SEDIMENTATION IN THE OCEANS AND COASTAL PROCESSES

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10/23	**The Sediment Factory: From Source to Sink**
10/28	**Morphology and Morphodynamics of Sedimentary Systems**
10/30	**Sequence Stratigraphy**
11/04	**The Anthropocene: Human Impacts on Sedimentation/Morphodynamics**
11/06	**Field and Laboratory Methods in Coastal Geology**
11/11	**No Class Veteran's Day**
11/13	**Modeling of Coastal and Seascape Evolution (visiting Andrew Ashton)**

Deep-Sea Sediments

I Production/Sources

*1. Continents
   (dissolved, particulate)
2. Submarine
3. Extraterrestrial

II Transport

1. Wind (eolian)
2. Ice
3. Water
4. Gravity

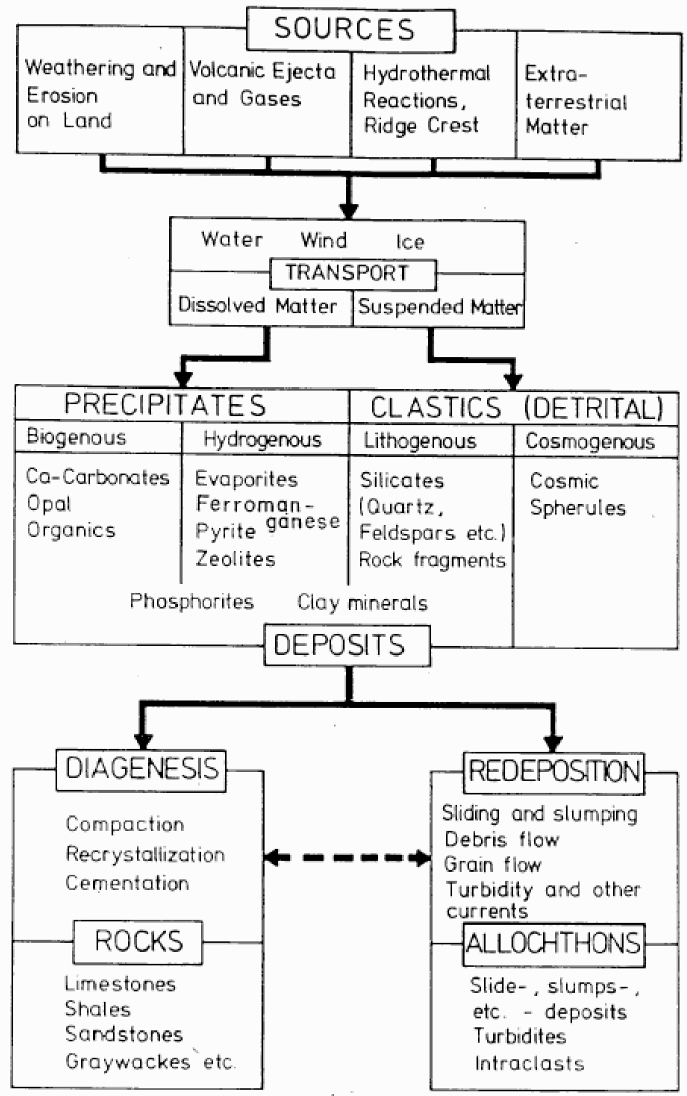
III Composition

1. Biogenic
   (opal, $CaCO_3$, C_{org})
2. Lithogenic
   (clastic)
3. Authigenic
   (inorganic precipitates)

IV Distribution influences:

1. Proximity of source (size)
2. Depth of sea floor ($CaCO_3$)
3. Seawater chemistry (opal, $CaCO_3$)
4. Sedimentation rate (opal, C_{org})
   vs. Accumulation

Sediment Factory: From Source to Sink



Weathering

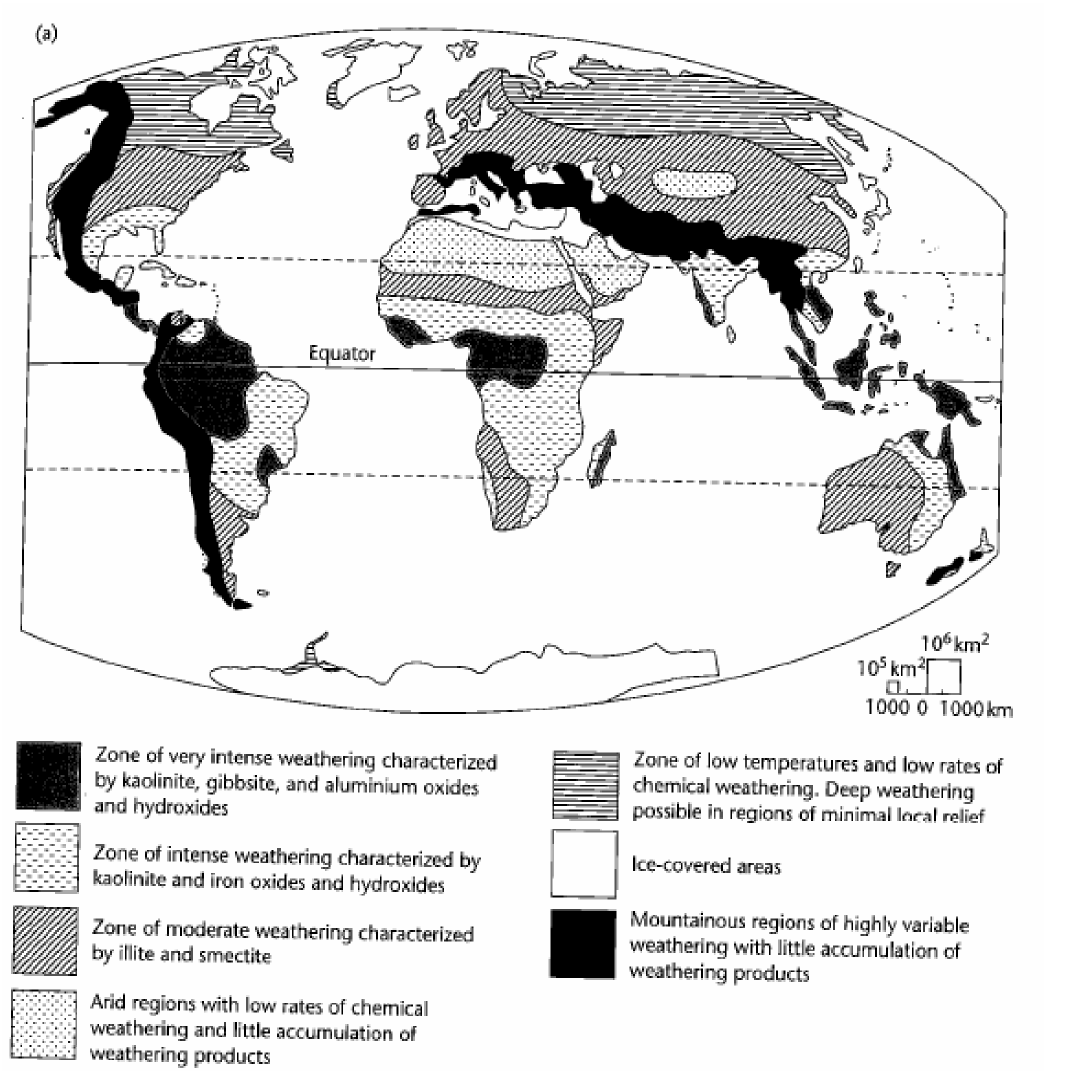


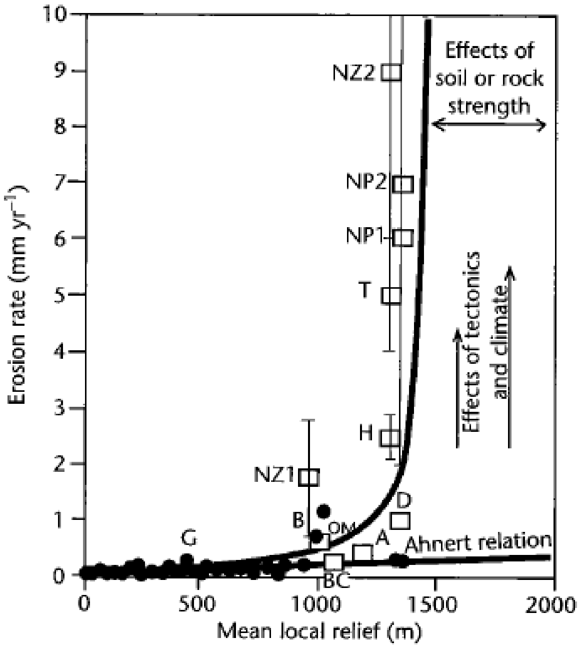
Table 7.4 Rock types at the Earth's surface by percentage.

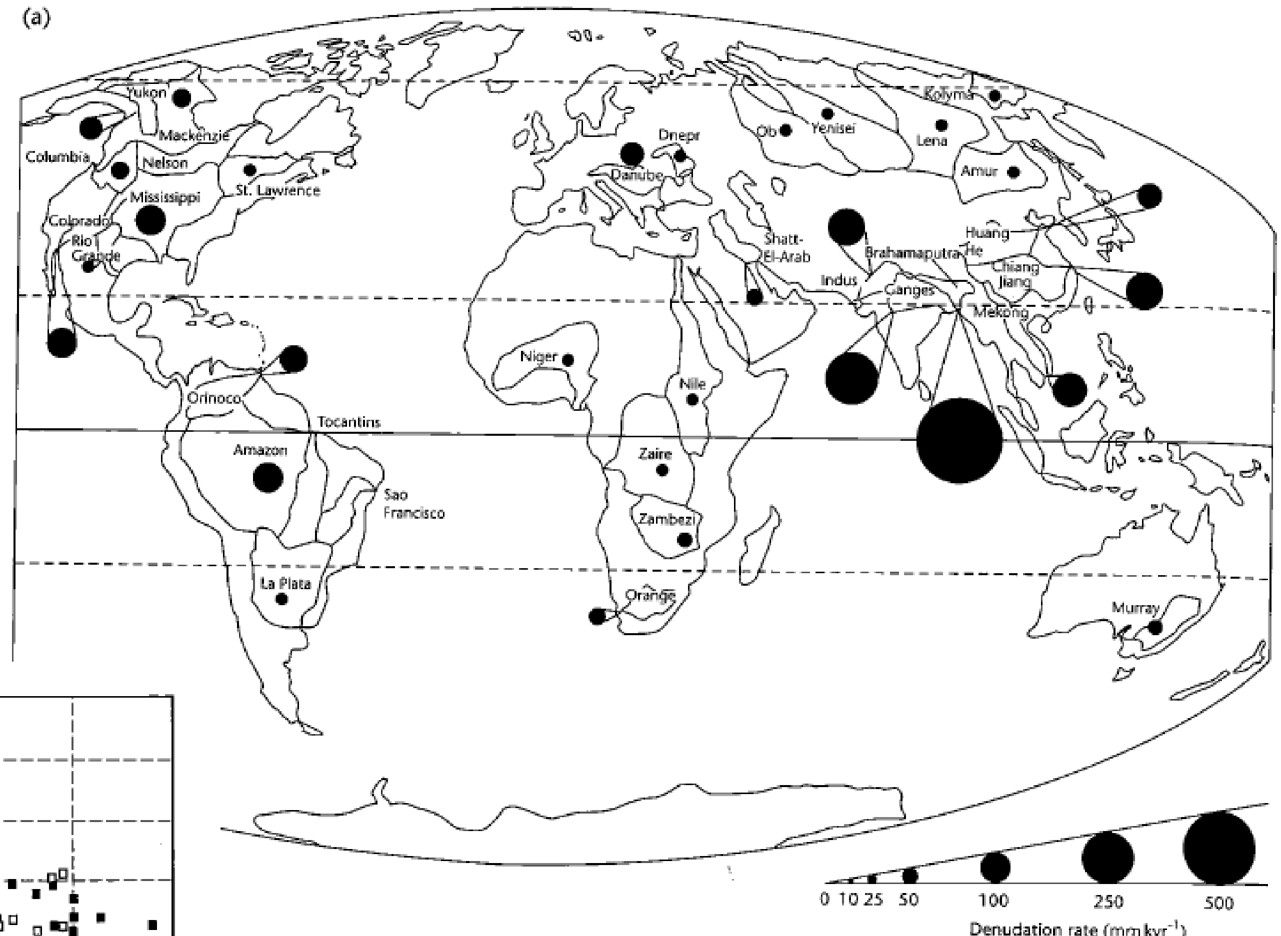
Class	Rock type	Percentage (by area)
Plutonic	Granite	10.4
	Gabbro and ultrabasics	0.6
Metamorphic	Marble	0.4
	Amphibolite	1.9
	Mica–schist	1.5
	Gneiss	10.4
	Quartzite	0.8
Volcanic	Basalt	4.15
	Andesite	3.0
	Rhyolite	0.75
Sedimentary	Quartz-arenite	12.6
	Arkose (felspathic arenite)	0.8
	Greywacke (lithic, argillaceous arenite)	2.4
	Shale	33.1
	Limestone and dolomite	15.9
	Evaporite (gypsum and halite)	1.3

Table 7.5 Weathering rates of major rock types, relative to granite.

Rock type	Weathering rate
Granite	1
Gneiss/schist	1
Gabbro	1.3
Sandstones	1.3
Volcanics	1.5
Shales	2.5
Other metamorphic	5
Carbonates	12
Gypsum	40
Rock salt	80

Denudation





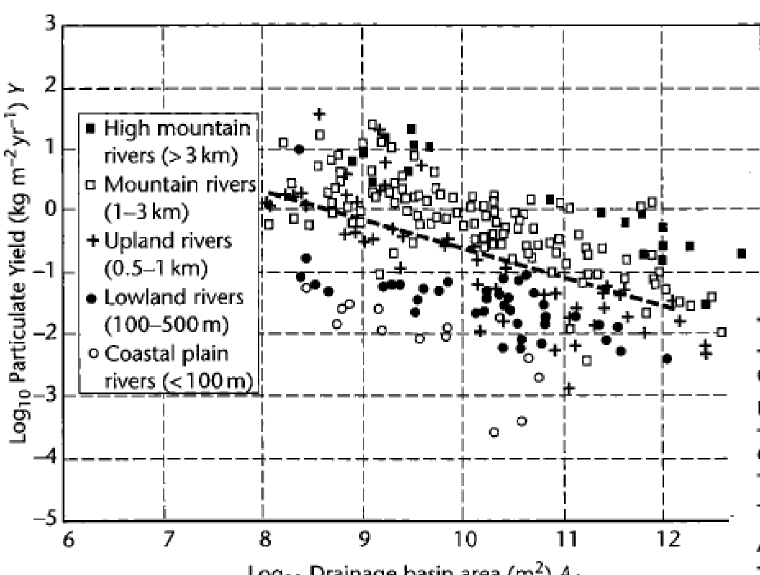


Table 7.3 Dissolved and suspended loads of rivers in different climatic regions. TOC is total organic carbon.

Geographic region	Area (%)	Run-off (%)	Dissolved SiO_2 (%)	Ions (%)	TOC (%)	Suspended matter (%)
Cold regions	23.4	14.7	5.4	15.5	17.5	2.7
Temperate	22.4	27.5	19.9	39.9	28.5	56.5
Tropical	37.0	57.2	73.6	41.8	52.0	34.2
Arid	17.2	0.65	1.0	2.8	1.3	6.6

Classification of Marine Sediment Types

Biogenic Sediments: Remains of organisms, mainly carbonates (calcite, aragonite), opal (hydrated silica), and calcium phosphate (teeth, bones, crustacean carpaces), also organic carbon (soft tissues). Arrival at the site of deposition by in situ precipitation (benthic organisms living there) or via settling through the water column (pelagic organisms).

Biogenic sediments are widespread on the sea floor, covering one half of the shelves and more than one half of the deep ocean bottom (total ~55%.) They constitute ~30% of total volume of sediment being deposited.

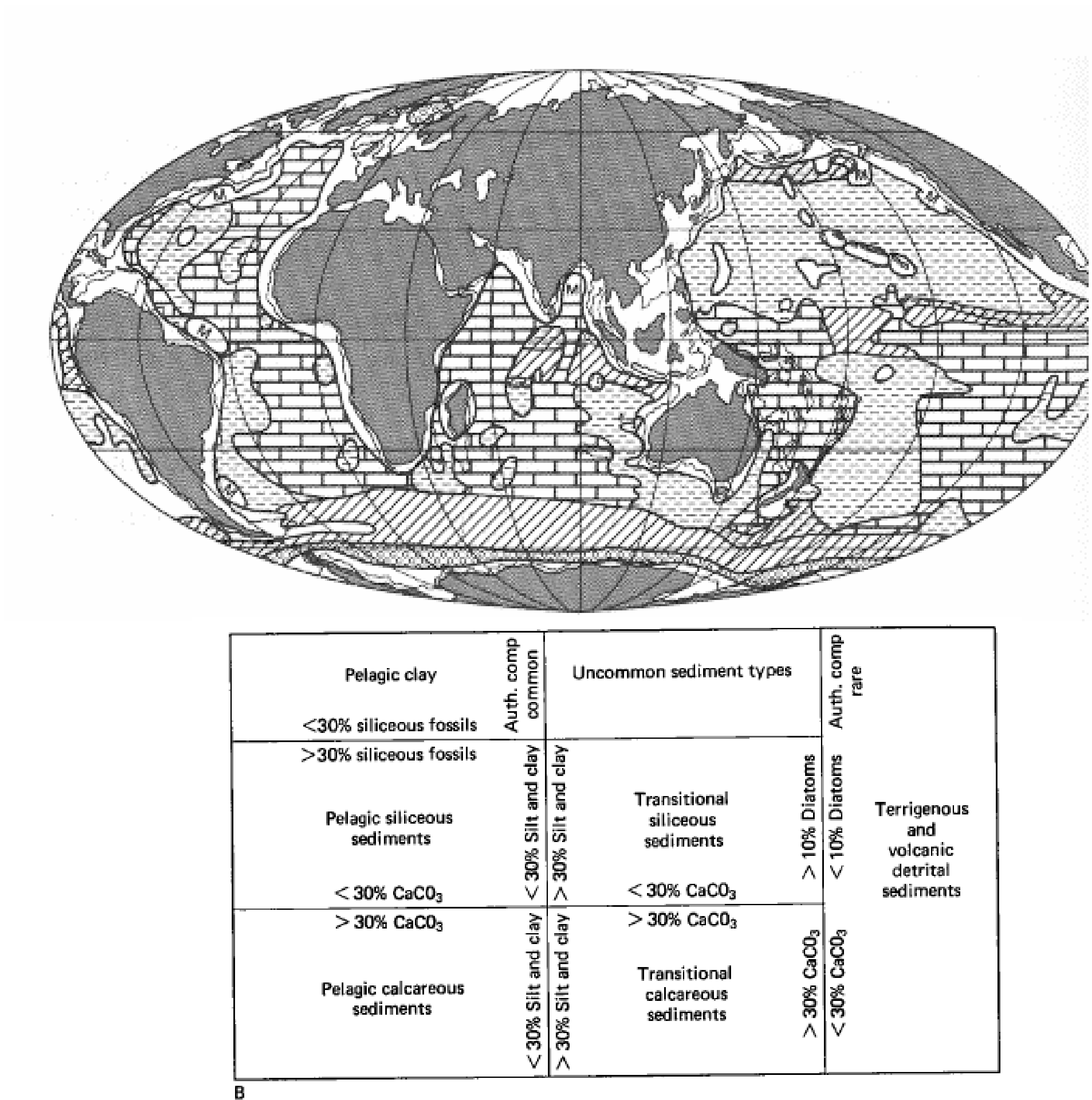
Lithogenic Sediments: Detrital products of pre-existing rocks (igneous, metamorphic, sedimentary) and of volcanic ejecta and extraterrestrial material. Transport by rivers, ice, winds. Nomenclature based on grain size (gravel, sand, silt, clay). Additional qualifiers derived from the lithologic components (terrigenous, bioclastic, volcanogenic) and from the structure of the deposits.

Fine-grained lithogenic sediments (which become shale upon aging and hardening) are the most abundant by volume of all marine sediments (~70%) primarily due to the great thickness of continental margin sediments.

Authigenic (or Hydrogenous) Sediments: Precipitates from seawater or from interstitial water. Also products of alteration during early chemical reactions within freshly deposited sediment. Redissolution common. Nomenclature based on origin (evaporates) and chemical composition.

Authigenic sediments, while widespread, are not volumetrically important at present. At times in the past they have been a much more substantial sediment component (e. g., Messinian crisis).

Marine Sediment Types



Marine Sediment Grain Size

The mathematical statement for the scale is as follows:

$$\varphi = -\log_2 d$$

where d is the particle diameter in millimeters. This statement can also be expressed as

$$\phi = -\log_2 \frac{d}{d_0}$$

where d_0 is the standard particle diameter (1.00 mm); ϕ values are dimensionless numbers.

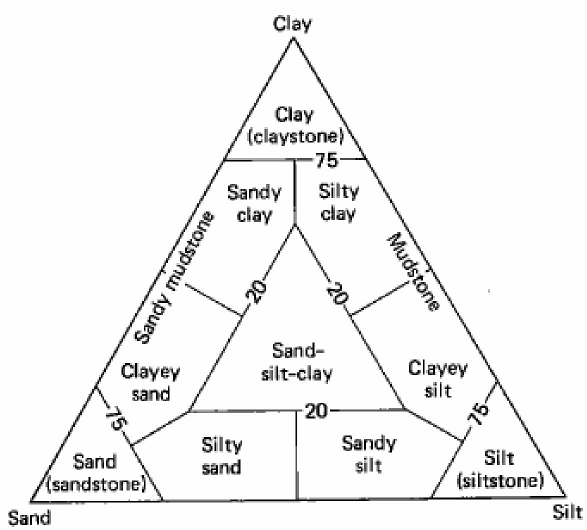


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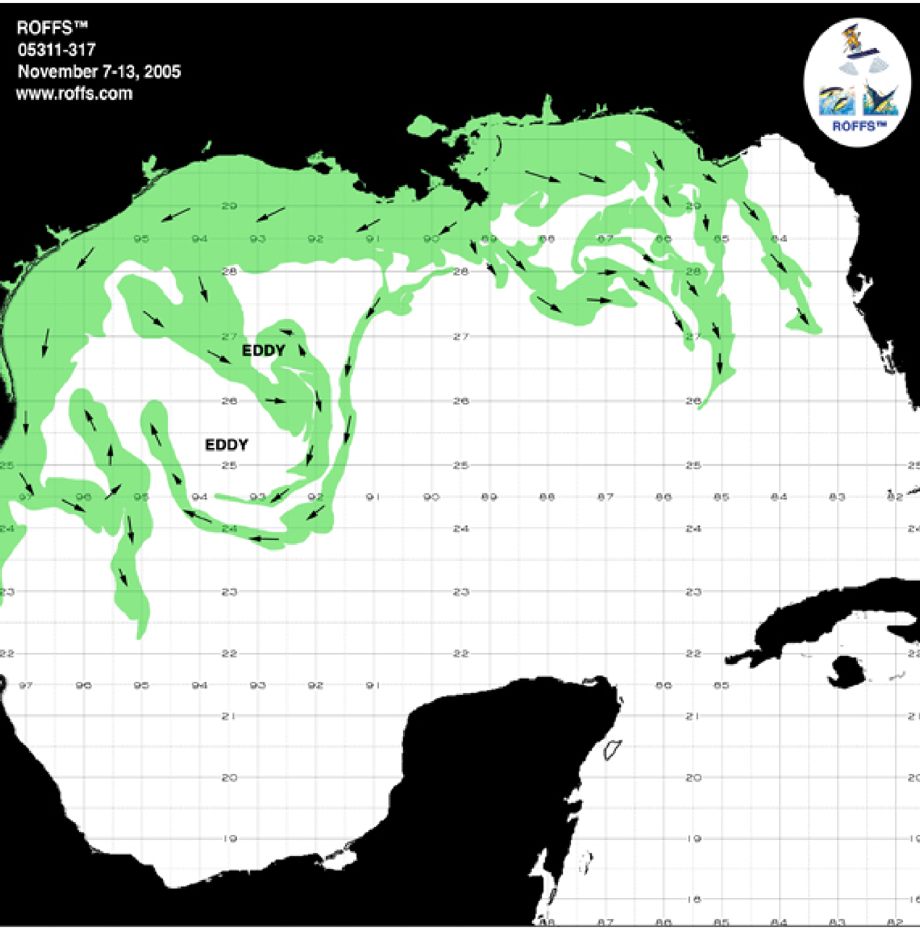
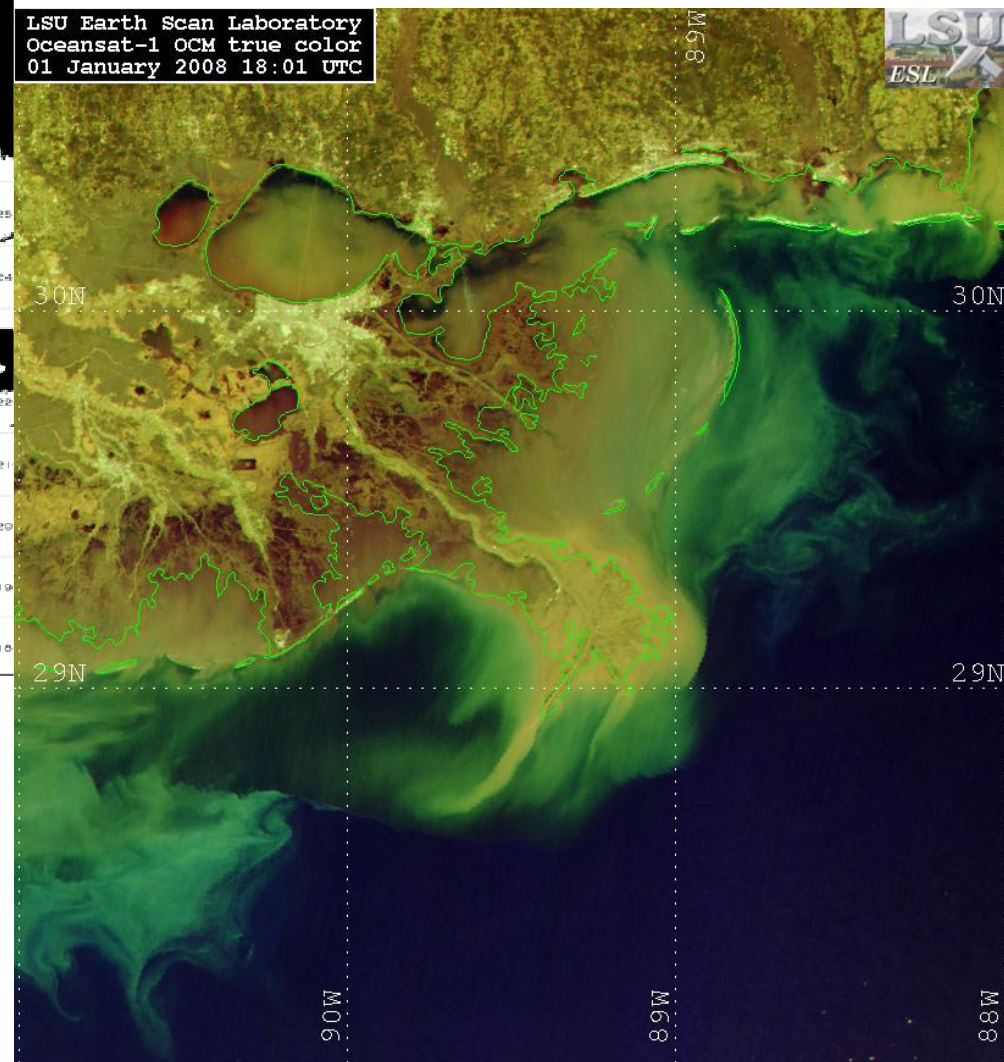
Table 3-1 Standard size classes of sediment

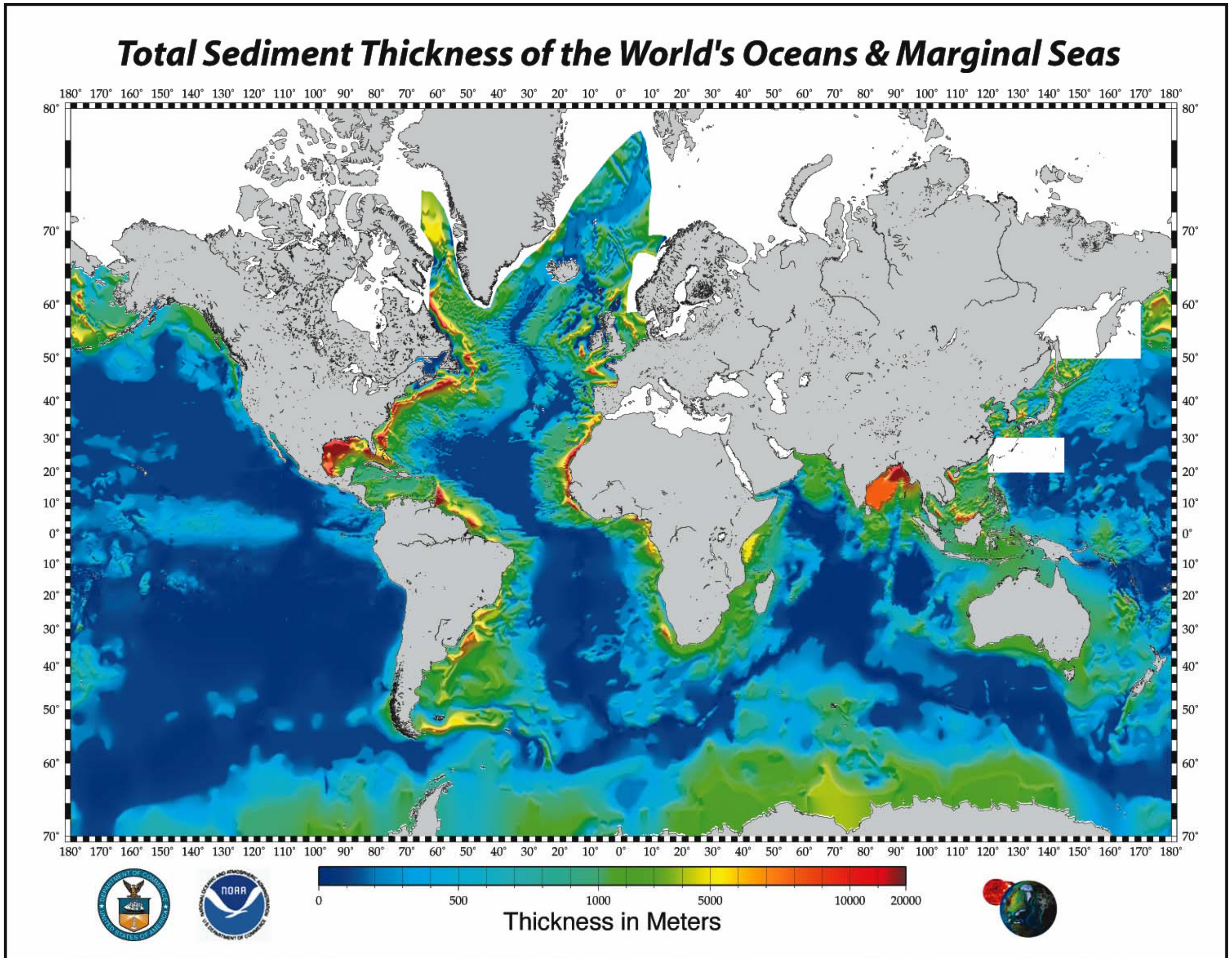
Limiting Particle Diameter (mm)	(ϕ units)	(Microns μ)	Size Class			
			V. Large	Boulders	GRAVEL	
2048	-11		Large			
1024	-10		Medium			1m
512	-9		Small			
256	-8		Large	Cobbles		
128	-7		Small			10^{-1}
64	-6		V. Coarse	Pebbles		
32	-5		Coarse			
16	-4		Medium			
8	-3		Fine			10^{-2}
4	-2		V. Fine			
2	-1		V. Coarse	Sand		
1	0		Coarse			10^{-3}
1/2	+1	500	Medium			
1/4	+2	250	Fine			
1/8	+3	125	V. Fine			10^{-4}
1/16	+4	62	V. Coarse	Silt	MUD	
1/32	+5	31	Coarse			
1/64	+6	16	Medium			
1/128	+7	8	Fine			10^{-5}
1/256	+8	4	V. Fine			
1/512	+9	2	Clay			

Water (riverine, currents)



Amazon discharge (NASA)

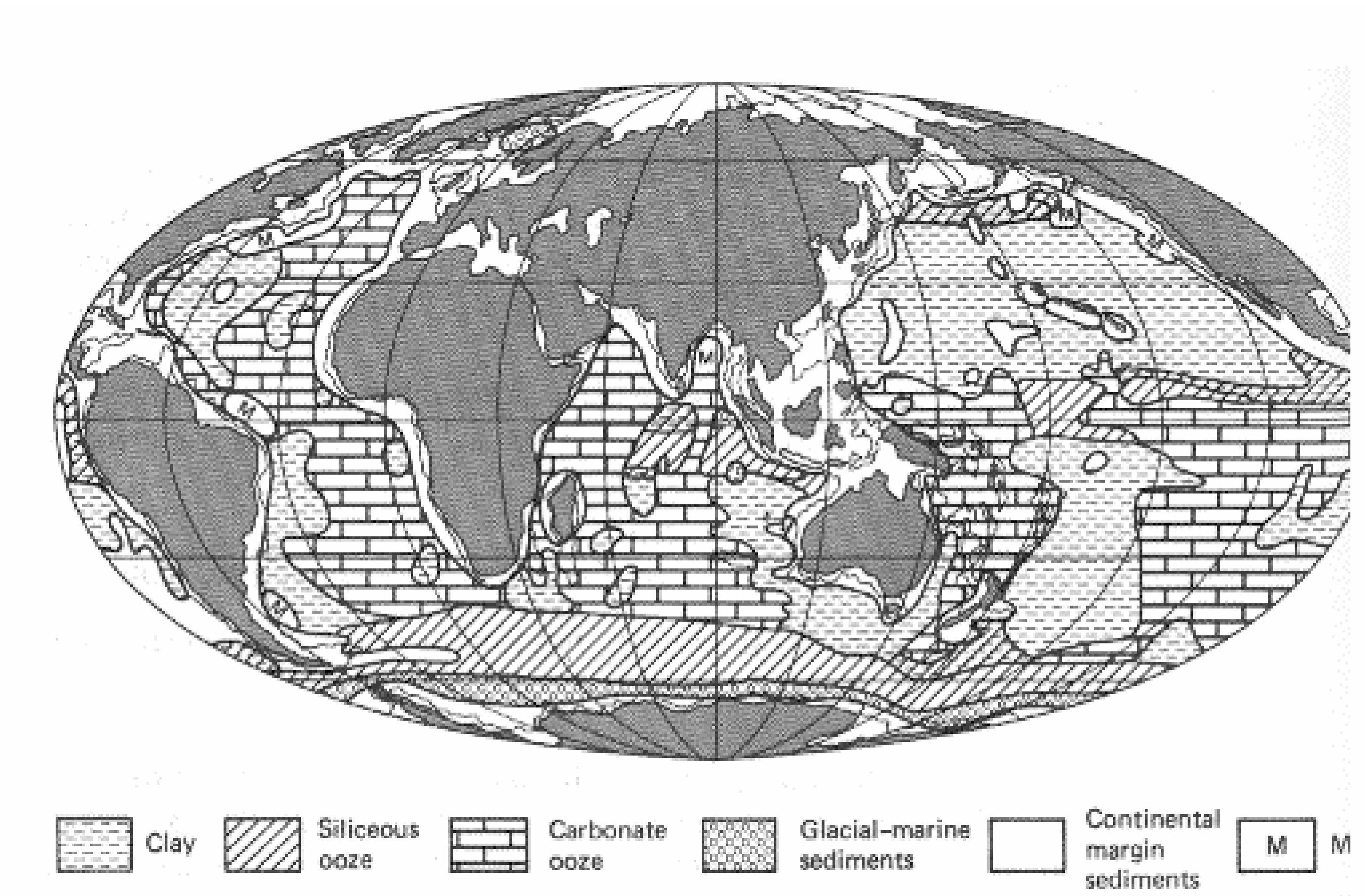




Thickest deposits

Terrigenous sediments delivered by rivers

Marine Sediment Types Distribution



Clay Minerals

Phyllosilicates, hydrous aluminosilicates

Chlorite (Mg, Fe) **and Illite** (K, Al, Mg, Fe**)**

Montmorillonite (Smectite) (Na, Ca, Mg) and **Kaolinite**

Clay minerals

rock -> chlorite (from Fe-Mg minerals) + illite (from feldspars) ->
montmorillonite -> kaolinite (in regions of high temperature, good drainage).

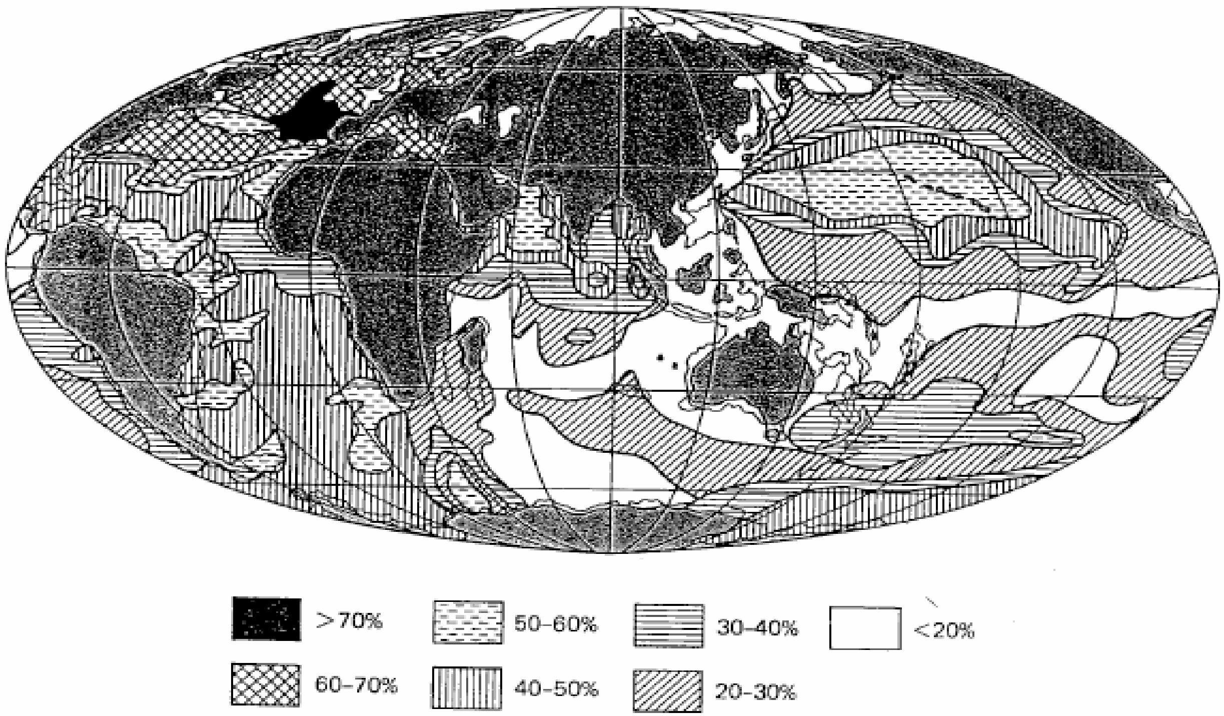
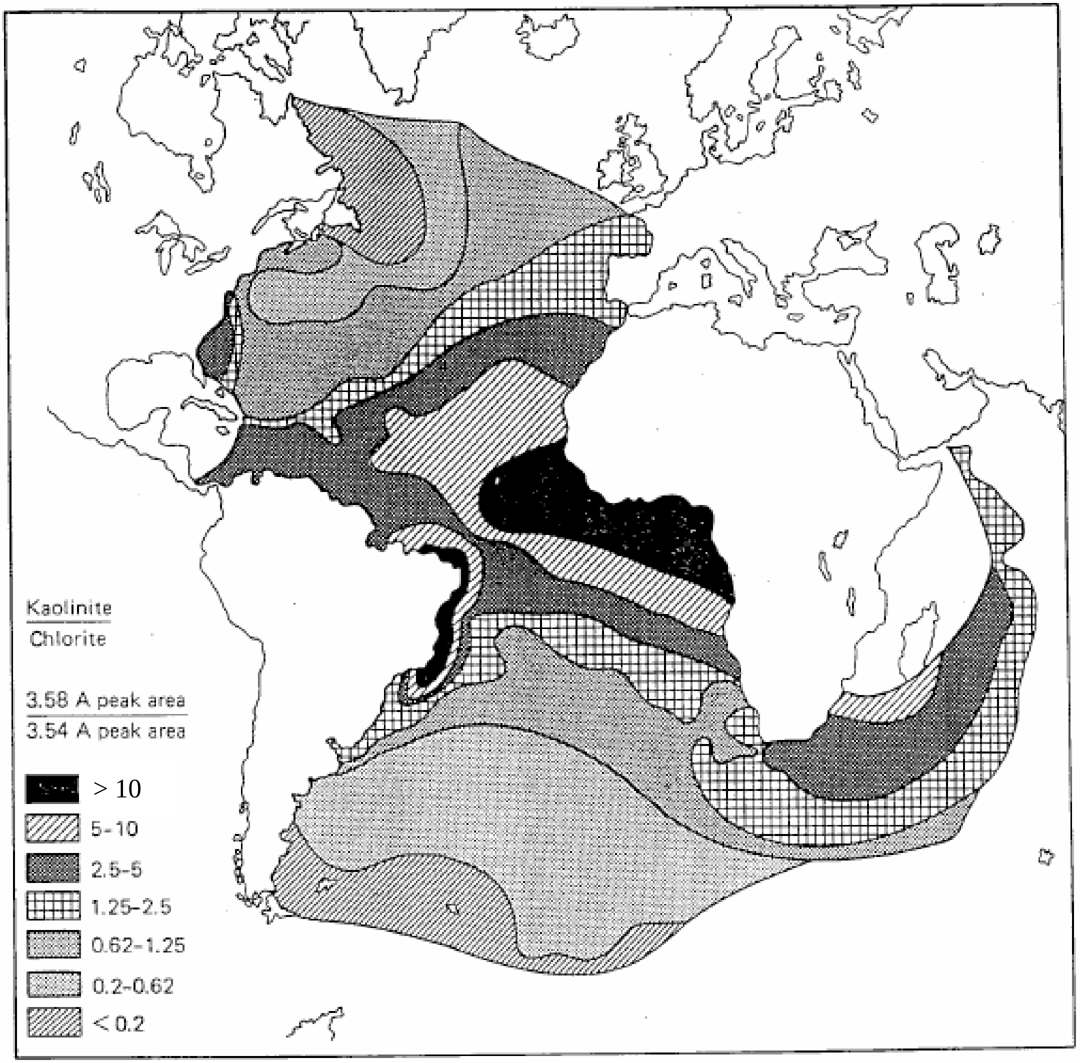
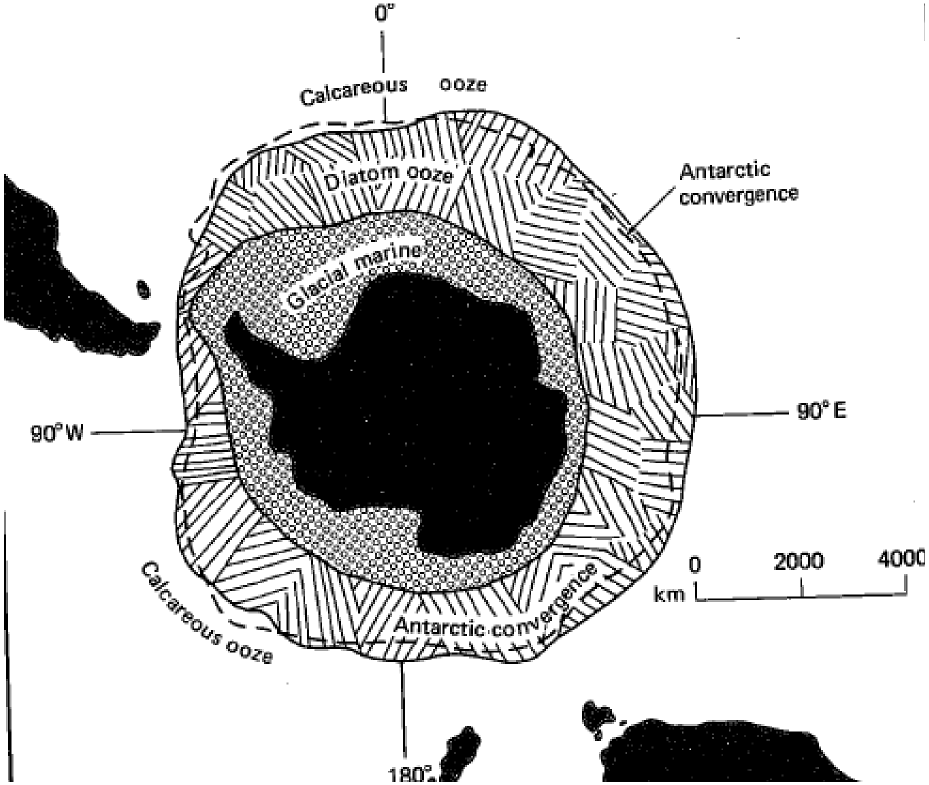


Figure 13–14 Illite concentrations in the less than 2μm fraction of surface sediments of the world ocean. Note maximum concentrations in certain middle latitude areas. (After H. L. Windom, 1976)

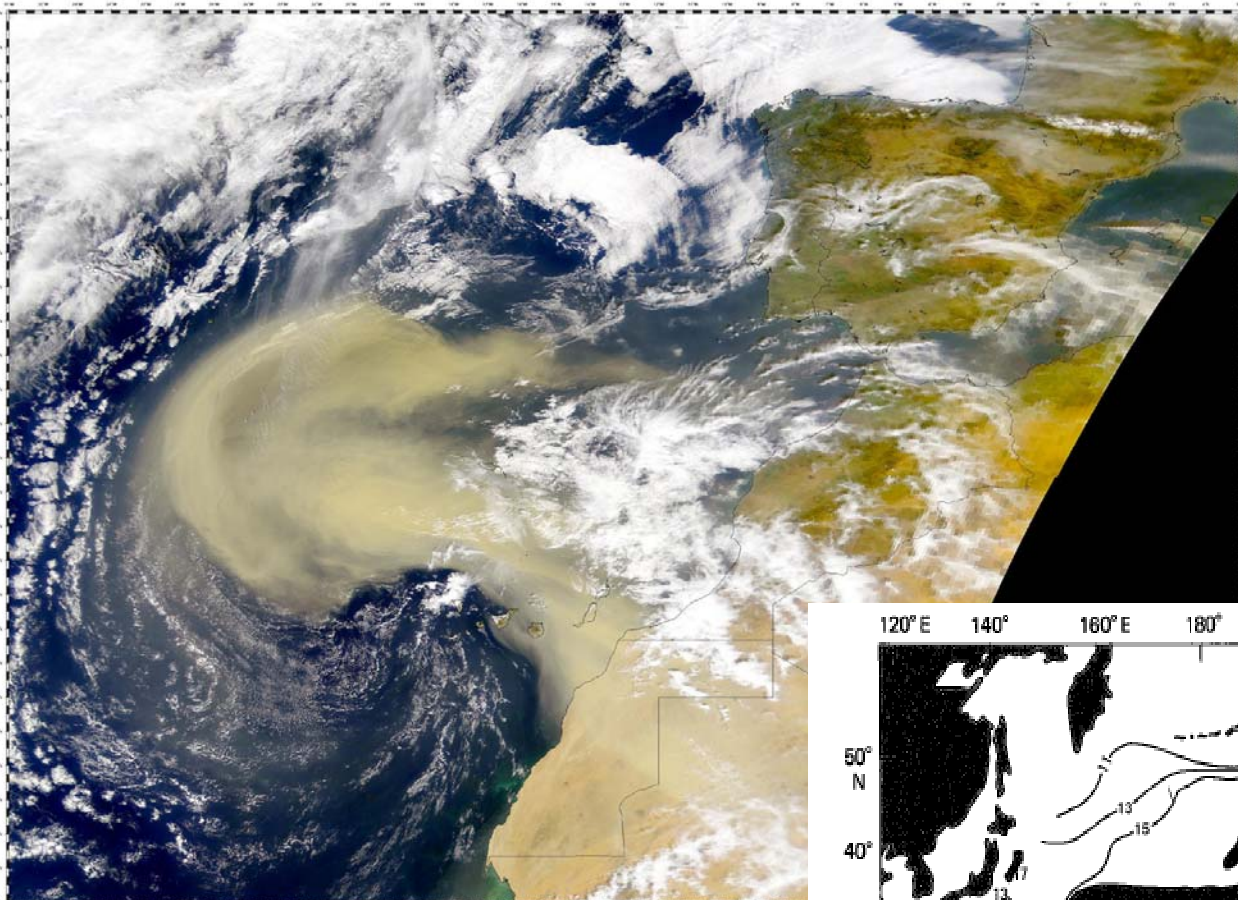
Clay type varies by weathering regime



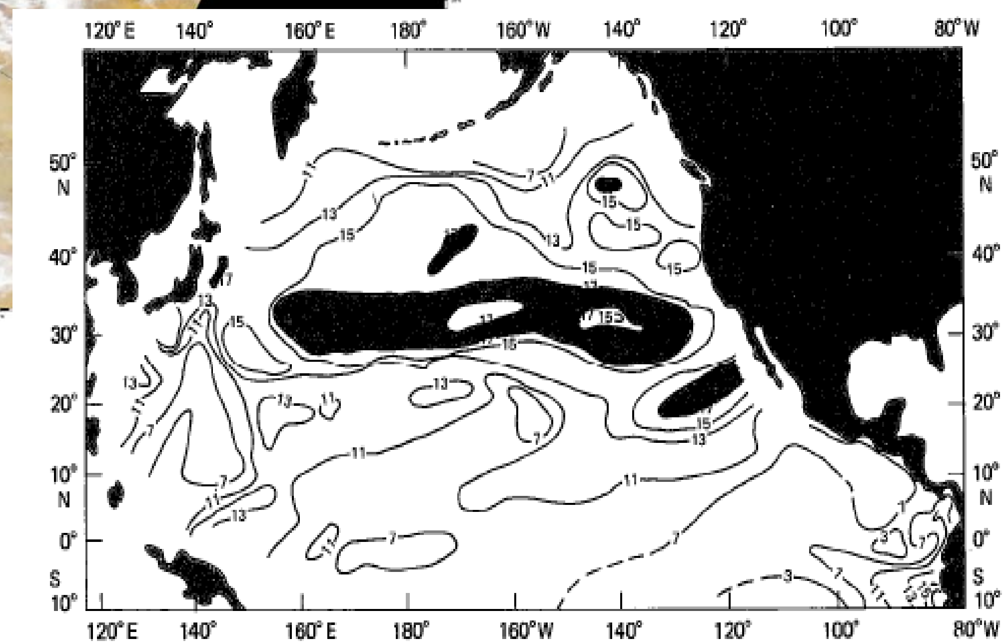
Chlorite ~ physical
Kaolinite ~ chemical



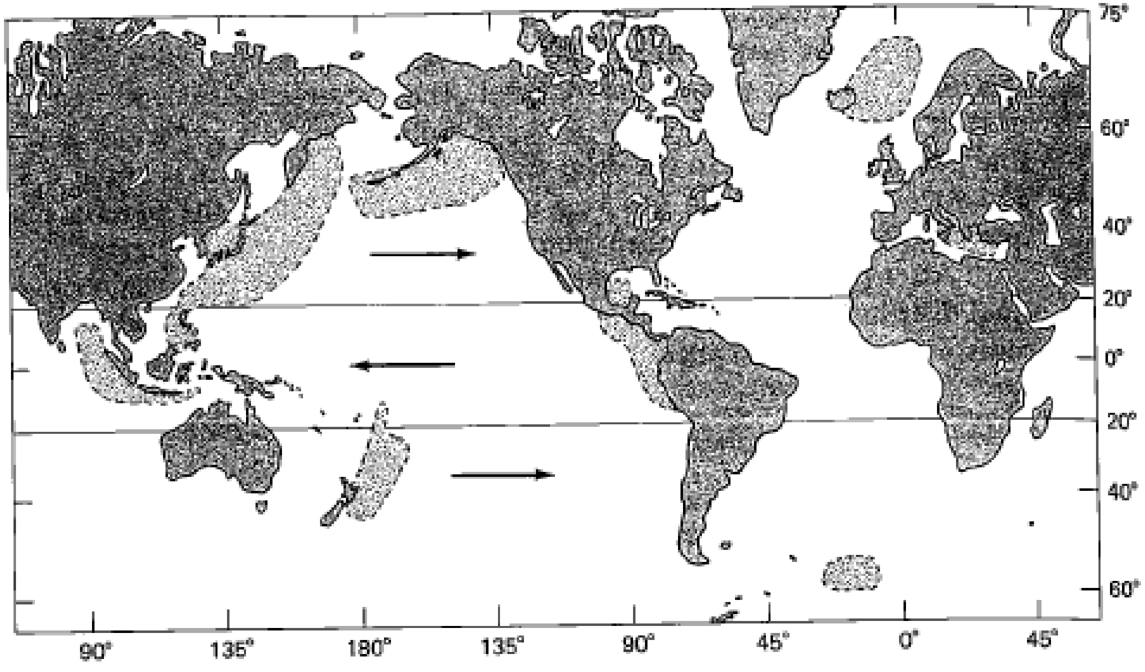
Ice
(glaciers, sea ice, icebergs)



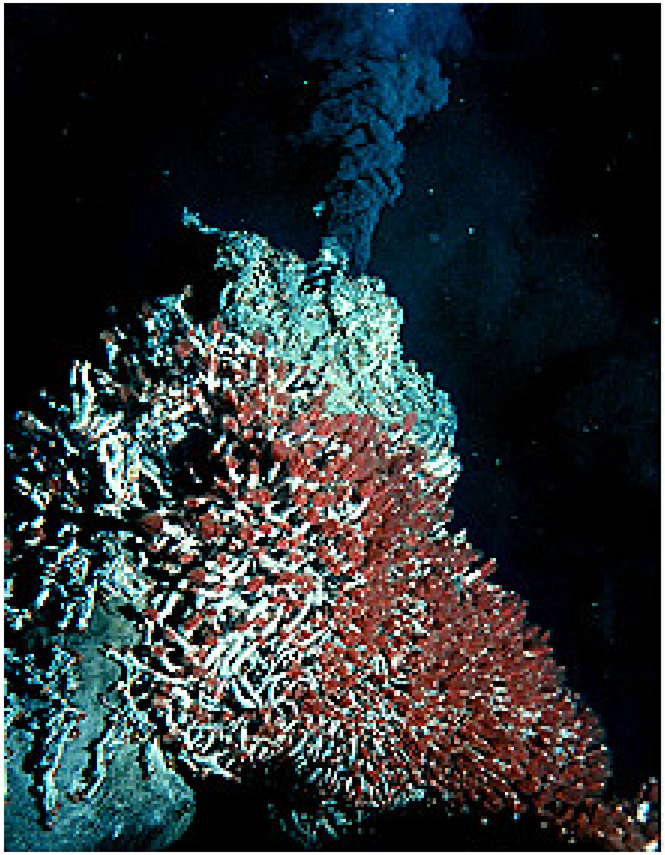
Sahara Dust (NASA)



Volcanic eruptions



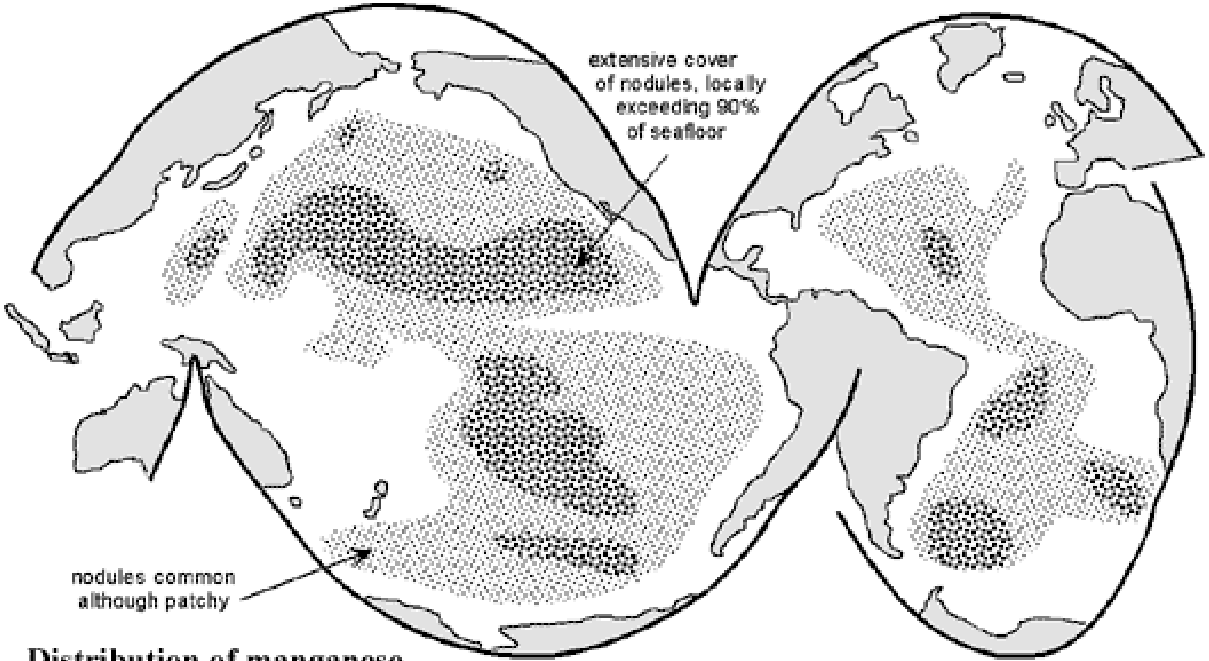
Hydrothermal input



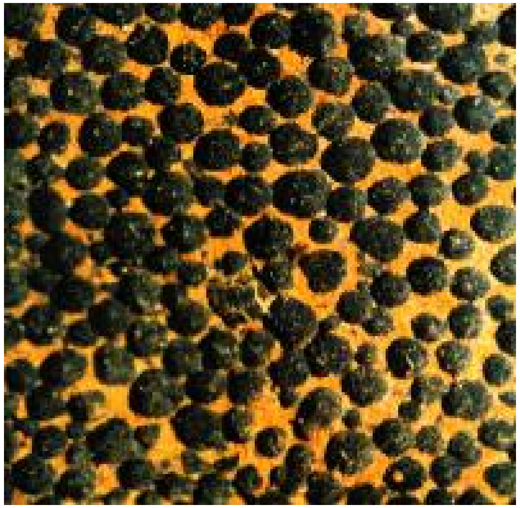
Black smoker vents (NOAA)

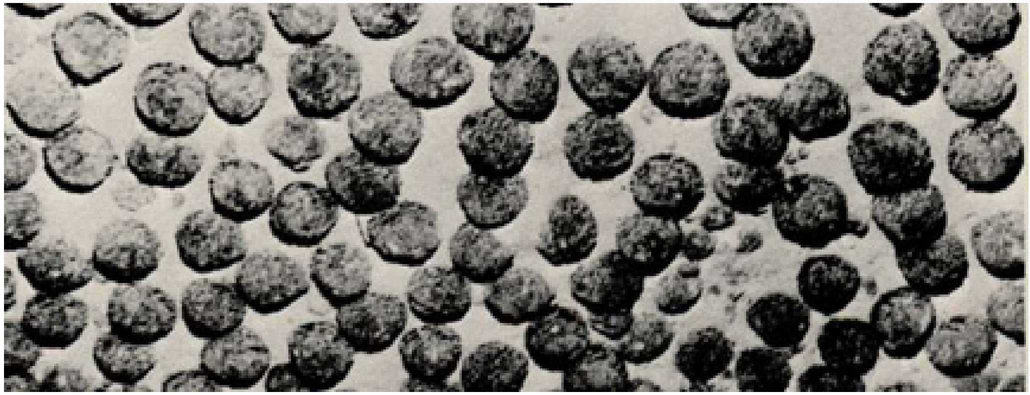
Ferro-manganese nodules

Slow-growing
Require metal input

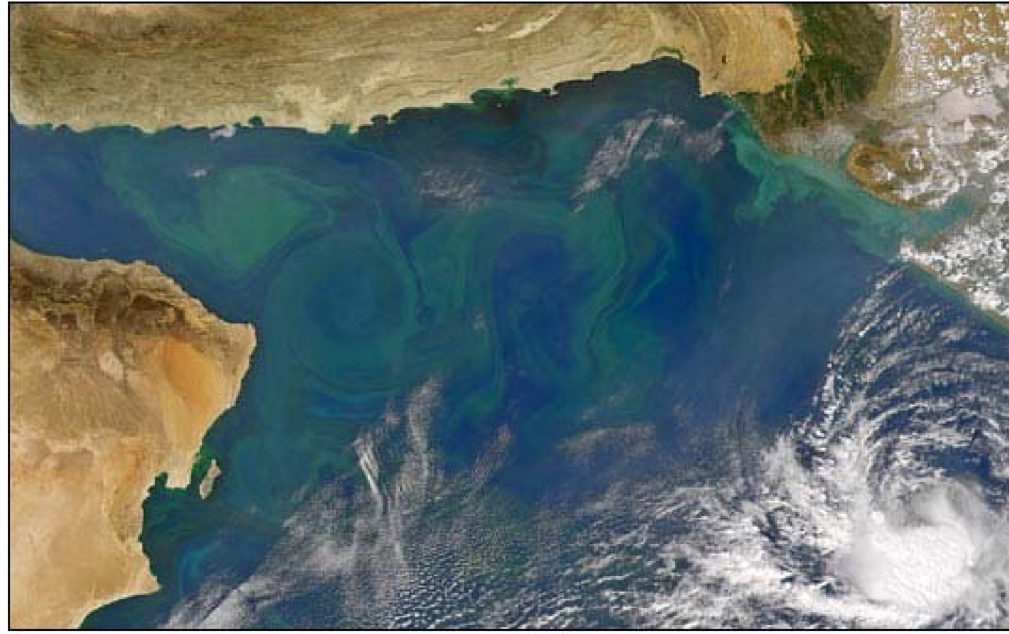


Distribution of manganese nodules in the Pacific and Atlantic Oceans

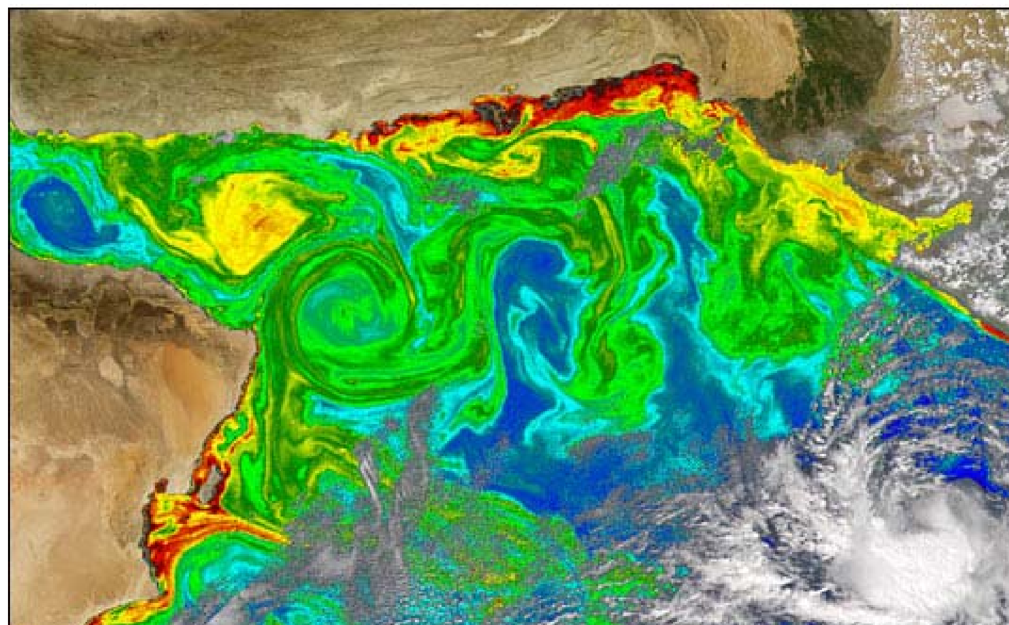




Biological activity
(plankton)

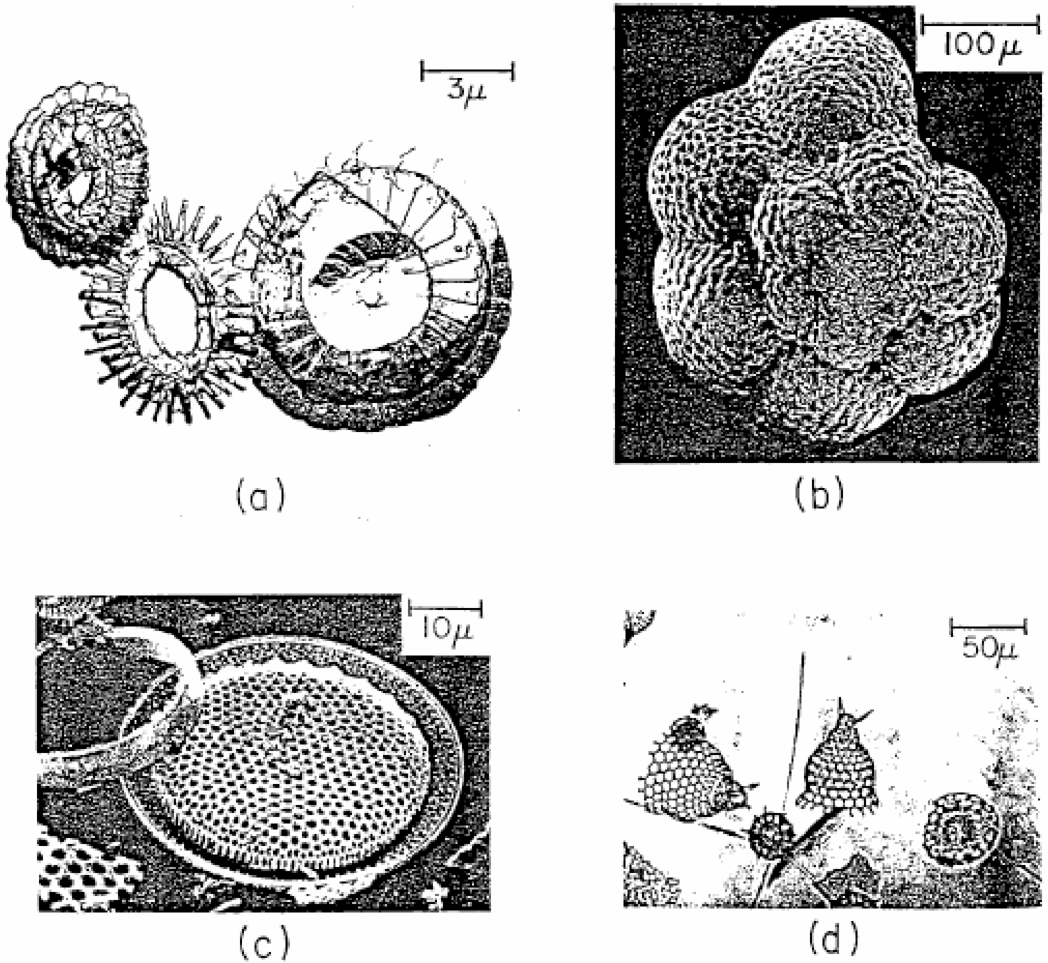


Natural Color



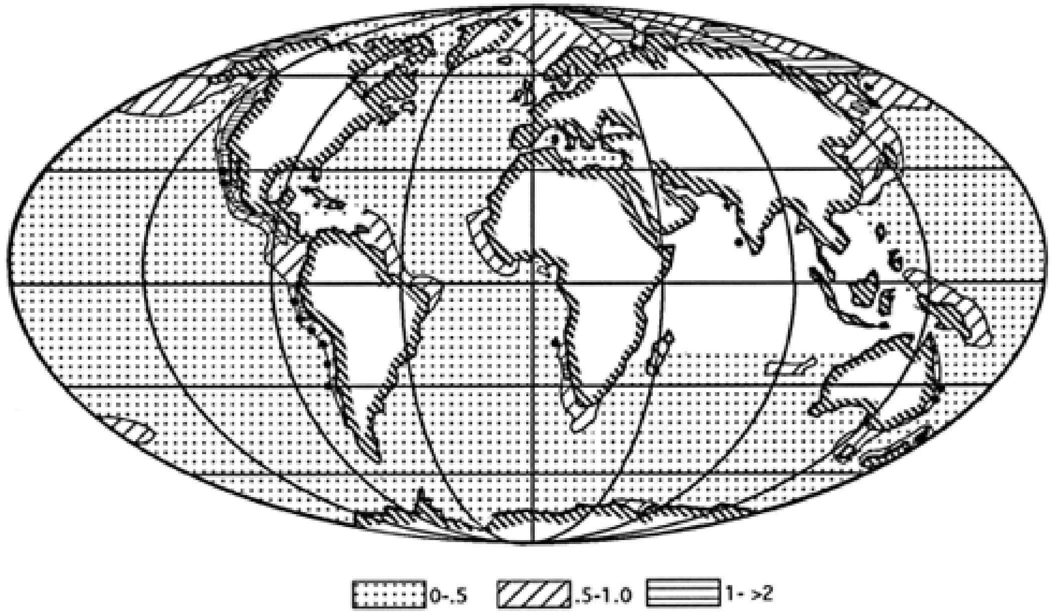
Chlorophyll Concentration

Arabian Sea bloom (NASA)



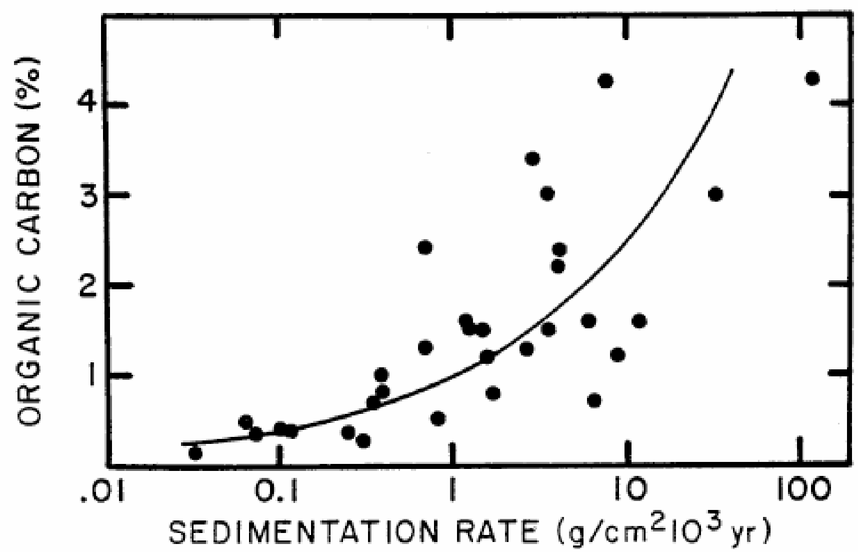
Biogenic sediments

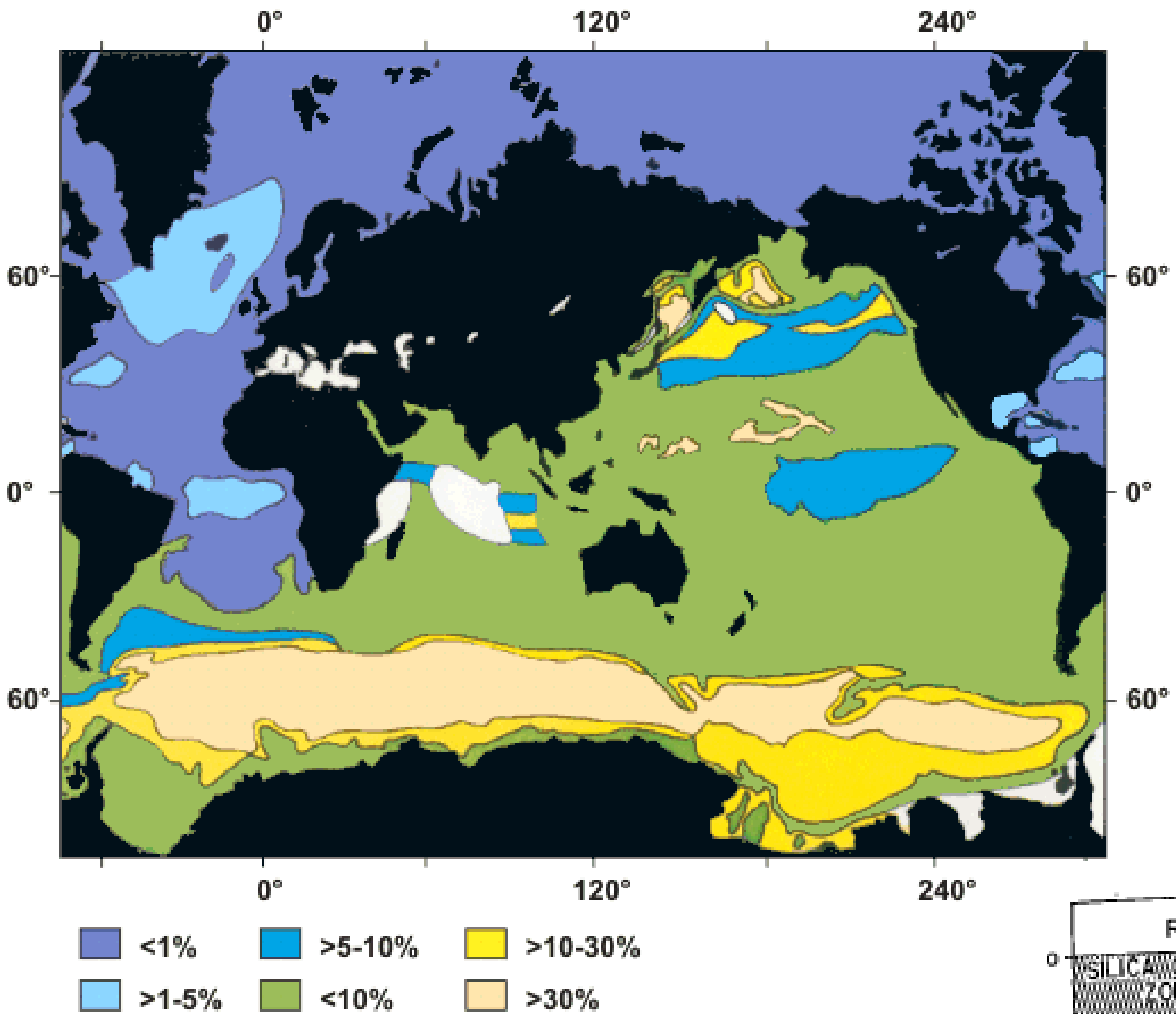
a) Coccoliths
b) Foraminifera
c) Diatoms
d) Radiolarians



Organic carbon

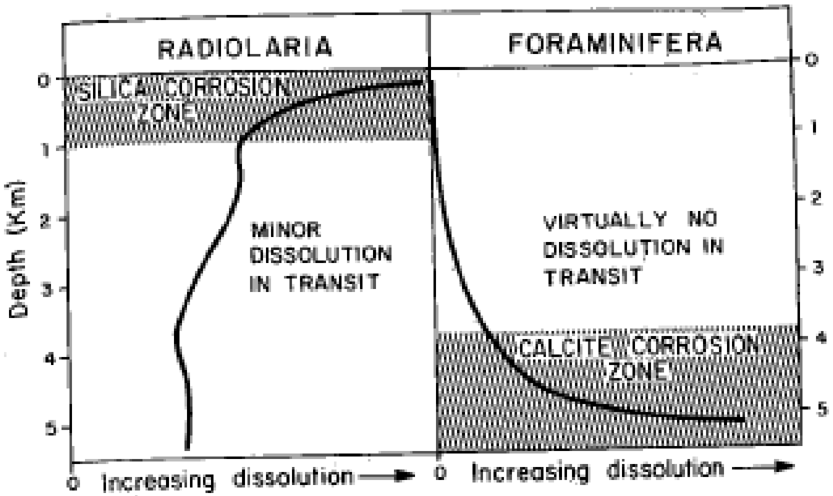
Preservation due to high productivity and rapid burial.

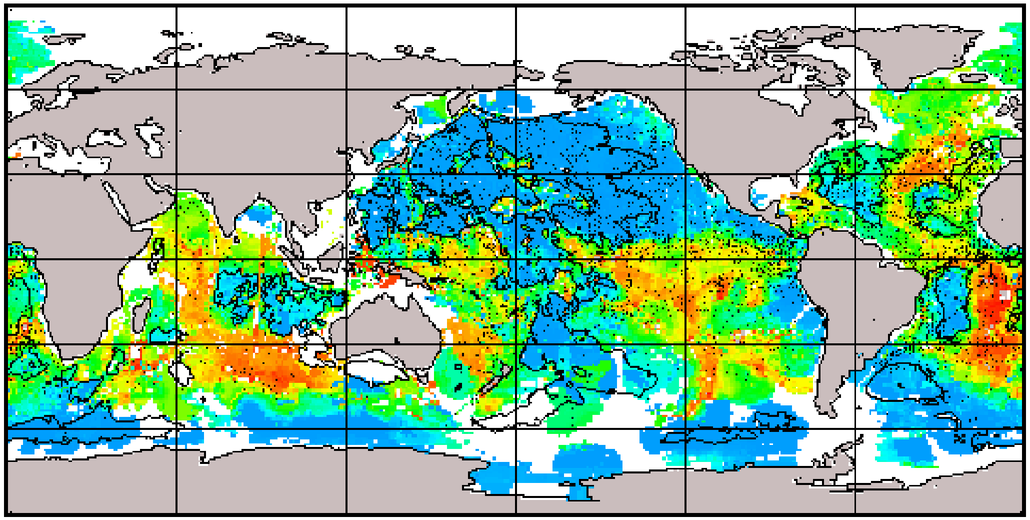


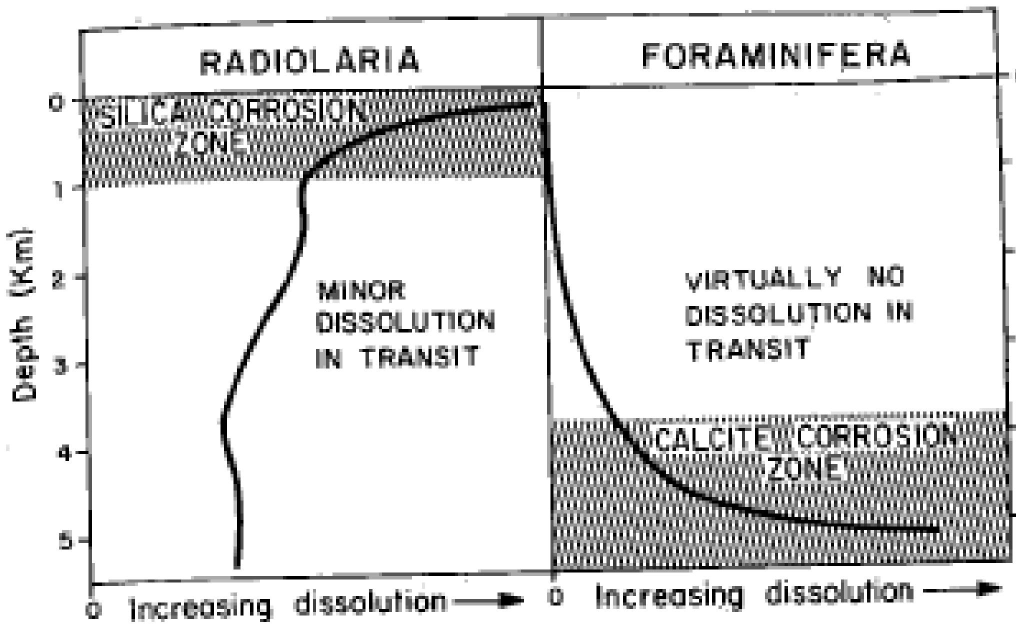


Opal deposits

Preservation due to high productivity and rapid burial.





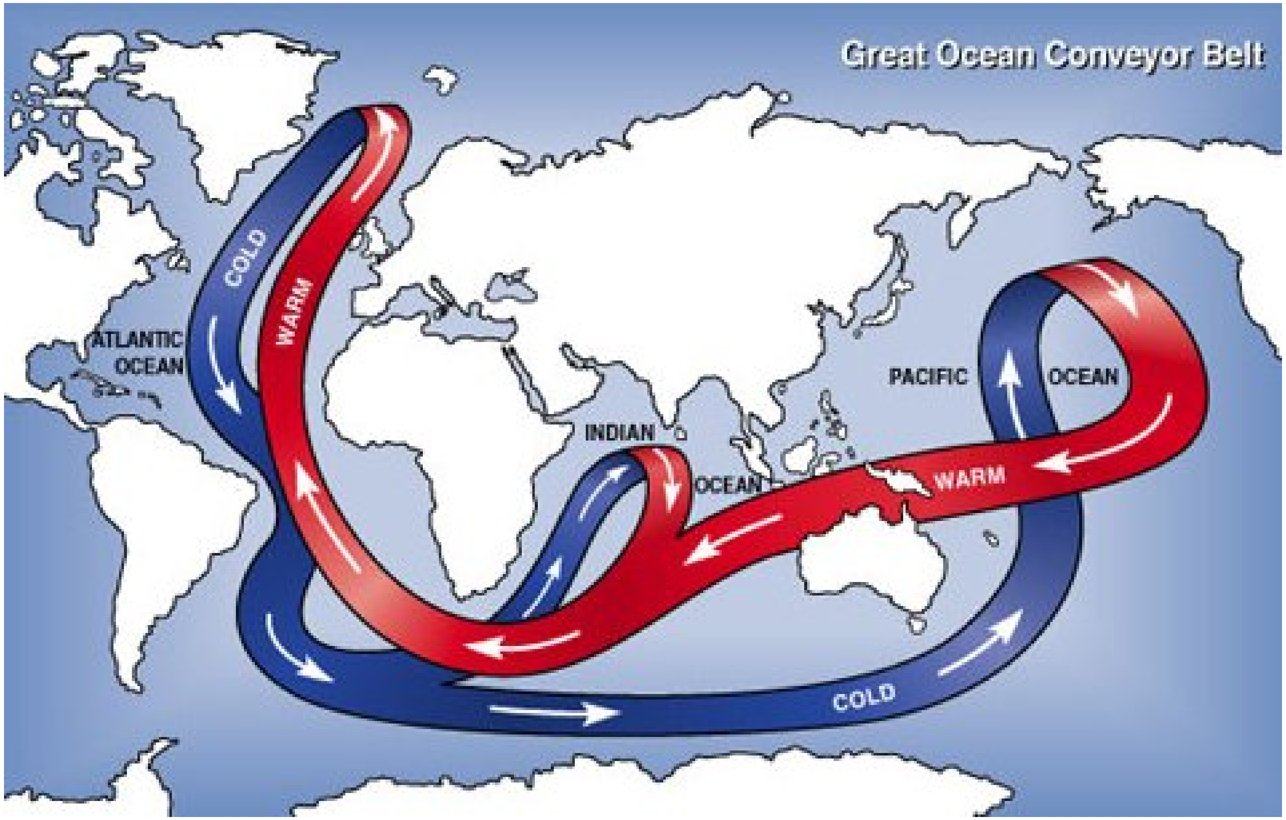


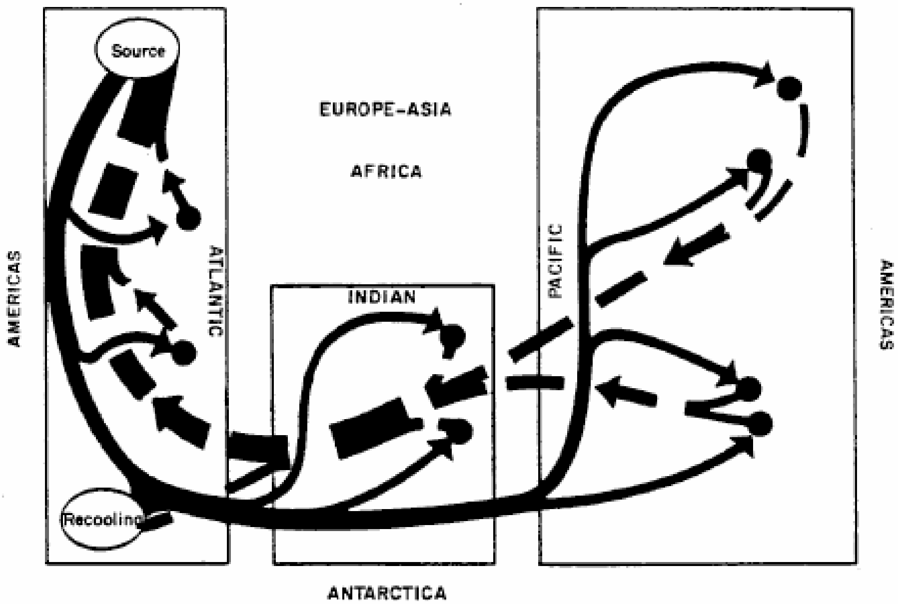
$CaCO_3$ deposits

Influenced by:

Productivity and seawater chemistry, ocean circulation.

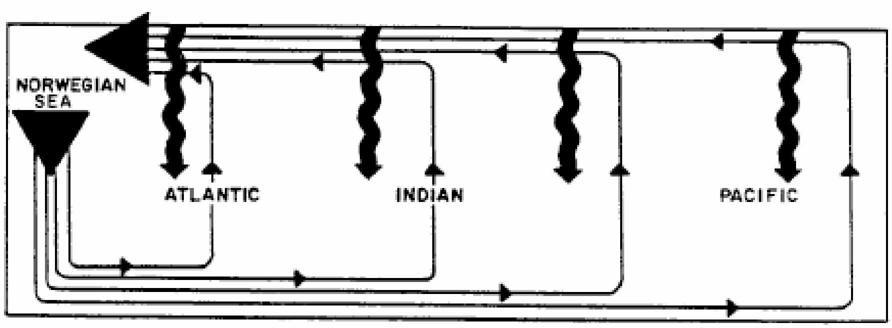
Intra-basin ocean circulation

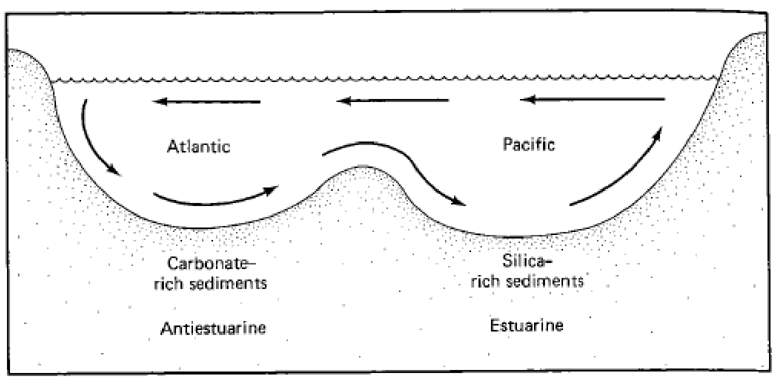


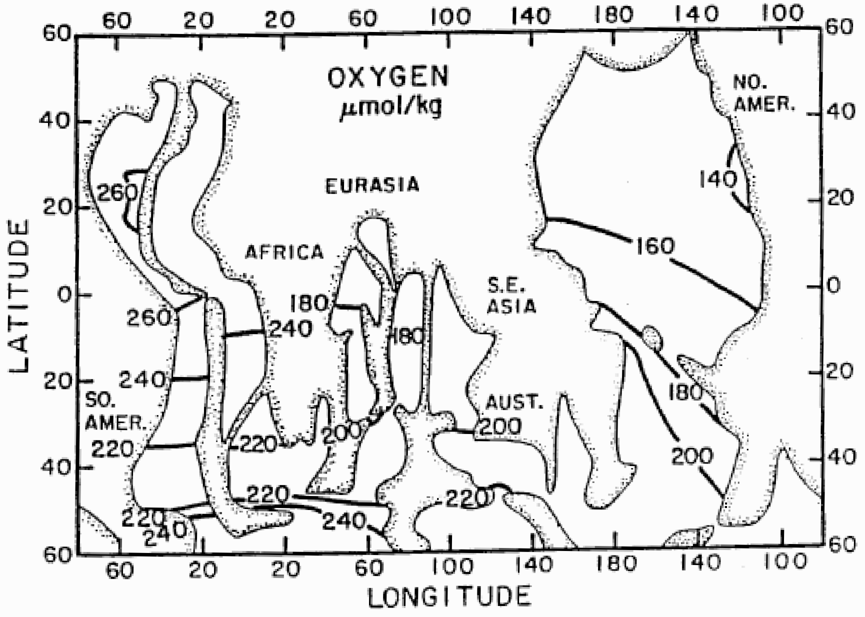


Biology and Physics influence Chemistry

Circulation sweeps nutrients toward the Pacific, and productivity tends to trap them there.

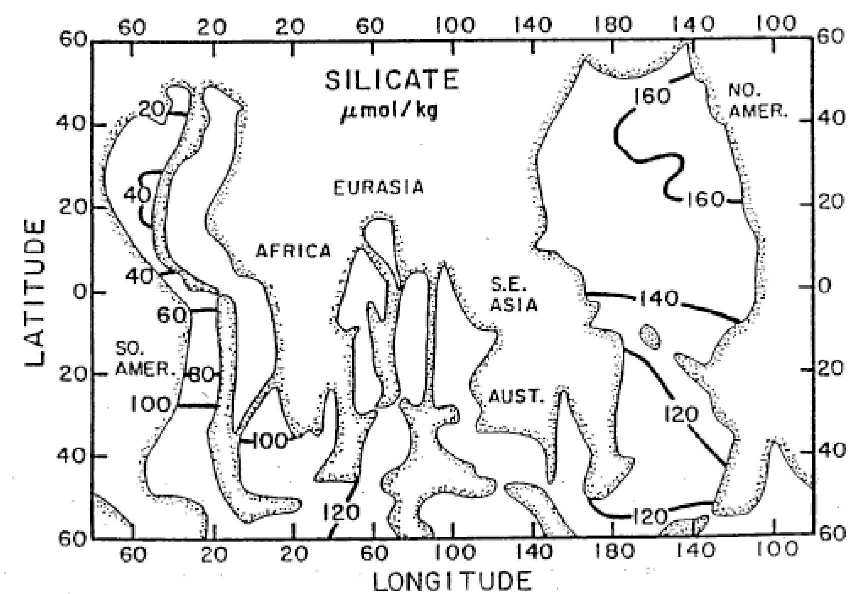


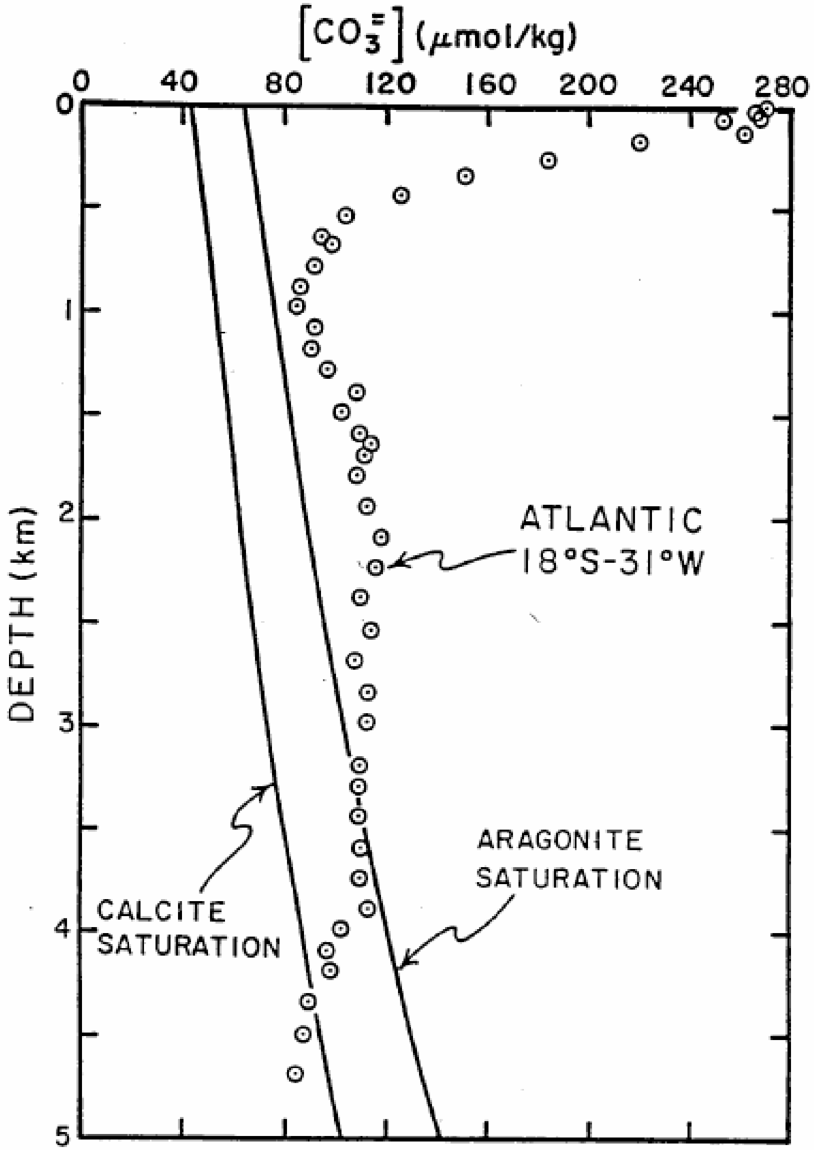




From Atlantic to Pacific Ocean:

Oxygen declines and silica increases in the deep water.





$CaCO_3$ more soluble in the deep ocean:

Pressure effect combines with lower $[CO_3^{=}]$.

Sedimentary sequence evolves through time.

Sediment cores will reflect that evolution, and can be used for reconstruction.