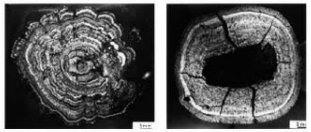
## Manganese Nodules

**($MnO_2$, $Fe_2O_3$ + Cu, Co, Ni)**

Mining of nodules

(a)

5-6. Manganese nodules on the Pacific Ocean Floor

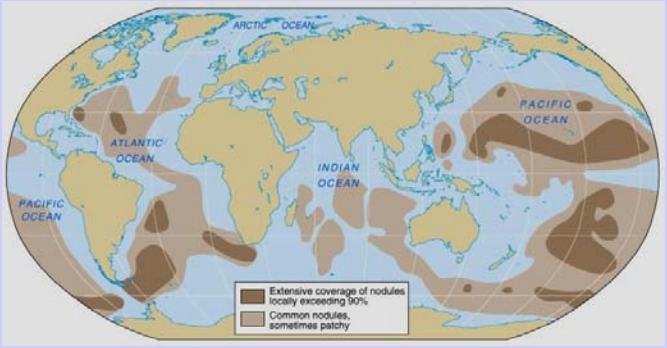


(b)

Cross section through a manganese nodu


(c)

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



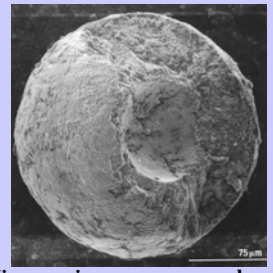

Manganese nodules distribution in the world ocean's. Accumulate in open ocean areas with low sedimentation rates.

## The 4 main types of sediment

1. **Lithogenous** = composed of weathered fragments of pre-existing rock material, 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

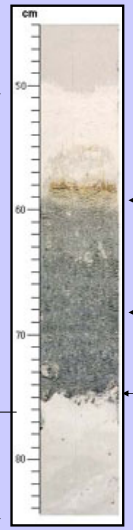
## *4. Cosmogenous sediment*

- 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**

Fig 5E




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

Fireball and fallout, iridium anomaly

Impact ejecta, tektites, spherules, shocked quartz

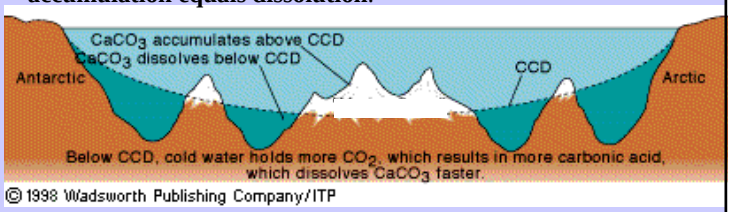
K-T Boundary

## *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)

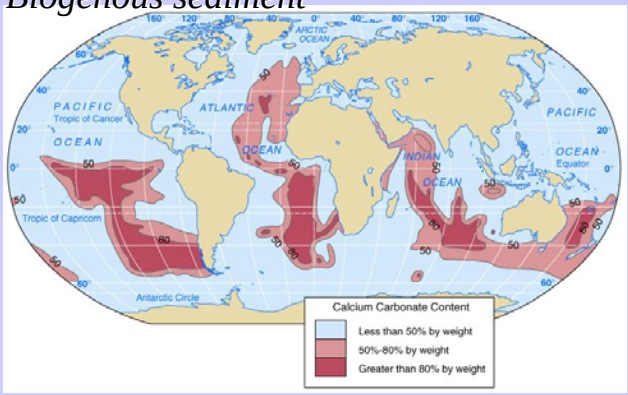
## *2. Biogenous sediment*

- Dissolution of calcium carbonate in the water column is depth dependent.
- With increasing depth, more $CO_2$ is dissolved, increasing the acidity of the water and calcium carbonate dissolves.
- 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

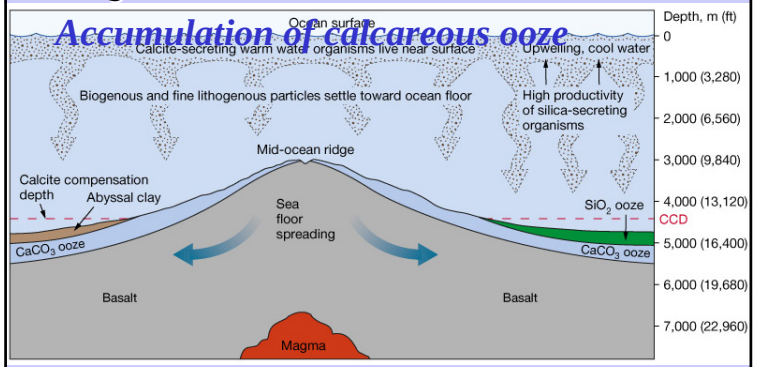
## *2. Biogenous sediment*




**Calcium carbonate** in modern surface sediments in the world oceans. The distribution follows the relatively shallow mid-ocean ridge that is above the **CCD**.

## 2. Biogenous sediment

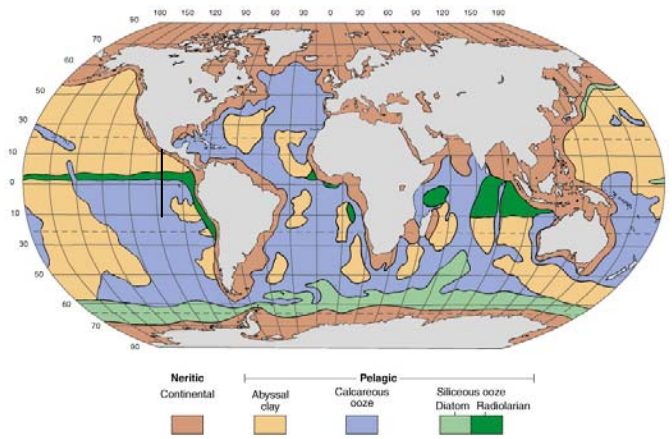
Fig. 5.16.



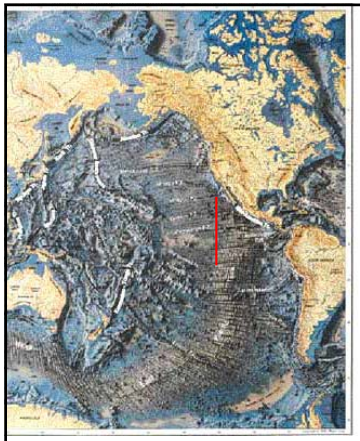

- Calcareous ooze accumulates on top of the mid-ocean ridge (or rise)
- As sea floor moves apart and becomes deeper than CCD, carbonate deposits are covered by either siliceous ooze (high production areas) or abyssal clay (open ocean basins away from high productivity).

## Biogenous ooze as environmental indicator

| | Siliceous ooze | Calcareous ooze |
|---|---|---|
| **Surface water temperature** | Cool | Warm |
| **Main locations found** | Sea floor beneath cool surface water in high latitudes; upwelling areas | Sea floor beneath warm surface water in low latitudes; not too deep (CCD) |



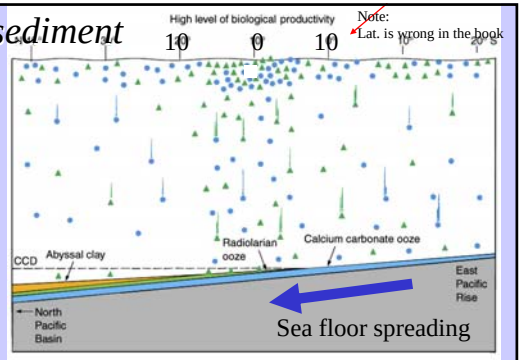

5-23. Distribution of neritic (continental margin) and pelagic sediments (open ocean)



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

## *2. Biogenous sediment*

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.

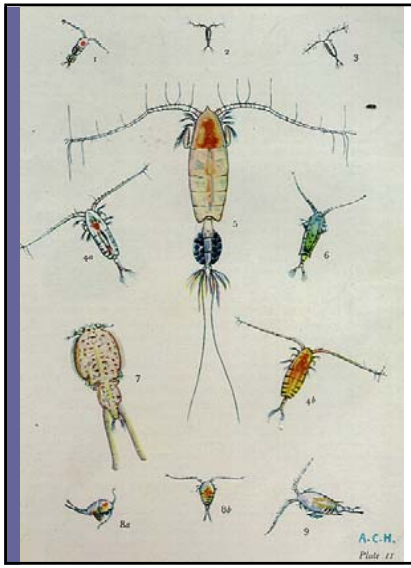
## Ocean sediments as a resource

- Ocean sediments contain many important resources, including:
  - Petroleum
  - Gas hydrates
  - Sand and gravel
  - Evaporative salts
  - Phosphorite
  - Manganese nodules and crusts

**Offshore drilling rig**

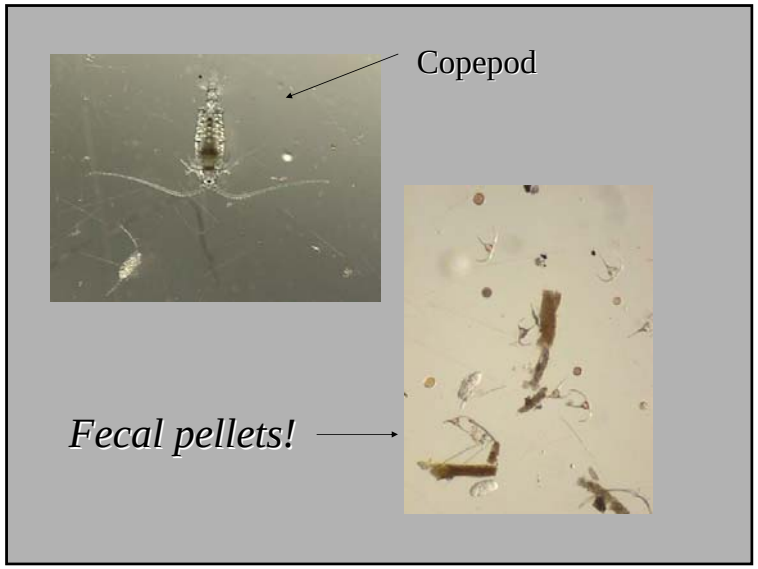
## *Deposition*

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 .


Copepod
*Fecal pellets!*