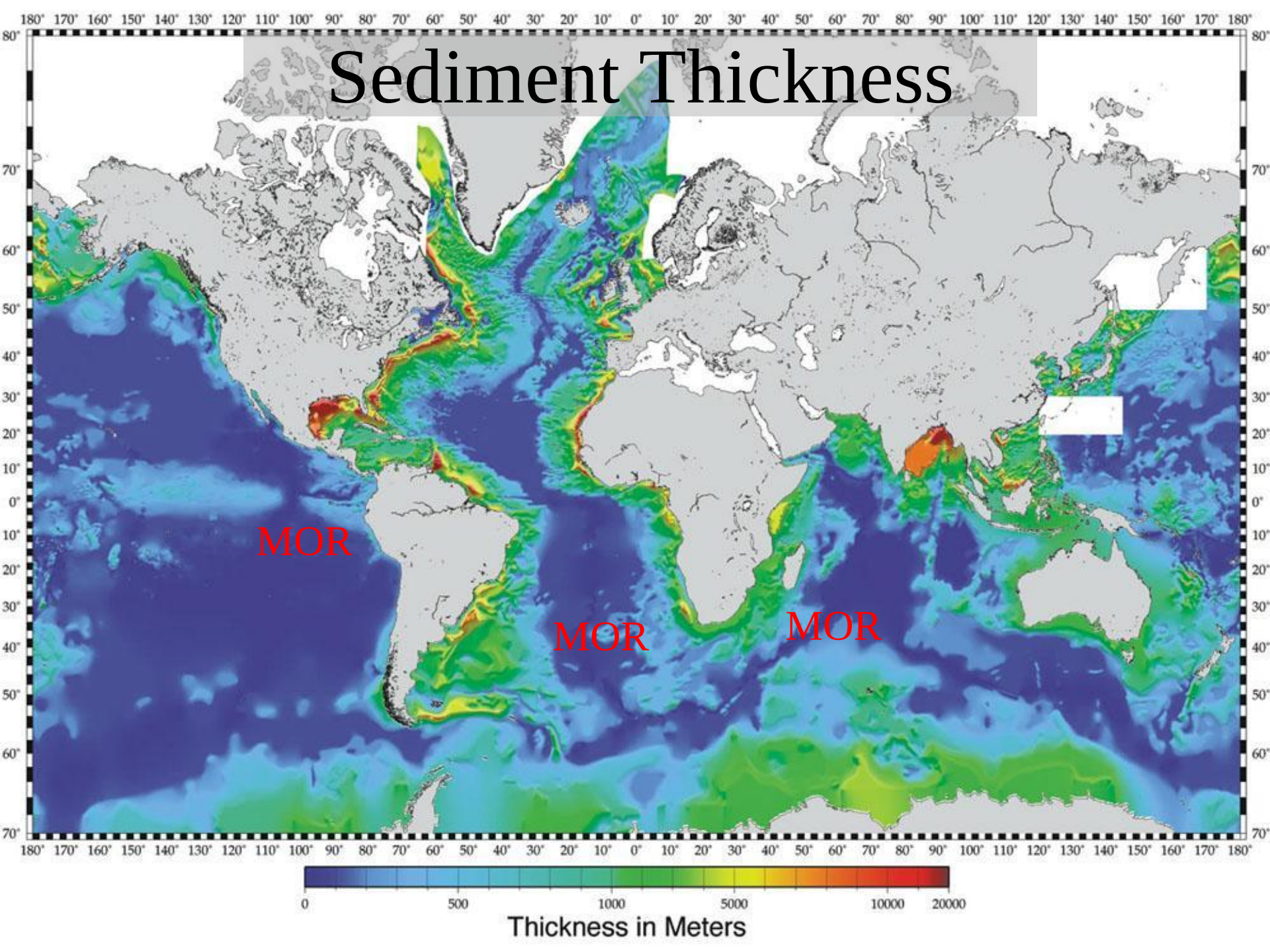
Classification by ***Location***

- **Pelagic**: Found in open ocean
- **Hemipelagic**: Oceanic but near land (>25% terrigenous component)
- **Neritic**: Nearshore, continental shelf

Classification by Degree of *Lithification*

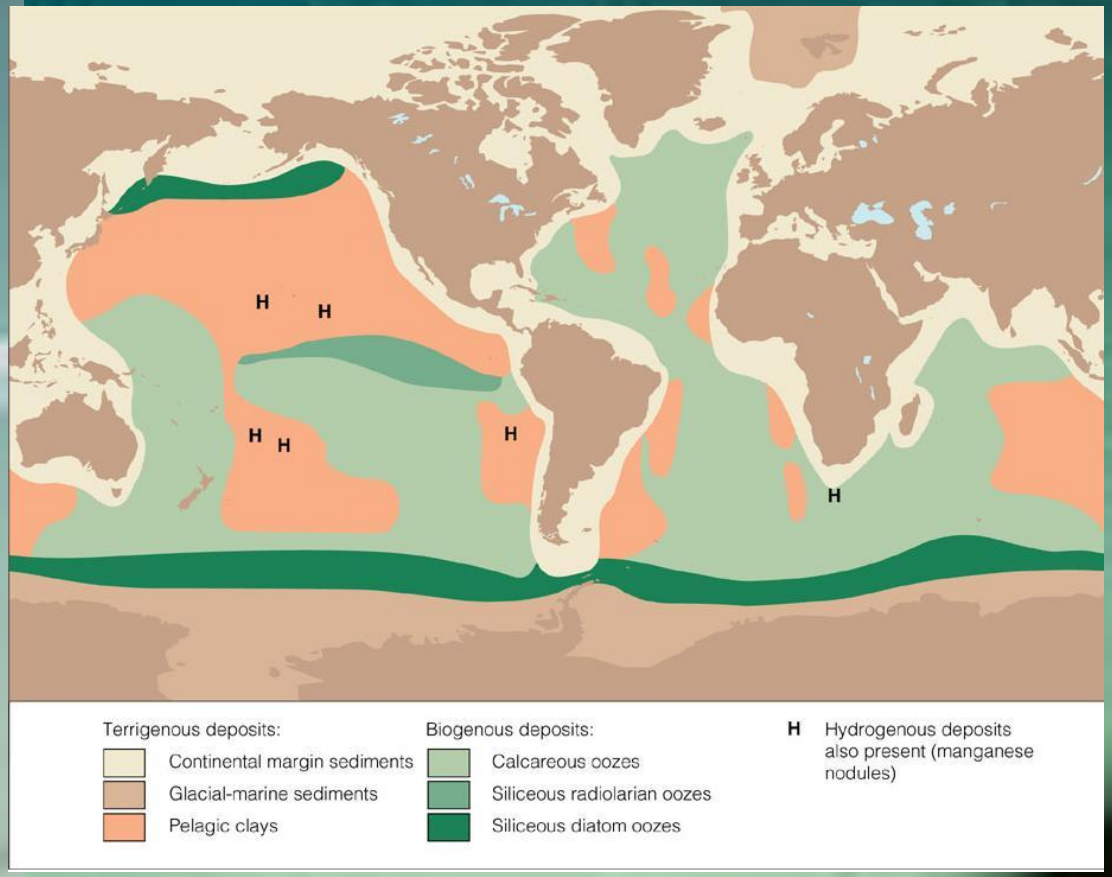
- **Ooze**: calcareous or siliceous
- **Chalk**: calcareous (soft rock)
- **Limestone**: calcareous rock
- **Chert**: siliceous rock

Sediment Thickness

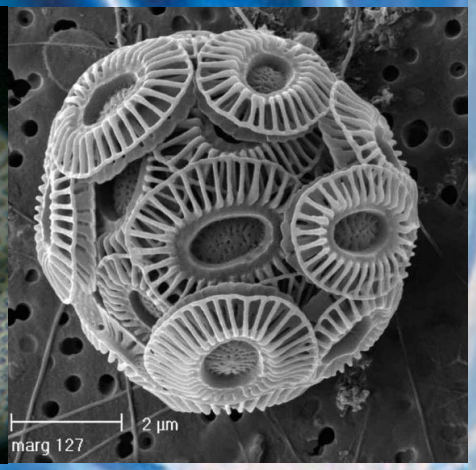


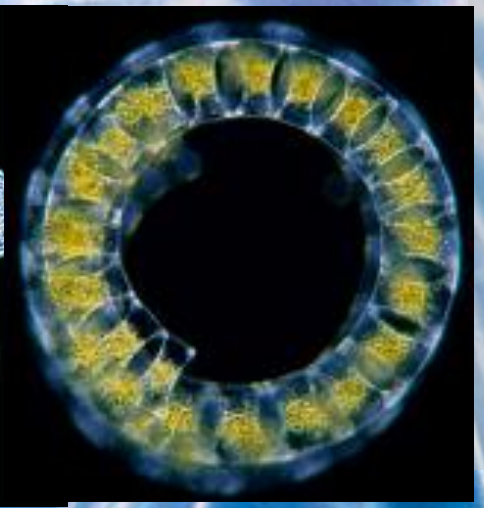
Distribution of Deep-Sea Sediment

- Mean thickness
  - –Atlantic: 1000 m, rivers
  - –Pacific: <500m, starved because of narrow cont. margins, marginal seas
- Nearly all sediments are mixtures
- Three dominant components…



Primary Sediment Components





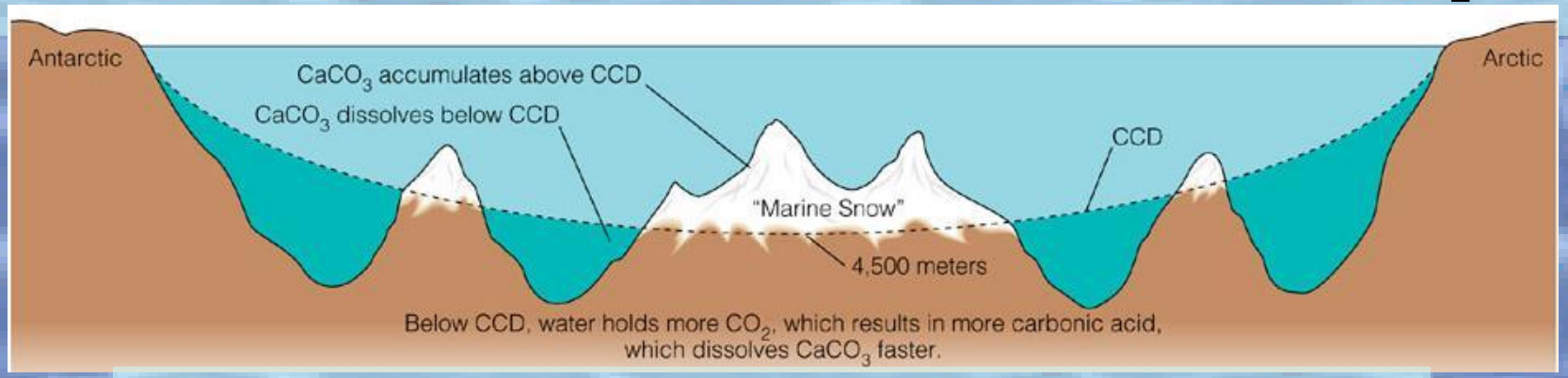
- Calcareous Oozes **48%**
  - Foraminifera (protozoa)
  - Nannofossils (algae)
  - Pteropods (planktonic mollusks, aragonite)
- Abyssal Clay **38%**
- Siliceoous Ooze **14%**
  - Radiolarians (protozoa, common near equator)
  - Diatoms (algae, very common near Antarctica)

Organisms Contributing to Biogenic Sediments

Composition	Plant	Animal
$CaCO_3$	**Coccolithophores**	**Foraminifera**
SiO_2	**Diatoms**	**Radiolaria**

Carbonate Compensation Depth: I

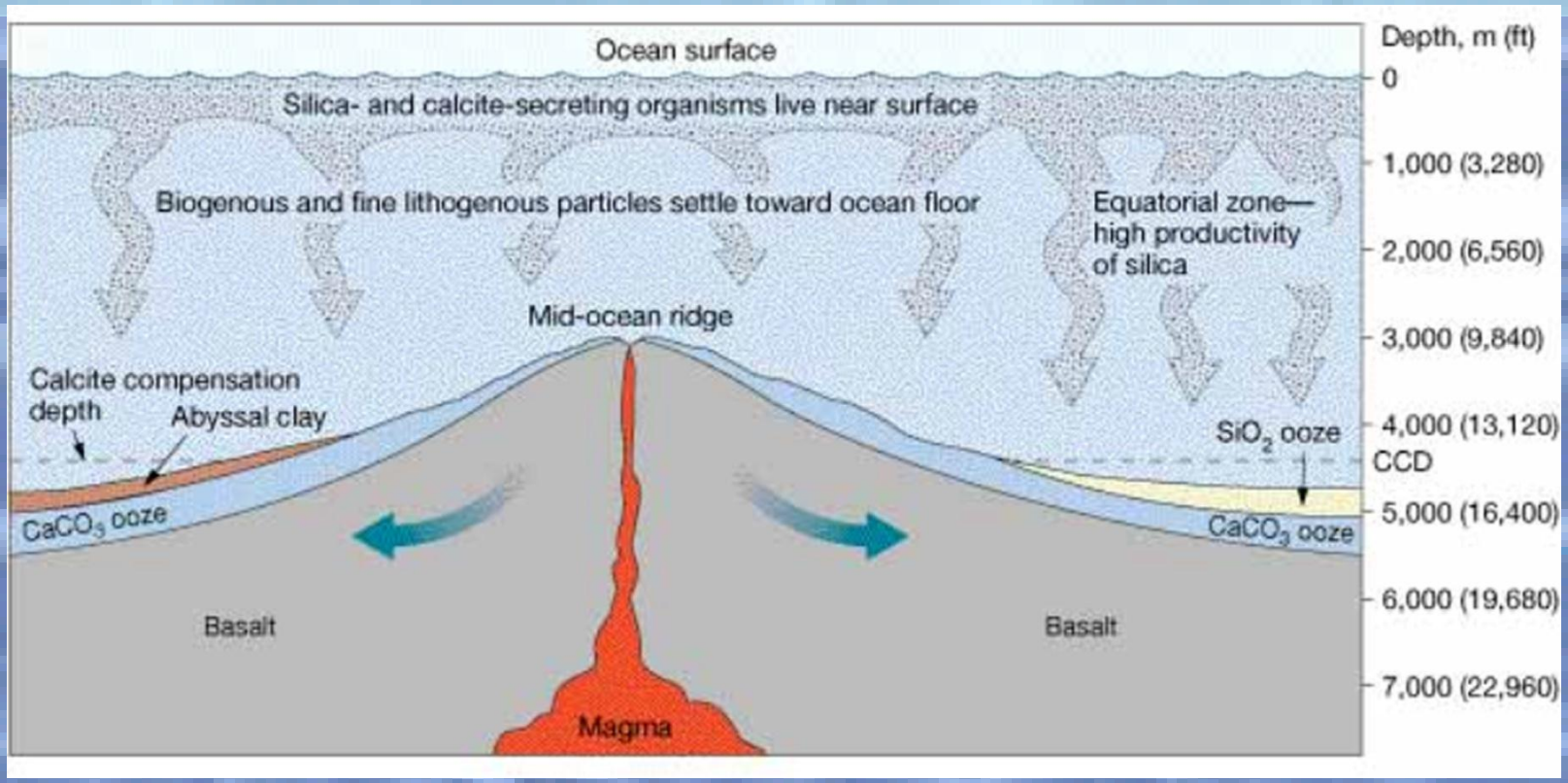
- $CaCO_3$ is more soluble in deeper colder water
- At the CCD, for $CaCO_3$ sediment:
  - **Sedimentation rate = Dissolution rate**
  - i.e., $CaCO_3$ dissolves as fast as it accumulates
  - **None accumulates in sediment below this depth**



Does previously deposited $CaCO_3$ "buried" by rain of SiO_2 sediment dissolve too?

Carbonate Compensation Depth: II

$CaCO_3$ sediment deposited previously and now "buried" by rain of SiO_2 sediment can "survive" dissolution below the CCD

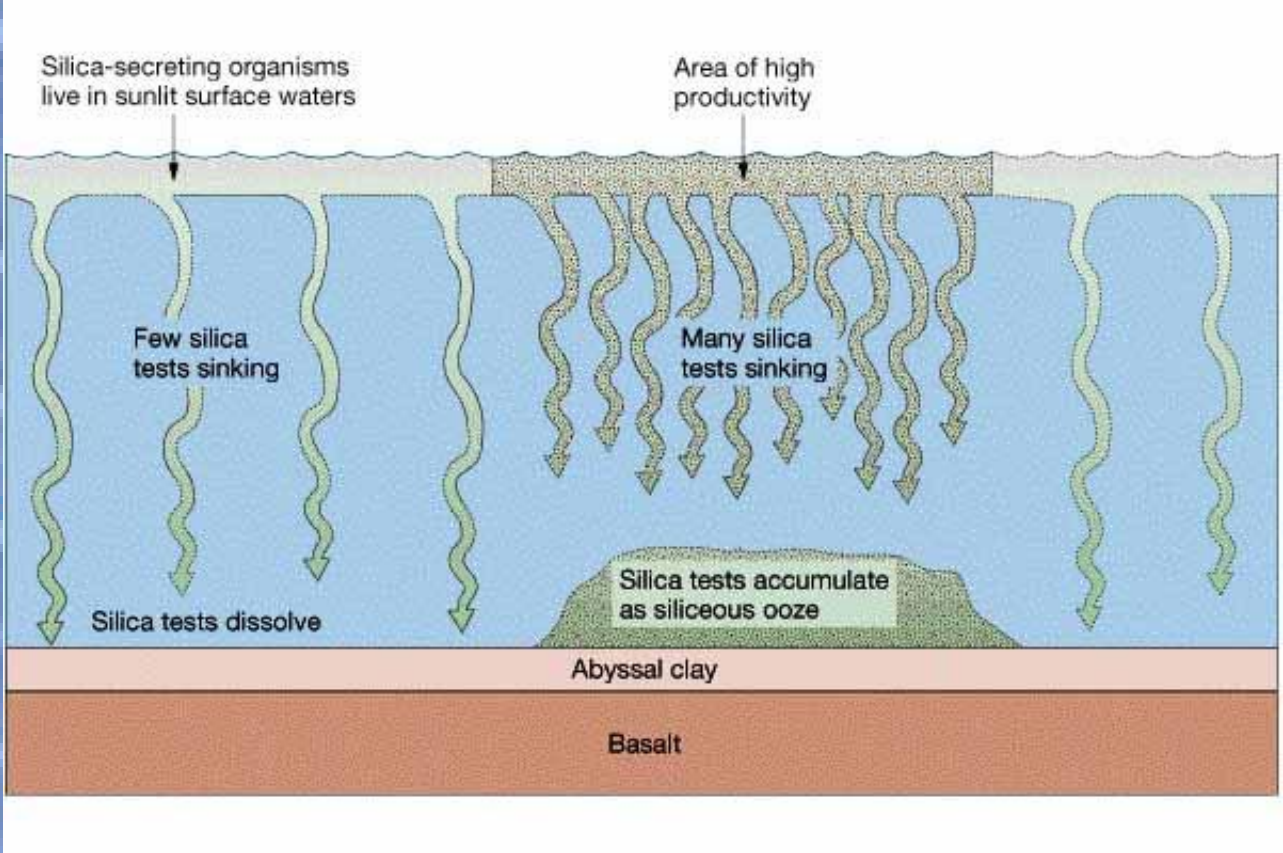


What are implications of ocean acidification from CO_2?

Supply vs Dissolution

Supply (Flux) of particles is important to accumulation

Areas of high productivity (equatorial, polar) have large particle fluxes which lead to accumulation



Summary Sediment Distribution

Table 5.2 Classification of Marine Sediments by Source of Particles

Sediment Type	Source	Examples	Distribution	Percent of All Ocean Floor Area Covered
Terrigenous	Erosion of land, volcanic eruptions, blown dust	Quartz sand, clays, estuarine mud	Dominant on continental margins, abyssal plains, polar ocean floors	~45%
Biogenous	Organic; accumulation of hard parts of some marine organisms	Calcareous and siliceous oozes	Dominant on deep-ocean floor (siliceous ooze below about 5 km)	~55%
Hydrogenous (authigenic)	Precipitation of dissolved minerals from water, often by bacteria	Manganese nodules, phosphorite deposits	Present with other, more dominant sediments	<1%
Cosmogenous	Dust from space, meteorite debris	Tektite spheres, glassy nodules	Mixed in very small proportion with more dominant sediments	<<1%

Sources: Kennett, *Marine Geology*, 1982; Weihaupt, *Exploration of the Oceans*, 1979; Sverdrup, Johnson, and Fleming, *The Oceans: Their Physics, Chemistry, and General Biology*, 1942.

Important table from your book… review it for exam