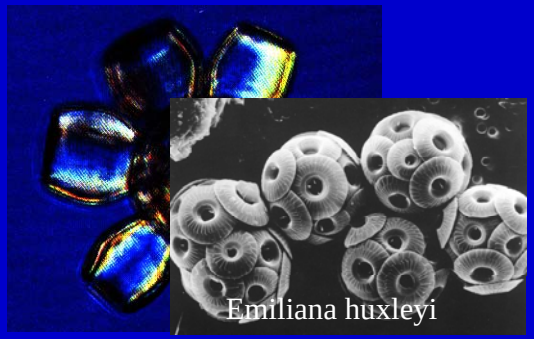
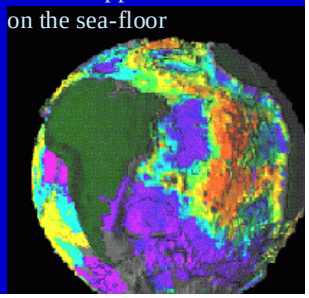
Biogenous sediment

Coccolithophorids, phytoplankton that carry calcite platelets on the cell wall (coccoliths) is most common in oligotrophic open ocean environments. The coccoliths accumulate in the sediments, where they form the main constituent of carbonate oozes.



Scyphosphaera apsteinii, diameter <20 µm

'Snow-capped' mountains on the sea-floor



Biogenous sediment

Biogenous ooze turns to rock

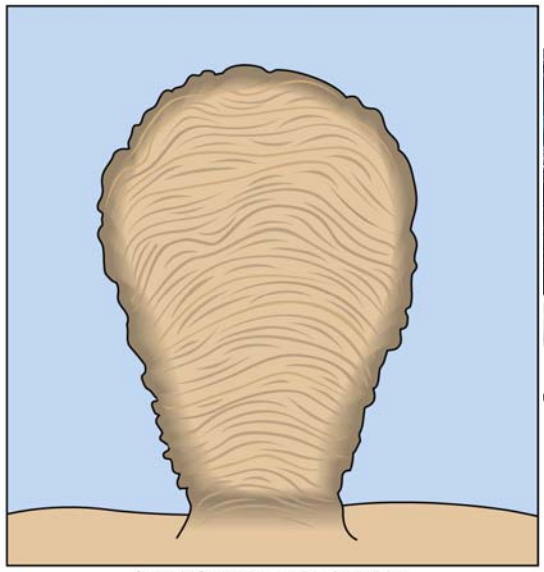
White cliffs of Dover (England) are made up of **lithified carbonate** from **coccolithophorids** = **chalk** which was deposited on the seafloor and then uplifted during the **Cretaceous**

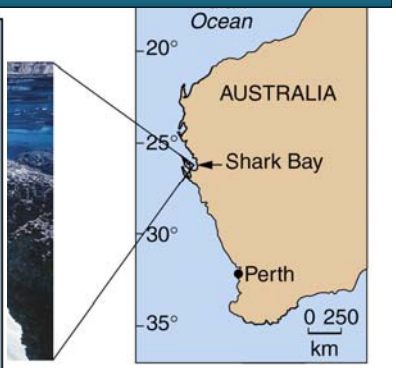
Biogenous sediment

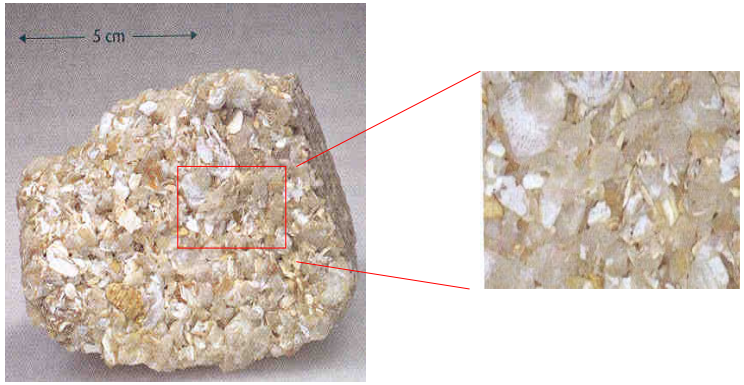
Other marine calcium carbonate producing organisms, mainly shallow seas, tropical to subtropical

- stromatolites = layering and sediment trapping by cyanobacteria and other algae, precipitation of calcium carbonate, very important reef builders 1-3 Ga ago, today in hypersaline environments
- corals (Reef builders)
- clams

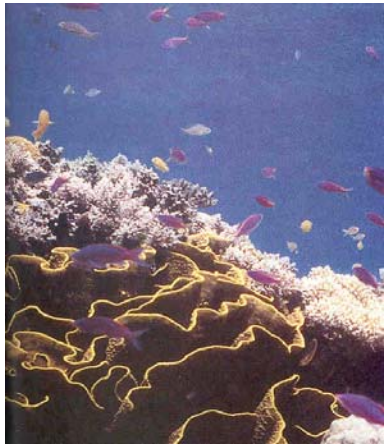
Biogenous sediment:Stromatolites







❖ coquina (rock of shell fragments)



Coral reef

limestone mountain

The 4 main types of sediment

1. **Lithogenous** = weathered fragments of preexisting rock, transported to the ocean by rivers, glaciers or wind
2. **Biogenous** = composed of hard remains of once-living organisms
3. **Hydrogenous** = formed when dissolved materials come out of solution (precipitate)
4. **Cosmogenous** = derived from outer space

Hydrogenous sediment

Origin of hydrogenous sediment

- Hydrogenous sediment forms when dissolved materials come out of solution (precipitate)
- Precipitation is caused by a change in conditions including:
  - Changes in temperature
  - Changes in pressure
  - Addition of chemically active fluids

Biogenous sediment

Types of hydrogenous sediment

- Evaporite salts
- Ooids
- Manganese nodules
- Phosphorites (Apatite= calcium phosphate), high productivity cont. shelves and slopes
- Metal sulfides (hydrothermal vent environment)

Hydrogenous sediment

- **Evaporite** minerals accumulate in areas where evaporation exceeds water supply such in evaporative basins, Salinas, or tidal flats, or remnants of ancient shallow oceans.
- **Evaporite** minerals precipitate in the following order: calcite and aragonite ($CaCO_3$, 90% water remaining), gypsum ($CaSO_4$, 50%), halite (NaCl,10 %) and finally bitter salts.

Hydrogenous sediment

Ooids

- Spheres of laminated calcium carbonate (about 2mm in size)
- Form sands in warm, shallow seas
- abiogenic precipitation (?)

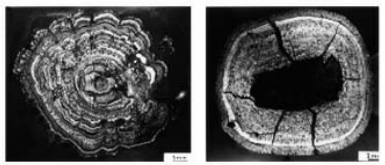
Manganese Nodules

(MnO_2, Fe_2O_3 + Cu, Co, Ni)

Mining of nodules

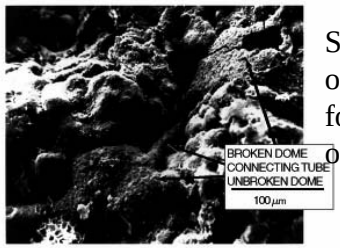
(a)

5-6. Manganese nodules on the Pacific Ocean Floor



(b)

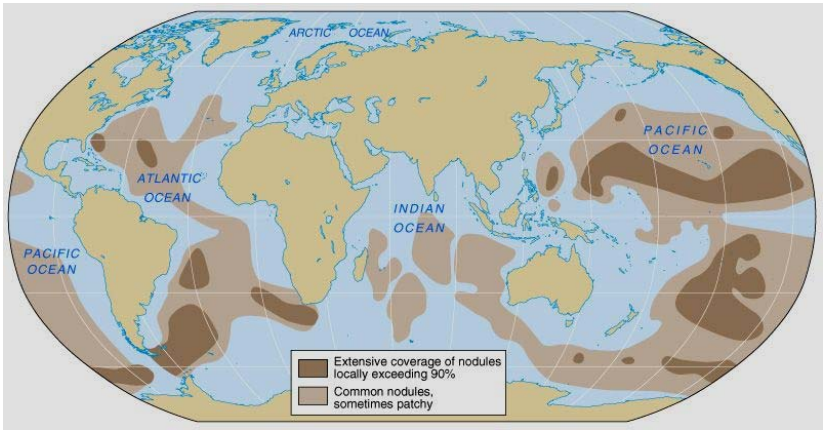
Cross section through a manganese nodu



(c)

SEM of the surface of a nodule, evidence for microbial mediatio of nodule formation?

Hydrogenous sediment



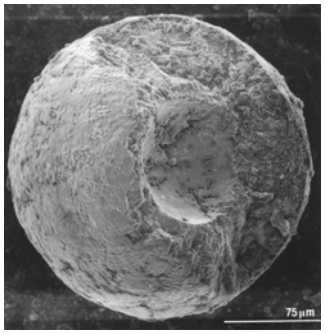
Manganese nodules distribution in the world ocean's. Accumulate in open ocean areas with low sedimentation rates.

The 4 main types of sediment

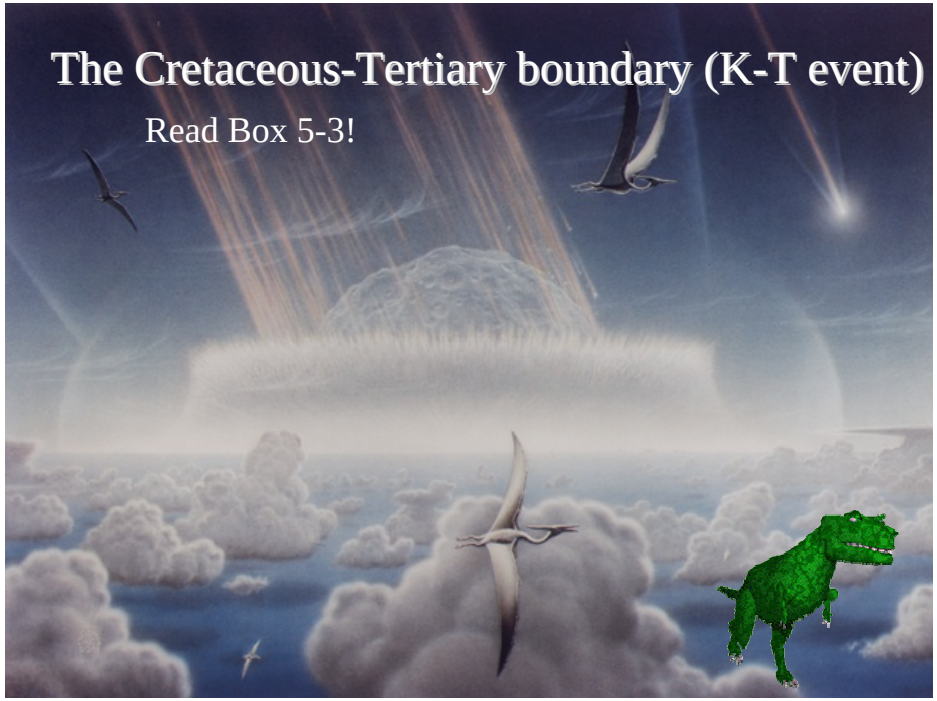
1. **Lithogenous** = weathered fragments of preexisting rock, transported to the ocean by rivers, glaciers or wind
2. **Biogenous** = composed of hard remains of once-living organisms
3. **Hydrogenous** = formed when dissolved materials come out of solution (precipitate)
4. **Cosmogenous** = derived from outer space

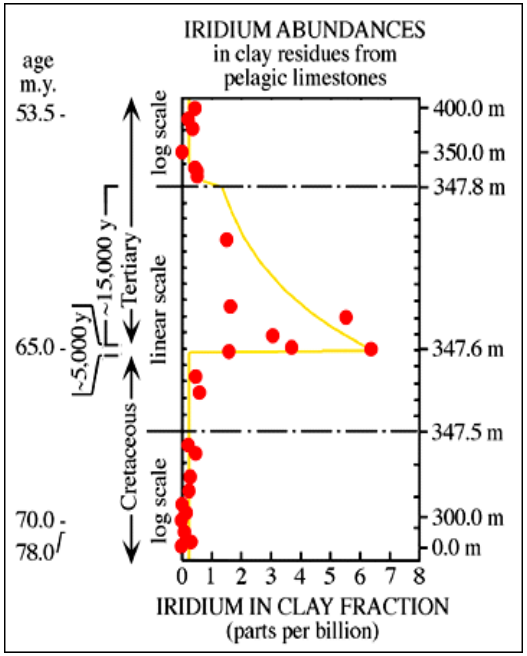
Cosmogenous sediment

- Cosmogenous sediment is composed of material derived from outer space
- Two main types:
  1. Microscopic space dust
  2. Macroscopic meteor debris
- Forms an insignificant proportion of ocean sediment



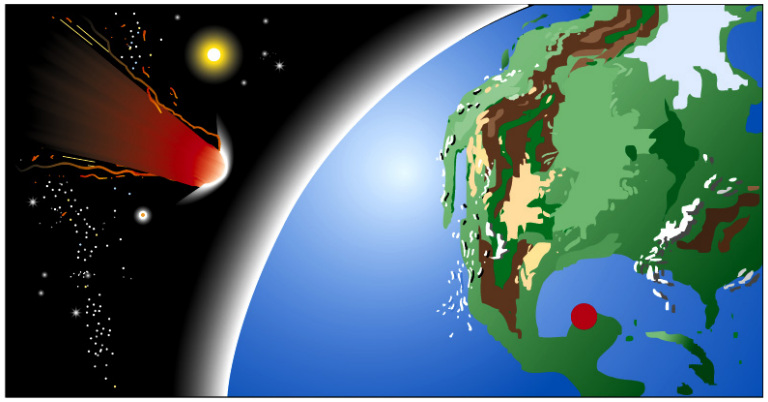
Microscopic cosmogenous spherule



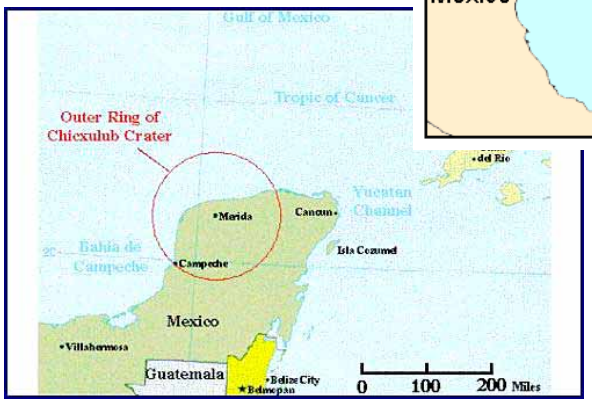


World-wide, a 1 cm layer of iridium was found in clay around the K-T boundary, first evidence of large meteorite impact

Where is the crater?

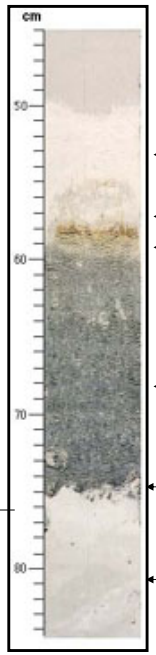


Chicxulub Crater off Yucatan, **180 km** in diameter, evidence for a 10 mile wide meteorite



BOX 5-3

Sediment core taken with drill-ship **Joides Resolution** in 1997 off Florida reveals first complete K-T deposits with meteor-debris



Tertiary

Cretaceous

- Only after 5000 yrs, biogenous sediment is being deposited
- "Strangelove" Ocean
- Fireball and fallout, iridium anomaly
- Impact ejecta, tektites, spherules, shocked quartz
- K-T Boundary
- Cretaceous microorganisms

TABLE 5-1 **Classification of marine sediments.**

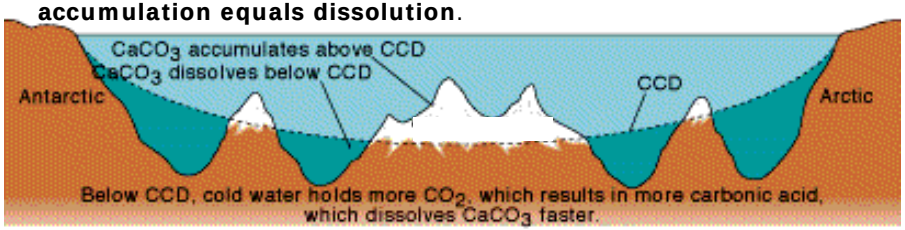
Type	Composition		Sources		Main locations found
Lithogenous	Continental Margin	Rock fragments Quartz sand Quartz silt Clay	Rivers; coastal erosion; landslides Glaciers Turbidity currents		Continental shelf Continental shelf in high latitudes Continental slope and rise; ocean basin margins
	Oceanic	Quartz silt Clay	Wind-blown dust; rivers		Deep-ocean basins
		Volcanic ash	Volcanic eruptions		
Biogenous	Calcium carbonate ($CaCO_3$)	Calcareous ooze (microscopic)	Warm surface water	Coccolithophores (algae); Foraminifers (protozoans)	Low-latitude regions; sea floor above CCD; along mid-ocean ridges & the tops o volcanic peaks
		Shell/coral fragments (macroscopic)		Macroscopic shell-producing organisms	Continental shelf; beaches
				Coral reefs	Shallow low-latitude regions
	Silica	Siliceous ooze	Cold surface water	Diatoms (algae); Radiolarians (protozoans)	High-latitude regions; sea floor below CCD; surface current divergence near theEquator
Hydrogenous		Manganese nodules (manganese, iron, copper, nickel, cobalt)	Precipitation of dissolved materials directly from seawater due to chemical reactions		Abyssal plain
		Phosphorite (phosphorous)			Continental shelf
		Oolites ($CaCO_3$)			Shallow shelf in low-latitude regions
		Metal sulfides (iron, nickel, copper, zinc, silver)			Hydrothermal vents at mid-ocean ridges
		Evaporites (gypsum, halite, other salts)			Shallow restricted basins where evaporation is high in low-latitude regions
Cosmogenous		Iron-nickel spherules Tektites (silica glass)	Space dust		In very small proportions mixed with all types of sediment and in all marine environments
		Iron-nickel meteorites Silicate chondrites	Meteors		Localized near meteor impact structures

Distribution of biogenous ooze

- Most biogenous ooze found as pelagic deposits
- Factors affecting the distribution of biogenous ooze:
  - Productivity (amount of organisms in surface waters)
  - Destruction (dissolving at depth)
  - Dilution (mixing with lithogenous clays once on floor)

Distribution of biogenous ooze

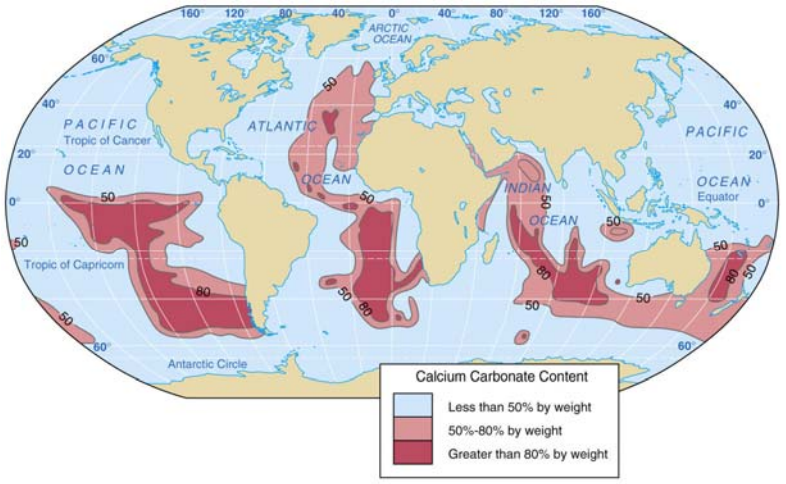
- Calcium carbonate dissolves in the water column below a certain depth, which is called is depth **Calcium Carbonate Compensation Depth (CCD)**
- Deeper water is more acidic because more CO_2 is dissolved from decay of organic matter, increasing the acidity of the water.
- At the **Calcium Carbonate Compensation Depth (CCD) accumulation equals dissolution**.



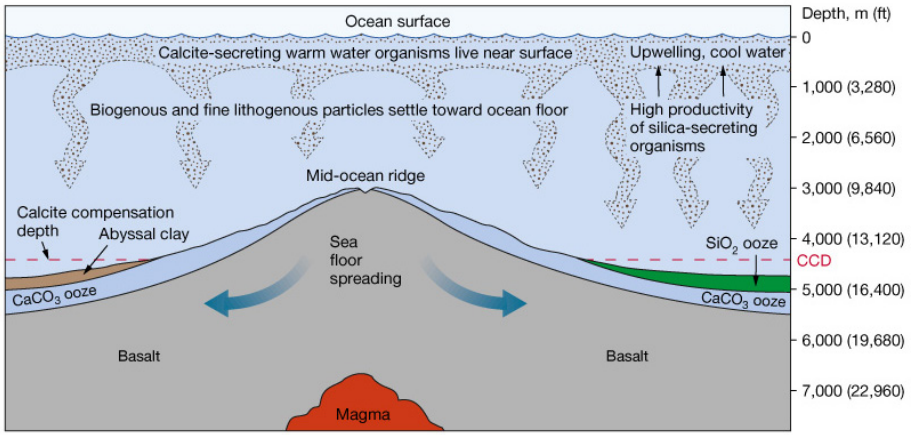
- Calcite dissolves beneath the calcite compensation depth (CCD) at 4.5 km
- Calcareous ooze can be found below the CCD if it is buried and transported to deep water

Distribution of biogenous ooze

Distribution of calcium carbonate in modern sediments



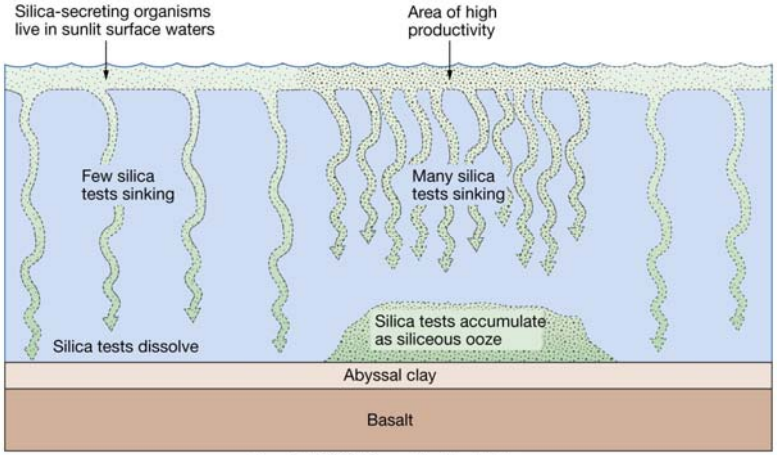
Distribution of biogenous ooze



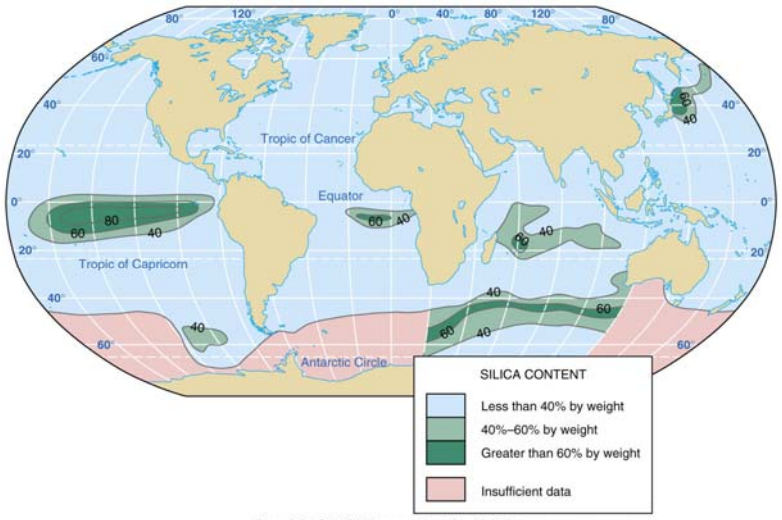
- Calcareous ooze accumulates on top of the mid-ocean ridge (or rise)
- As sea floor moves apart and becomes deeper than CCD, carbonate deposits are covered by either siliceous ooze (high production areas) or abyssal clay (open ocean basins away from high productivity).

Distribution of biogenous ooze

Siliceous ooze accumulates where production of silica-bearing plankton is highest



Distribution of biogenous ooze



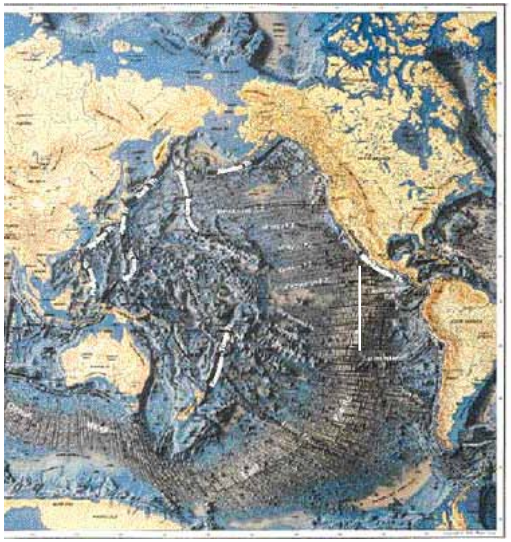
Distribution of biogenous ooze

Biogenous ooze as environmental indicator

TABLE 5-3 **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

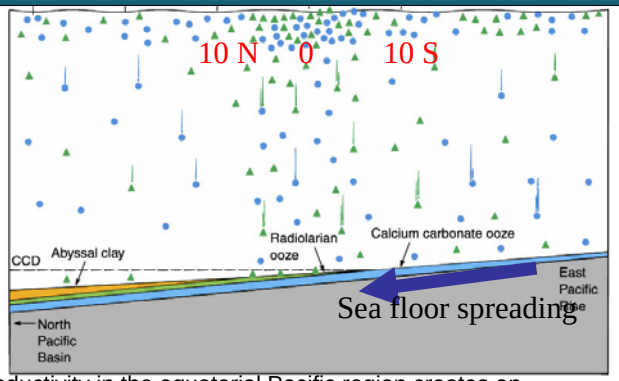
Distribution of biogenous ooze



Lets look at a transect of the sediments across the East Pacific Rise and across the equator.

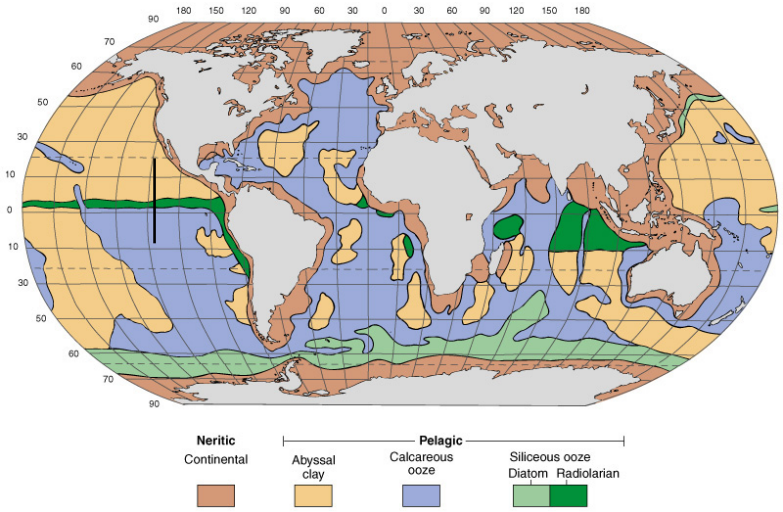
Distribution of biogenous ooze

North-South cross section through the East Pacific Equatorial Region



- High level of biological productivity in the equatorial Pacific region creates an unusually large supply of microscopic shells (from diatoms, radiolaria, coccolithophorids, foraminifera)
- South of the equator, ocean floor is above CCD and calcium carbonate accumulates
- North of the equator, the ocean floor deepens below CCD and sediment becomes siliceous.
- Further north, productivity is less and not enough biogenous particles reach the ocean floor to form an ooze, and the sediment is abyssal clay.

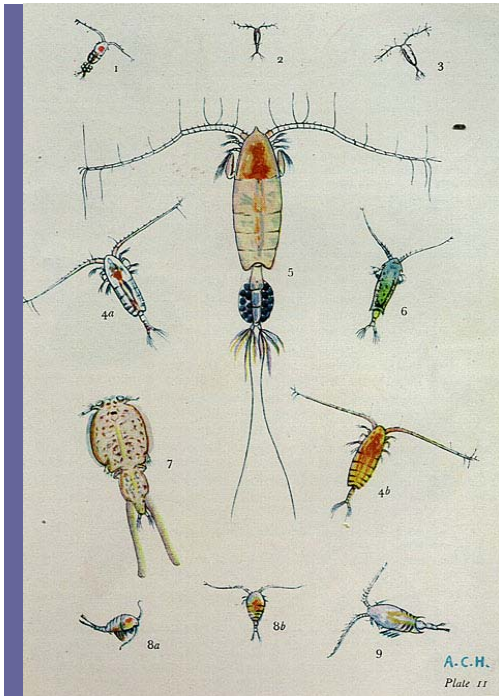
Distribution of biogenous ooze



5-23. Distribution of neritic (continental margin) and pelagic sediments (open ocean)

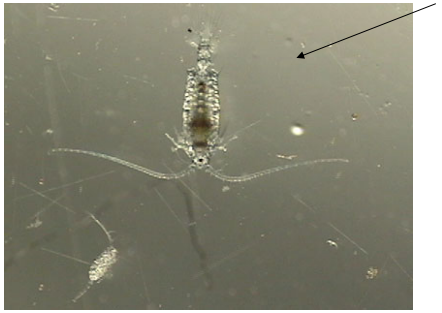
Deposition

How do we get particles to the ocean floor?



Copepods are segmented planktonic crustaceans, relatives of shrimps. They are very common and can make up 70% of net-collected plankton. They are from a few mm to 1 cm in size.

They produce **fecal pellets** which are major transport vehicles of particles through the water column and to the sediment. Depending on the diet, fecal pellets are stuffed with diatom frustules or coccoliths. Fecal pellets can sink several 100 m/day (see Fig. 4-20).



Copepod

Fecal pellets!

Particle Traps

Schematic drawing of a typical mooring with particle traps.

- Particles are caught in the Oceans with large funnels (particle traps).
- A wheel with bottles attached underneath is programmed to change every few days to weeks.
- This way particle flux can be measured in programmed intervals.