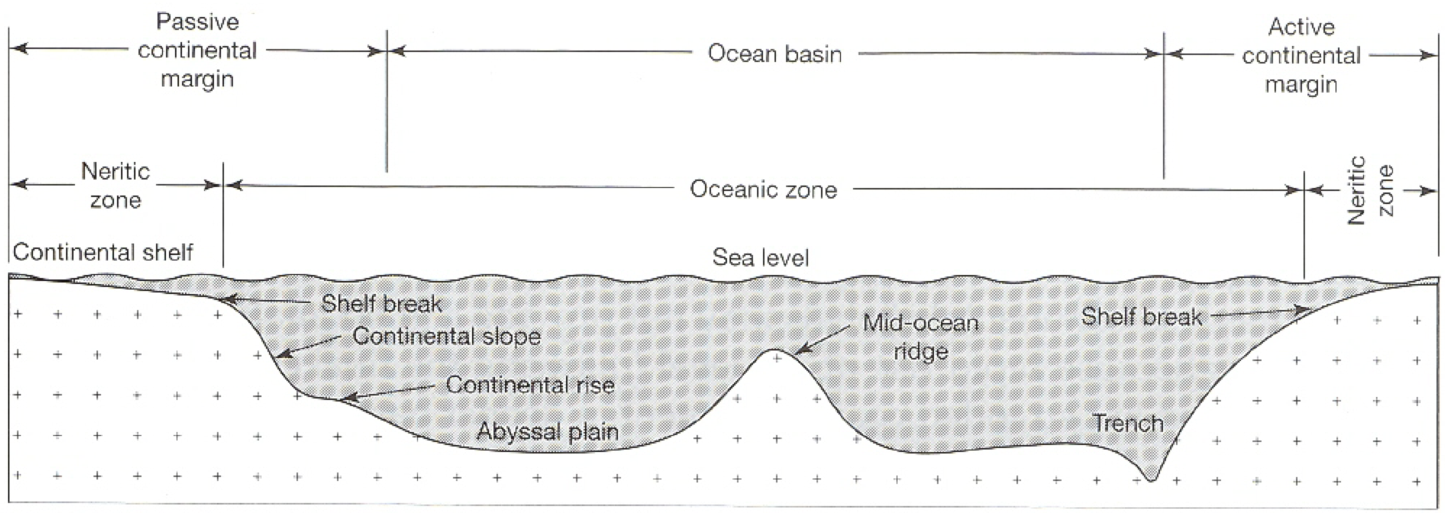
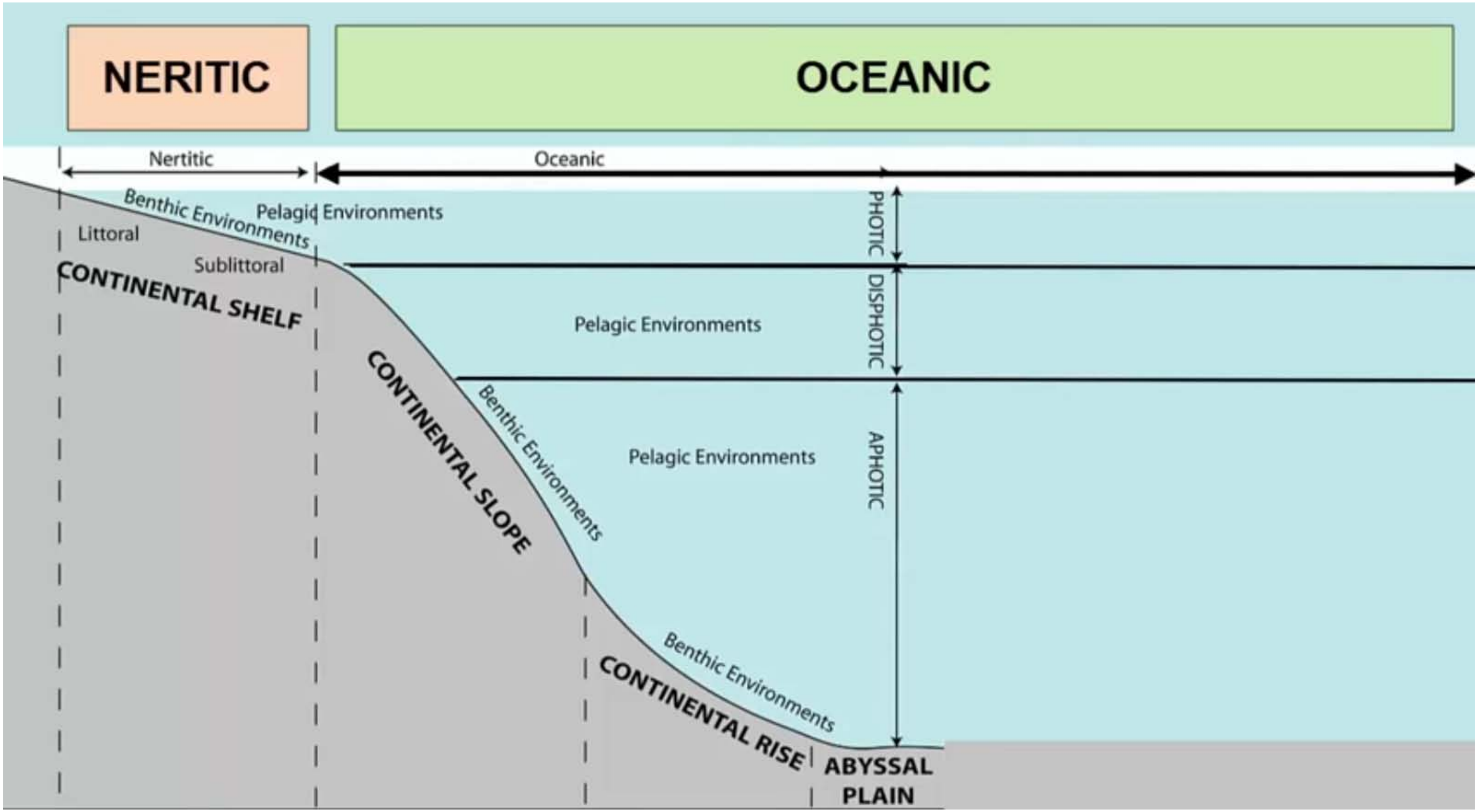
The shelf environment

+ the reef environment

The marine environment



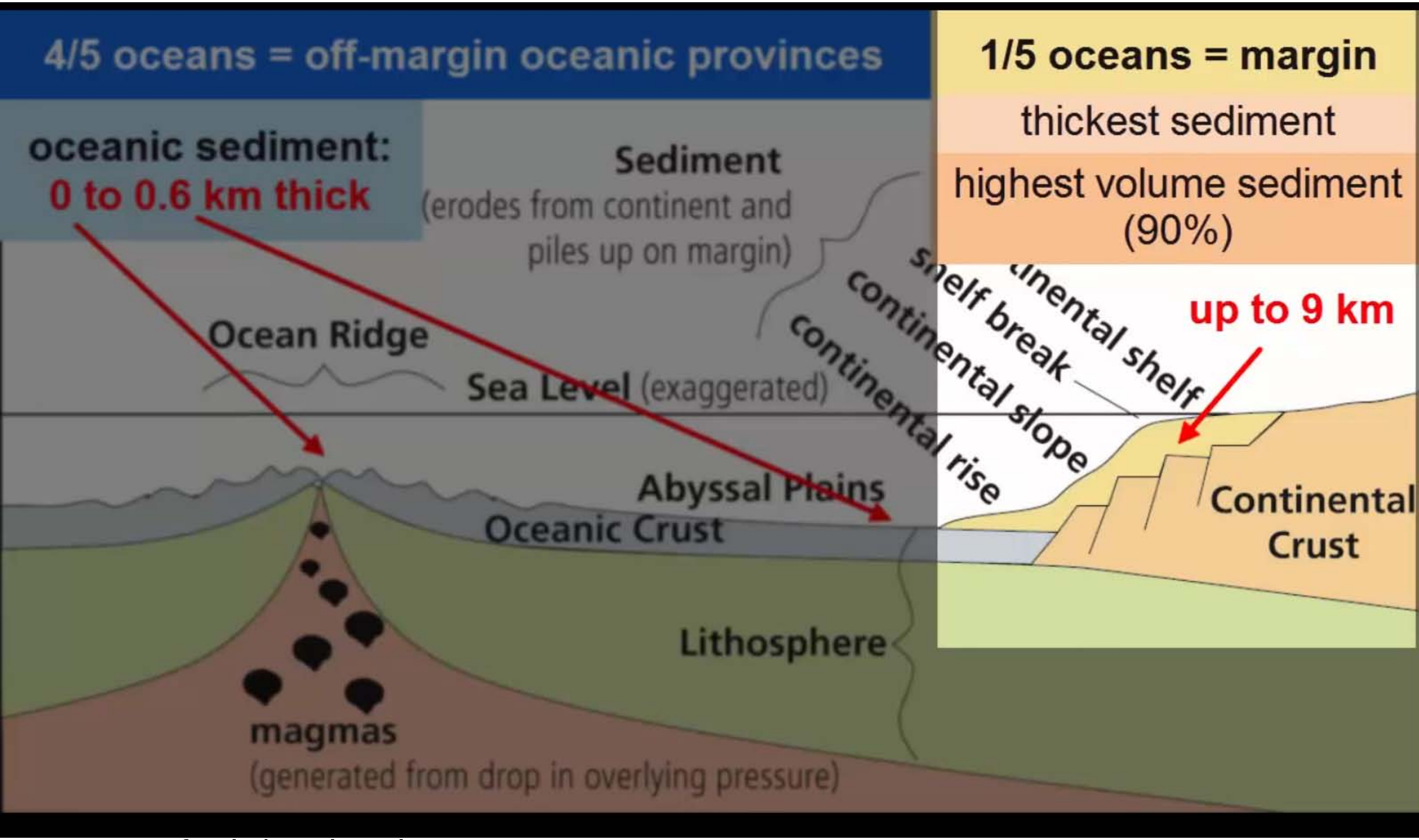
Subdivisions



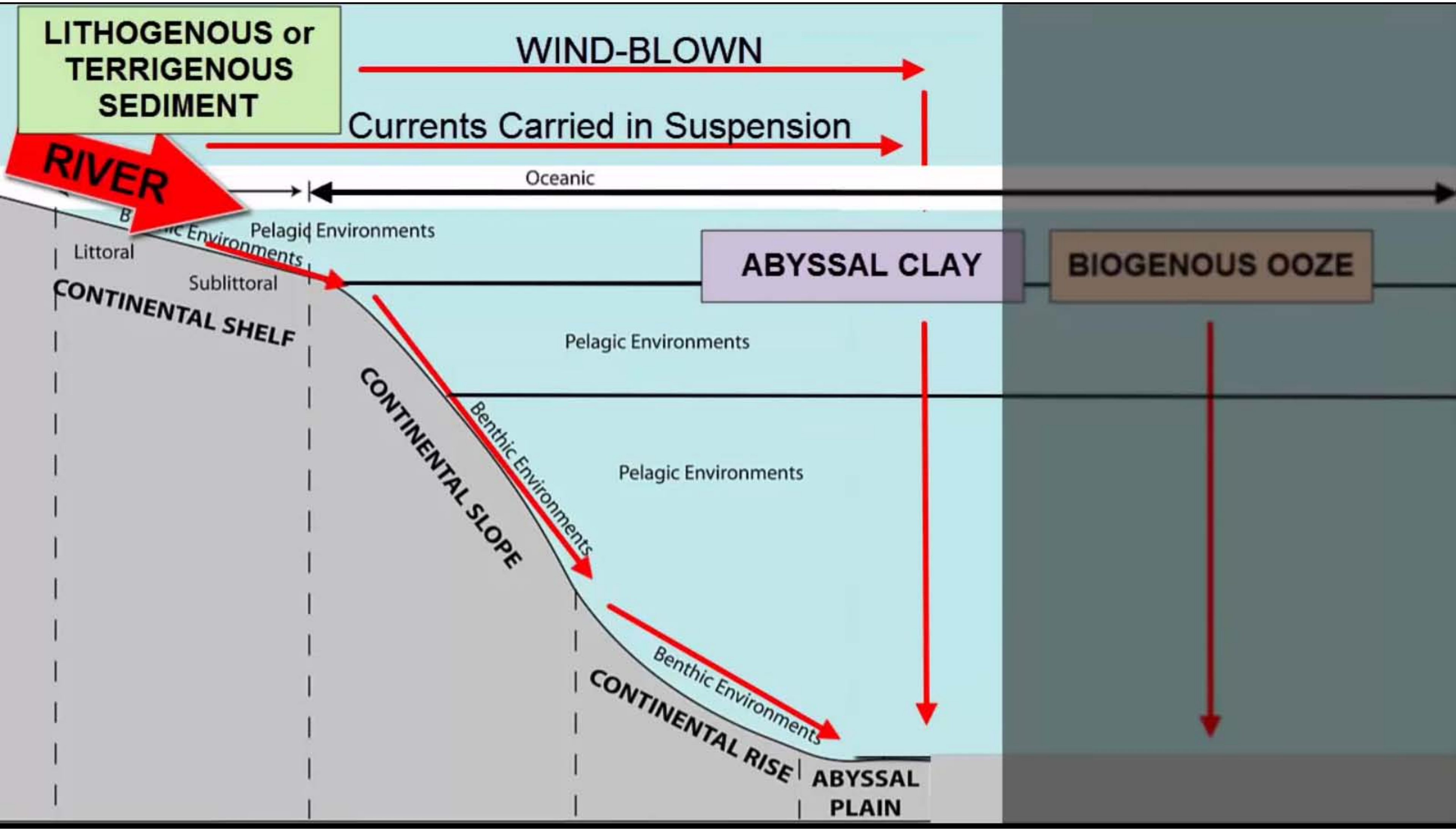
www.ccsf.edu/earthrocks

https://www.youtube.com/channel/UCBEwiHo718rNAekZrqjjDjQ

Sediments along ocean margins



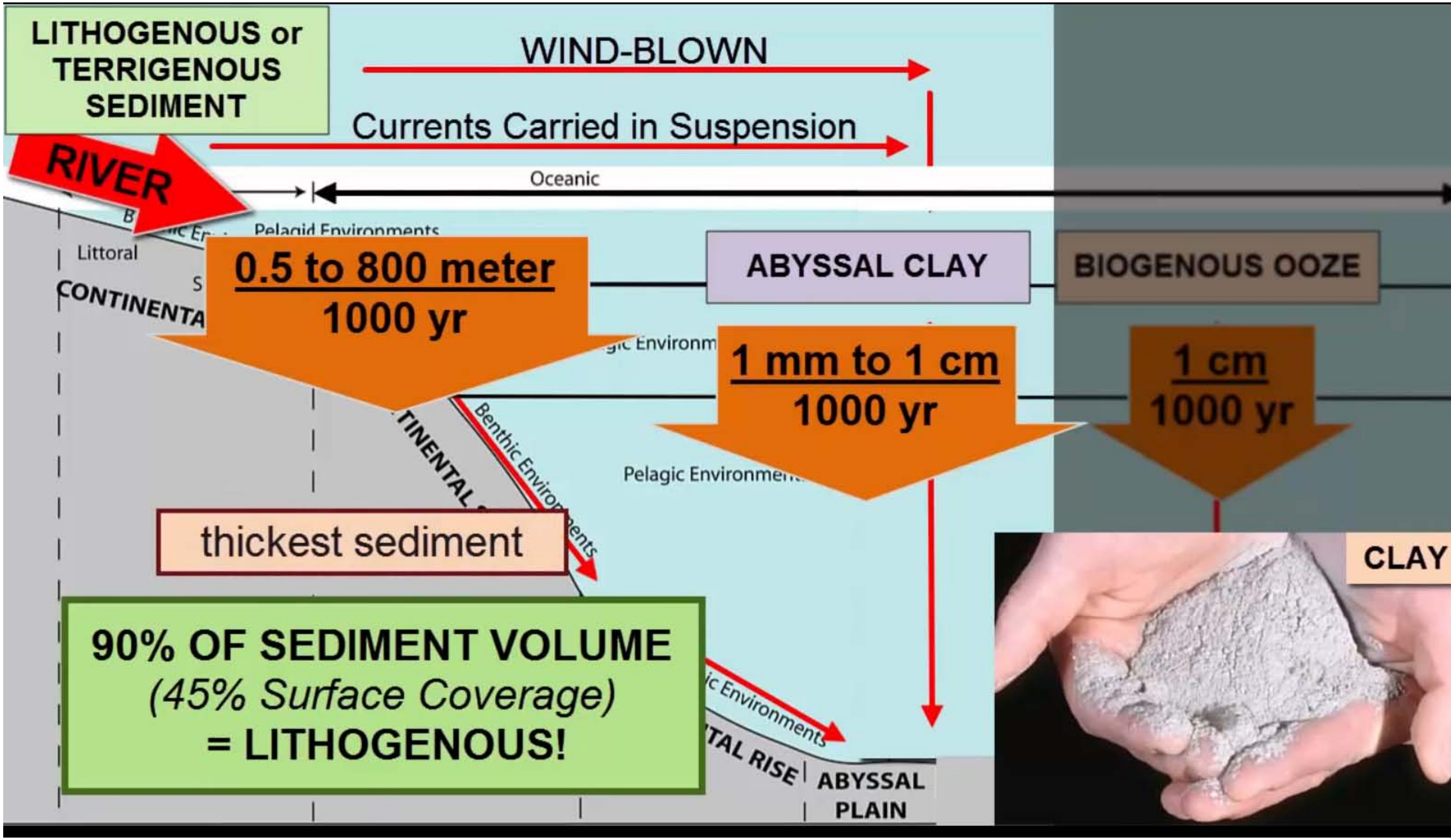
Terrigenous sediments



www.ccsf.edu/earthrocks

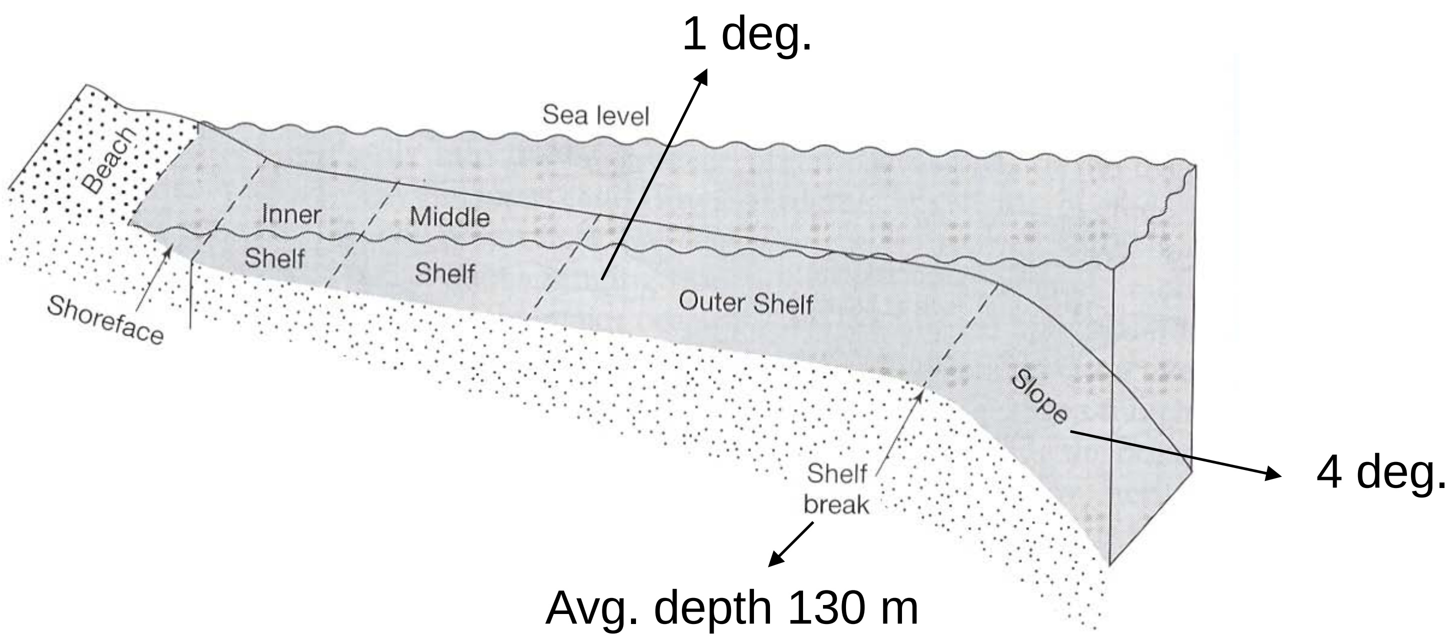
https://www.youtube.com/channel/UCBEwiHo718rNAekZrqjjDjQ

Sediment volume

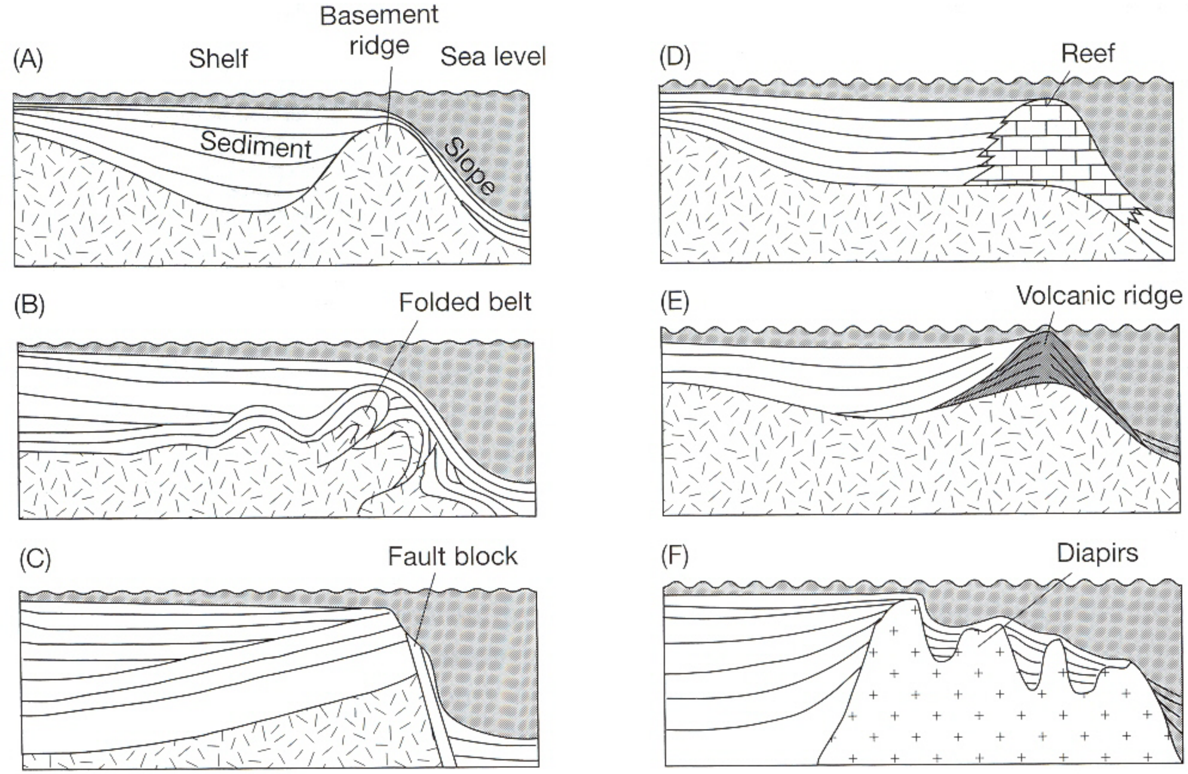


https://www.youtube.com/channel/UCBEwiHo718rNAekZrqjjDjQ

Subdivisions of the continental shelf



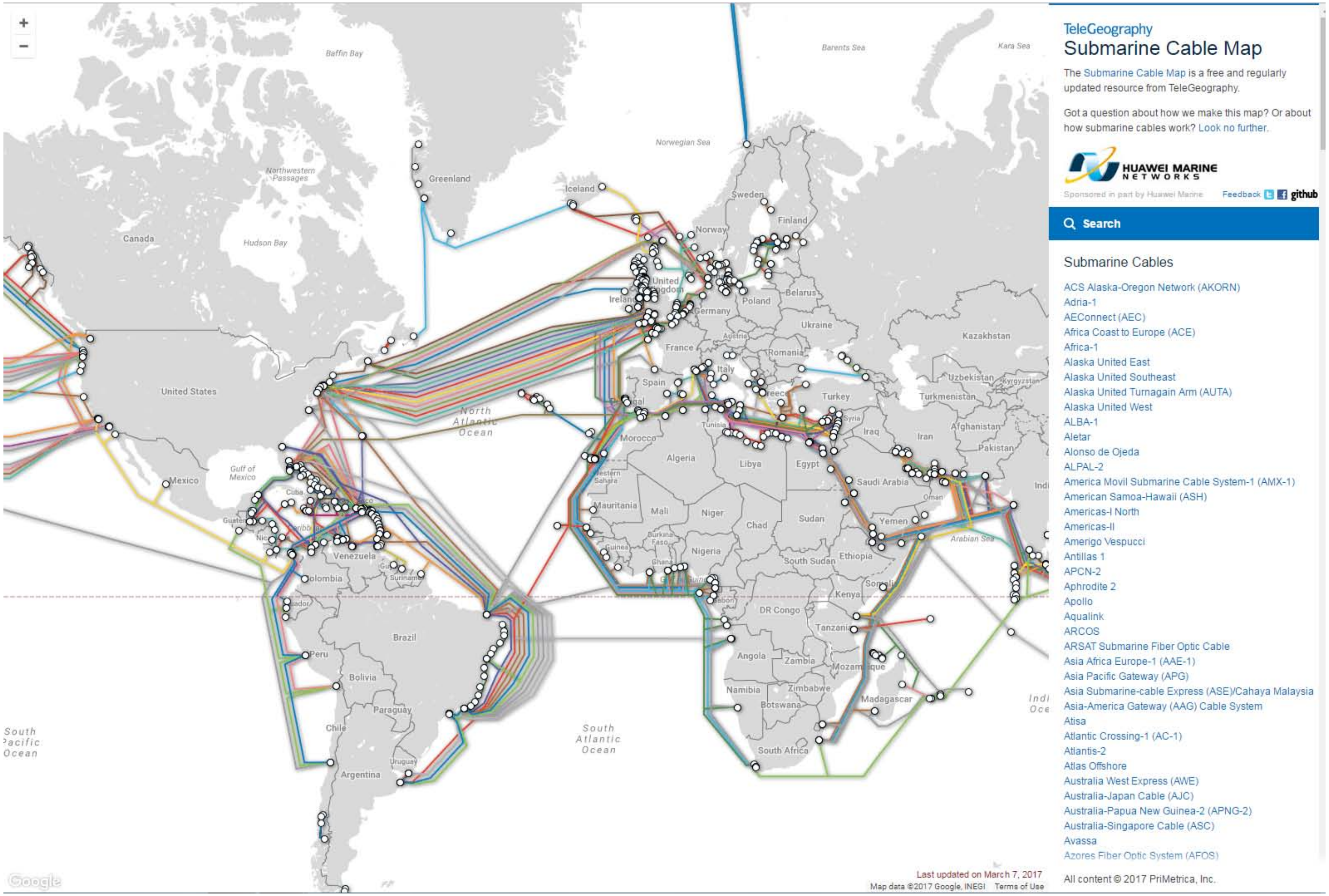
Margins of continental shelves



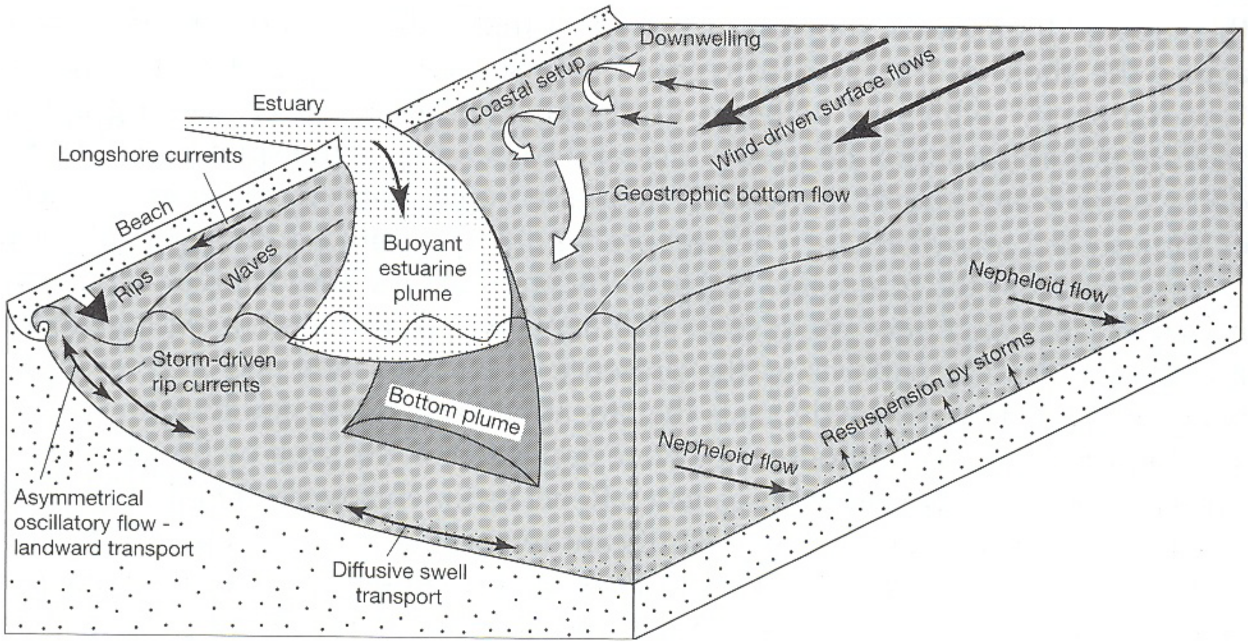
Why study ocean floor and sediments?

- Important for things like
  - navigation safety
  - coastal erosion and sea level rise,
  - Fisheries
  - earthquake and tsunami hazards
  - Offshore infrastructures (e.g., submarine cables)
  - And of course... understanding the earth!

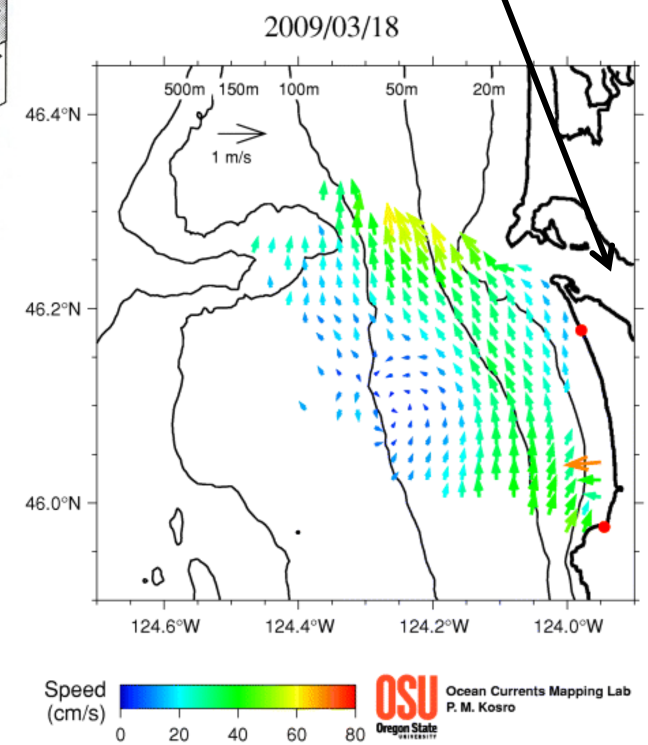
Submarine Telecom Cable Map



Wave- and storm-dominated shelves



Columbia River
Oregon Coast



Sable Is. Bank

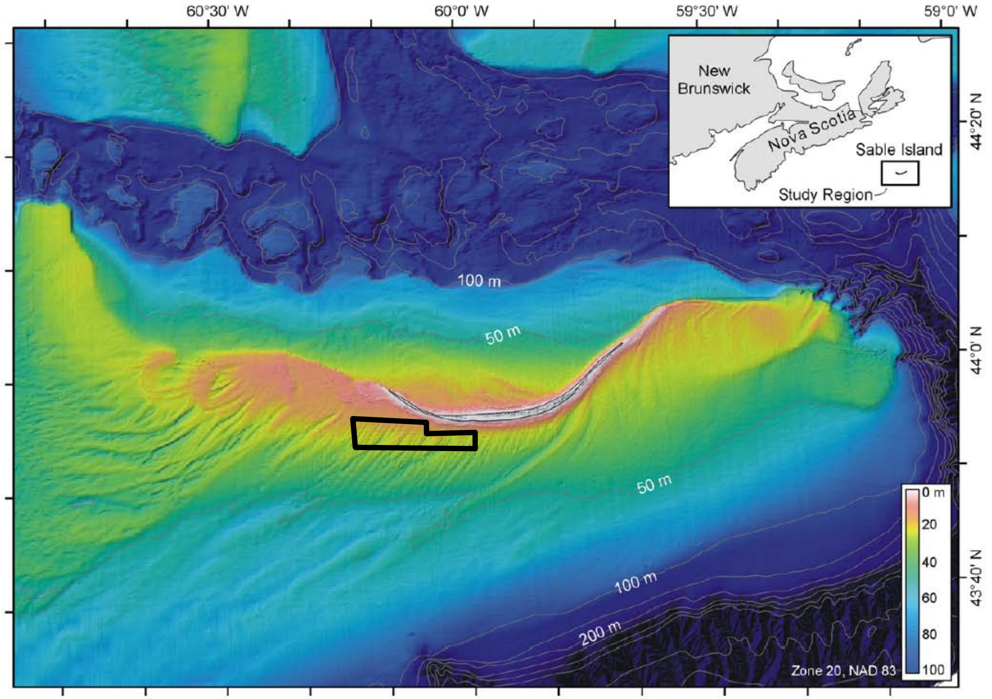


Fig. 1. Shaded bathymetry map of Sable Island Bank, compiled from Canadian Hydrographic Service bathymetric charts, showing the study area and the prominent NE–SW trending shoreface-connected and offshore sand ridges.

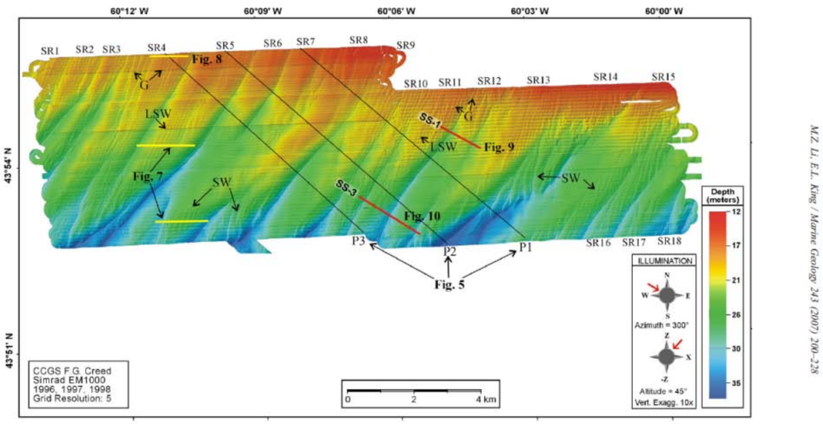


Fig. 3. Shaded-relief color multibeam bathymetry of the South Sable area showing sand ridges (marked SR1–SR18) and superimposed sand waves (SW), linear-crest sand waves (LSW) and gutters (G). The bathymetric data are illuminated from the northwest at 45° from the horizon. Long black lines (labeled P1, P2 and P3) represent the sand ridge profiles shown in Fig. 5. Yellow lines (top to bottom) are the locations of gutter, LSW, and SW profiles shown in Figs. 7 and 8, respectively. The thick red lines (SS-1 and SS-3) indicate the locations of sand ridge transects presented in Figs. 9 and 10, respectively.

M.Z. Li, E.L. King / Marine Geology 243 (2007) 200–228

Li and King, 2007. Marine Geology 243 (2007) 200–228

Sediment facies of sand ridges

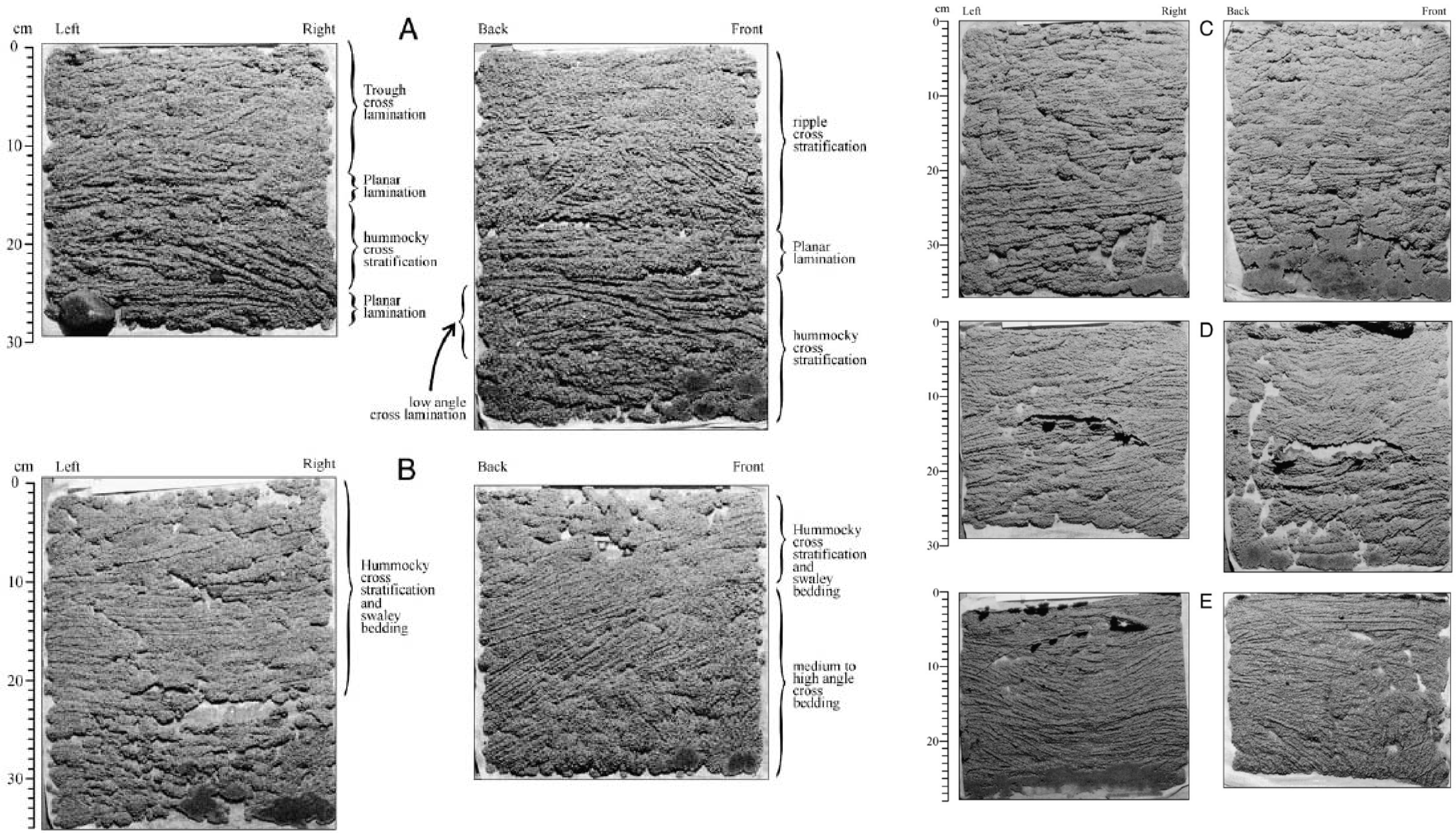


Fig. 18. Resin peels collected along CoPan-1 sand-ridge transect illustrating shallow subsurface sedimentary structures: A, lower stoss side; B, mid-stoss side; C, sand ridge crest; D, mid-lee flank; E, lower lee flank. In C–E, B (back), F (front) indicate back and front, and R (right), L (left) indicate right and left relative to the ship's orientation.

Li and King, 2007. Marine Geology 243 (2007) 200–228

Effect of glaciations on continental shelves

BOREAS 36 (2007) *Glacial landforms on German Bank, Scotian Shelf* 149

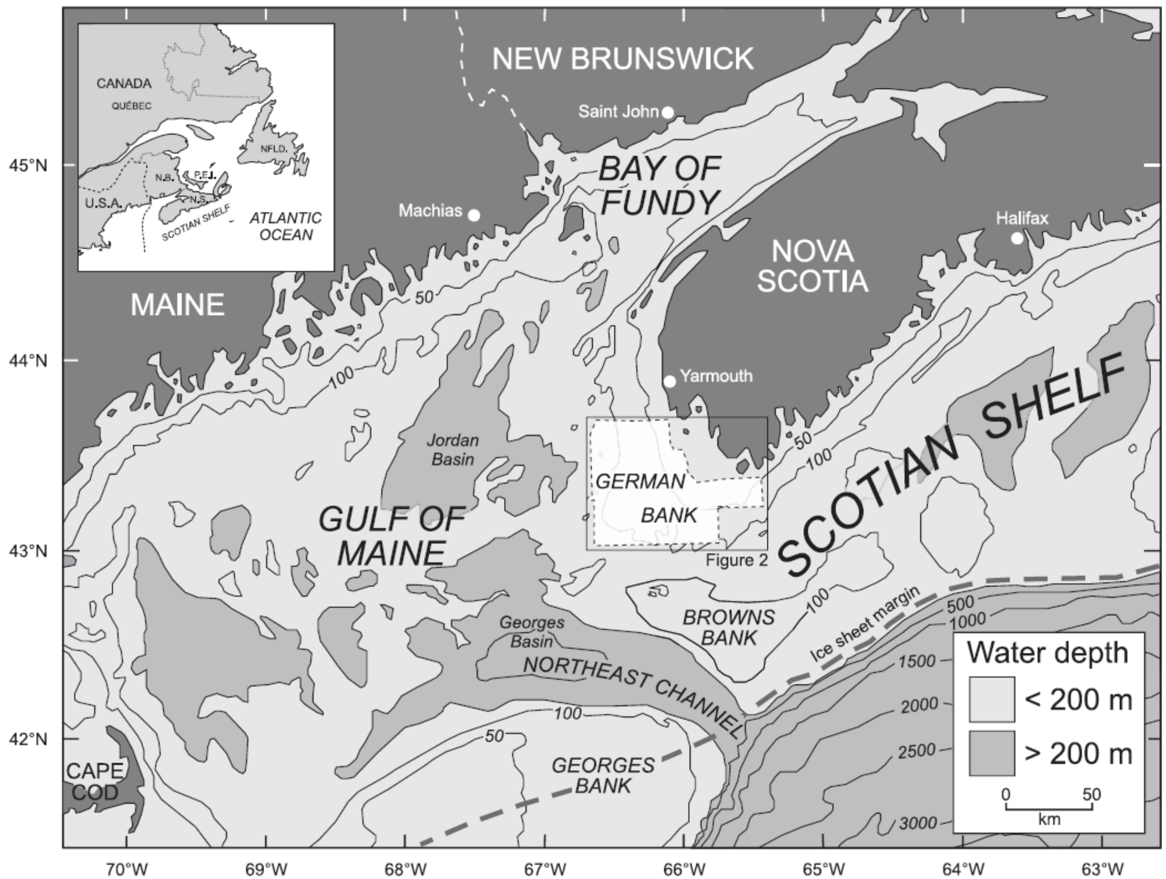


Fig. 1. Location map showing the dashed outline of the multibeam survey area of German Bank on the southwestern Scotian Shelf. These data are shown in Fig. 2. Labelled ice sheet margin on the continental shelf shown by black dashed line.

Todd, B. J., Valentine, P. C., Longva, O. & Shaw, J. 2007 Boreas, Vol. 36, pp. 148169.

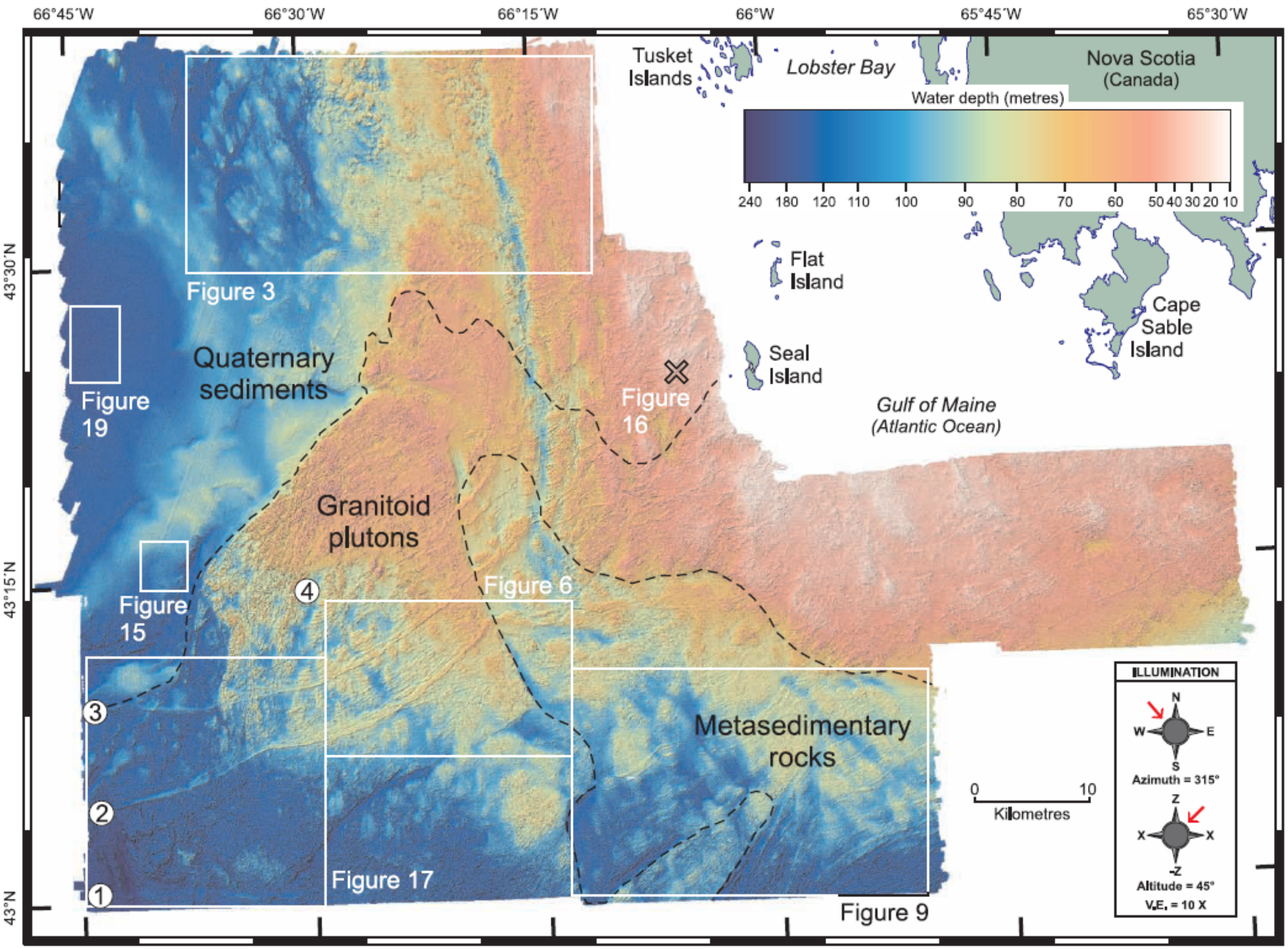


Fig. 2. Seabed topography of German Bank based on multibeam sonar mapping. Locations of multibeam topographic images in subsequent figures are indicated by white, labelled boxes. Dashed black lines mark approximate geological boundaries (Todd *et al.* 2005). Artificial illumination and vertical exaggeration of the multibeam sonar image is illustrated in this figure (and subsequent figures containing similar imagery) by the inset box (lower right). In this case, the direction of illumination is from 315° at an elevation above the horizon of 45° with a vertical exaggeration of 10 times. The horizontal resolution of the image is 50 m. The water depth colour bar (upper right) is hypsometrically optimized for the water depth range in the image. Note that the colour bars for subsequent figures containing similar imagery are optimized for their specific water depth ranges. The white circles at the left labelled 1–4 identify regional moraines. The open cross west of Seal Island marks the location (43°24.254′N, 66°5.873′W) of recovered *Crassostrea virginica* (American oyster) specimens and the relative sea level curve shown in Fig. 16 and described in the Discussion.

Todd, B. J., Valentine, P. C., Longva, O. & Shaw, J. 2007 Boreas, Vol. 36, pp. 148169.

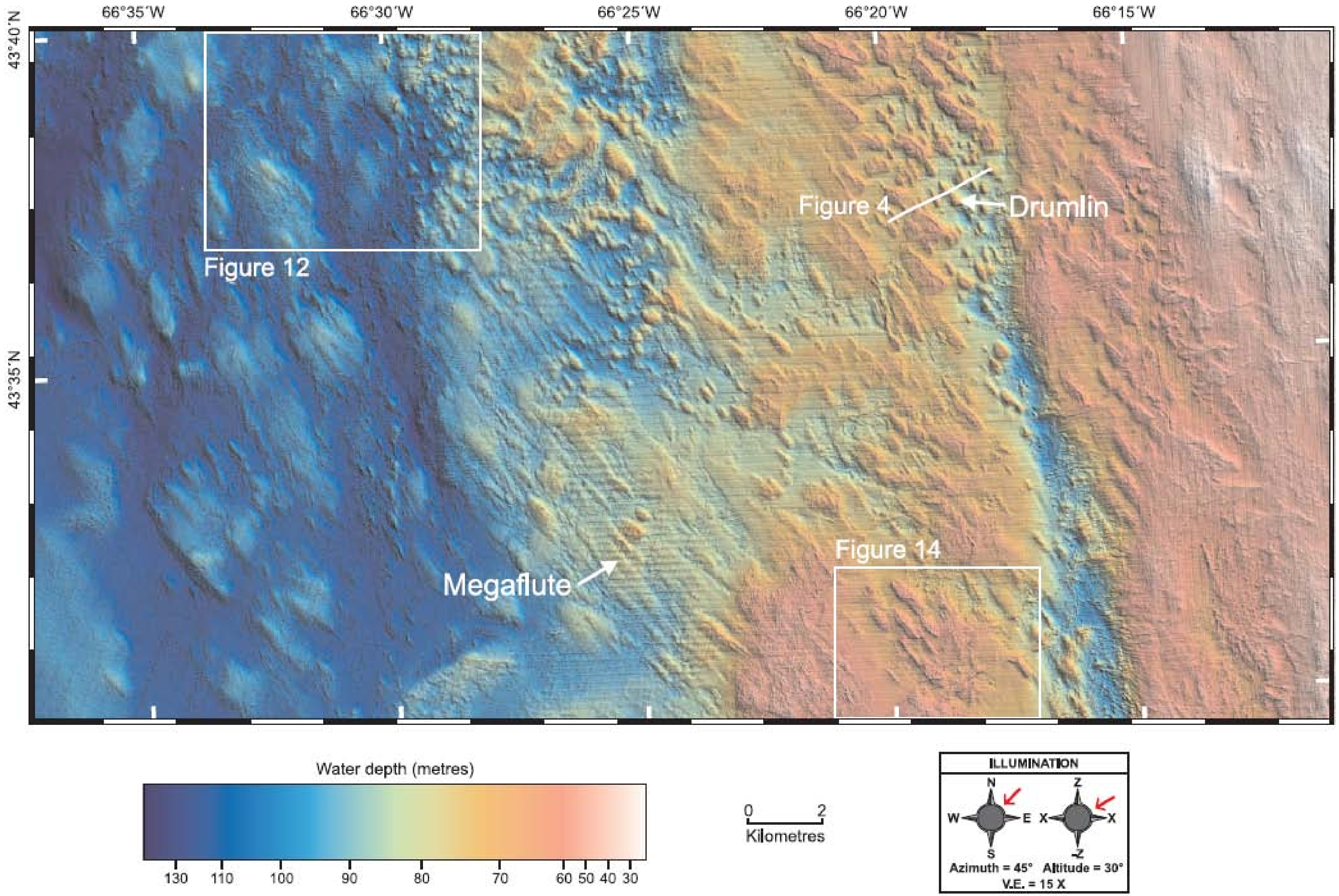


Fig. 3. Drumlinized terrain and megaflutes on northern German Bank. See Fig. 2 for location. Horizontal resolution of this image, and all subsequent multibeam sonar images, is 5 m. The white line indicates the location of the seismic reflection profile in Fig. 4.

Todd, B. J., Valentine, P. C., Longva, O. & Shaw, J. 2007 Boreas, Vol. 36, pp. 148169.

Glacial sediments on the shelf

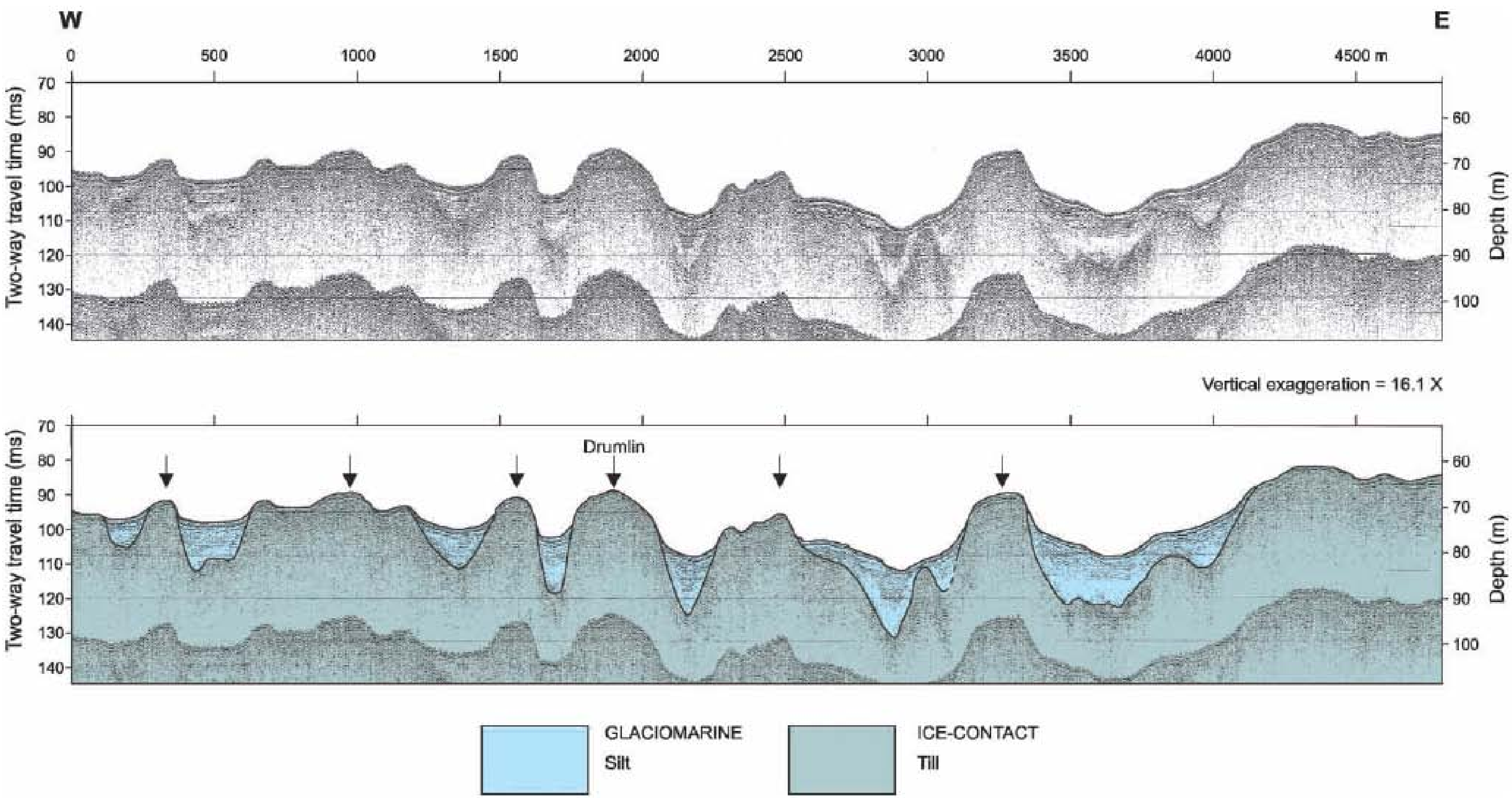


Fig. 4. Seismic reflection profile (upper) and interpreted geological cross-section (lower) of drumlinized terrain, northern German Bank. Arrows indicate drumlins. See Fig. 3 for location of profile (CCGS *Hudson* 2003-054, Line 14, Day 254, 0410-0440).

Todd, B. J., Valentine, P. C., Longva, O. & Shaw, J. 2007 Boreas, Vol. 36, pp. 148169.

Moraines

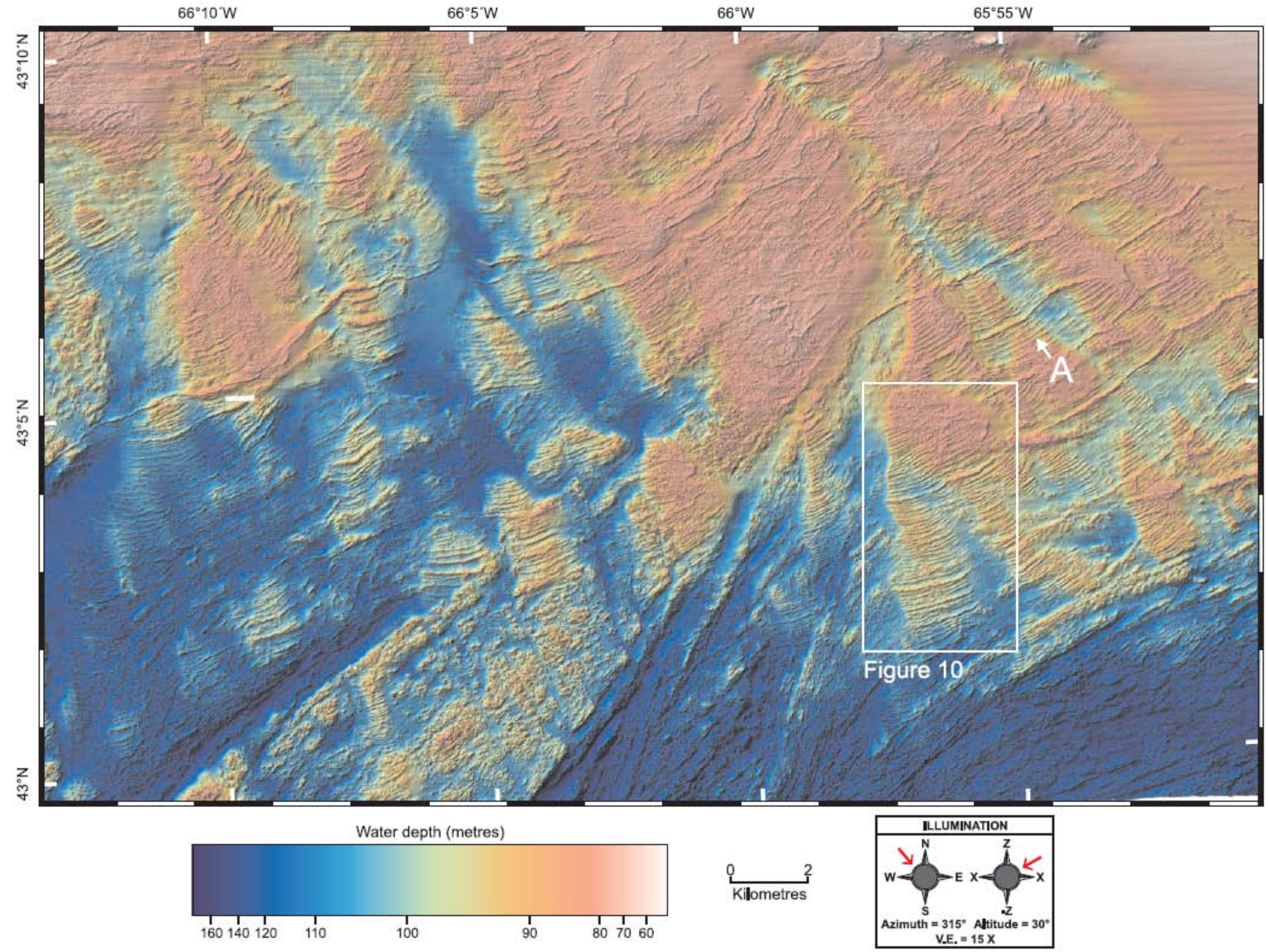
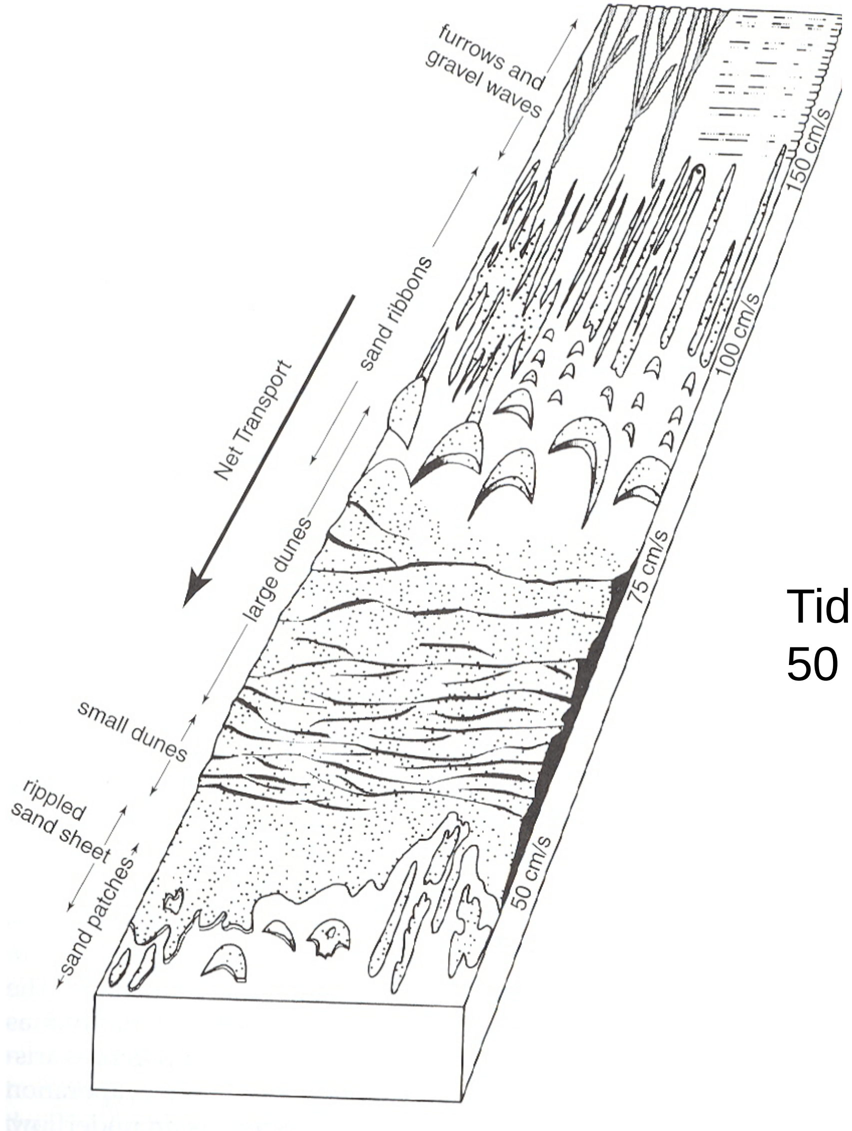


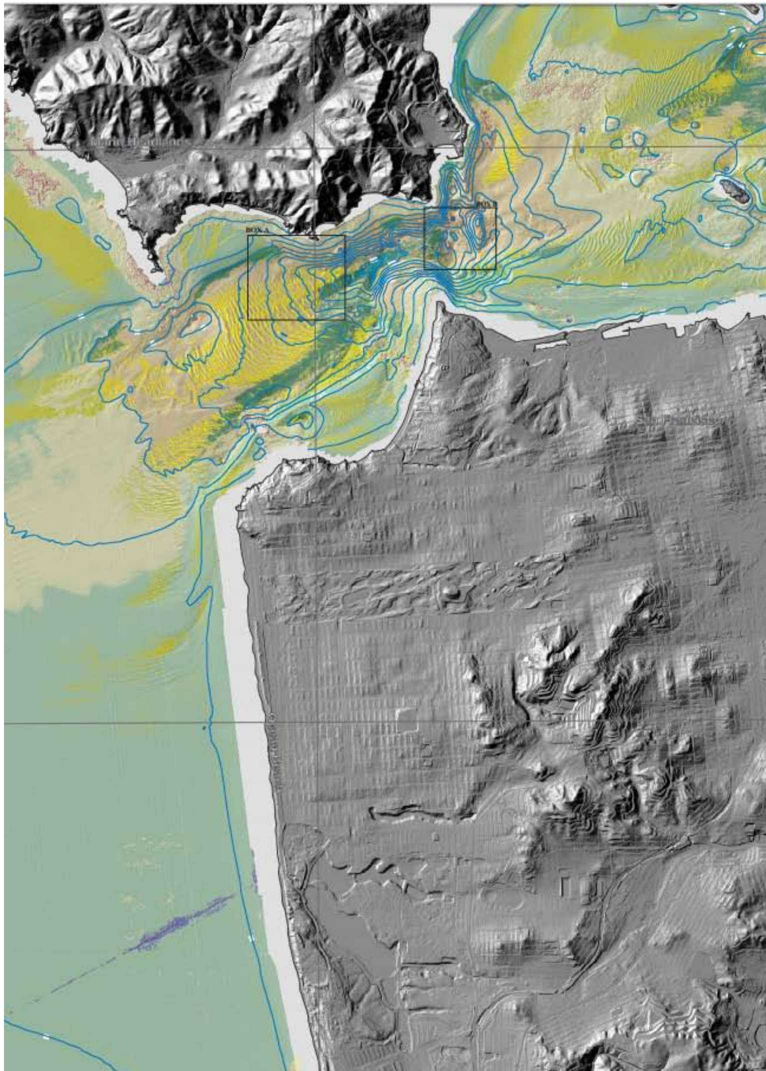
Fig. 9. De Geer moraines and regional fluting on southeast German Bank. See Fig. 2 for location. Well-defined moraines at location A have regularly spaced crests 150–200 m apart.

Todd, B. J., Valentine, P. C., Longva, O. & Shaw, J. 2007 Boreas, Vol. 36, pp. 148169.

Tide-dominated shelves



Tidal currents
50 to 150 cm/s



ZONE 2—INTERTIDAL TO 30 METERS WATER DEPTH

SLOPE CLASS 1—0 TO 5 DEGREES

SLOPE CLASS 2—5 TO 30 DEGREES

ZONE 3—30 METERS TO 100 METERS WATER DEPTH

SLOPE CLASS 1—0 TO 5 DEGREES

SLOPE CLASS 2—5 TO 30 DEGREES

ZONE 4—100 METERS TO 200 METERS WATER DEPTH

SLOPE CLASS 1—0 TO 5 DEGREES

SLOPE CLASS 2—5 TO 30 DEGREES

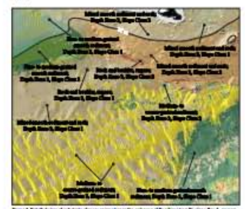
EXPLANATION OF MAP SYMBOLS

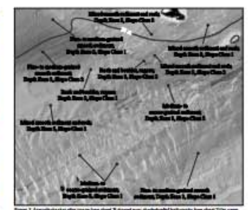
DISCUSSION

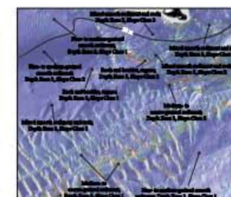
Table 1. Coverage of classified seafloor, in square kilometers (sq km) and percent of total area, broken into California Marine Life Protection Act Depth Zones 2, 3, and 4.

	Total		Depth Zone 2 (water depth 0–30 m)		Depth Zone 3 (water depth 30–100 m)		Depth Zone 4 (water depth 100–200 m)	
	percent	sq km	percent of total	sq km	percent of total	sq km	percent of total	sq km
Fines to medium-grained smooth sediment	70.5	122.0	68.1	117.9	2.3	3.9	0.1	0.2
Mixed smooth sediment and rock	18.2	31.3	11.9	20.7	6.1	10.5	0.1	0.2
Rock and boulder, rugose	0.8	1.4	0.5	0.8	0.3	0.6	<0.1	<0.1
Medium to coarse-grained sediment	10.5	18.1	8.1	13.9	2.4	4.1	<0.1	<0.1
Anthropogenic, smooth, hard (sewers, coarse sediment)	0.1	0.2	0.1	0.2	0.0	0.0	0.0	0.0
Anthropogenic, rugged (pipe)	<0.1	<0.1	<0.1	<0.1	0.0	0.0	0.0	0.0

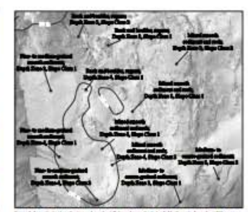
BOX A

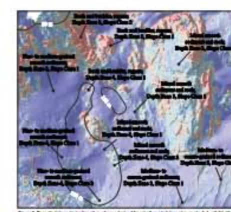






BOX B

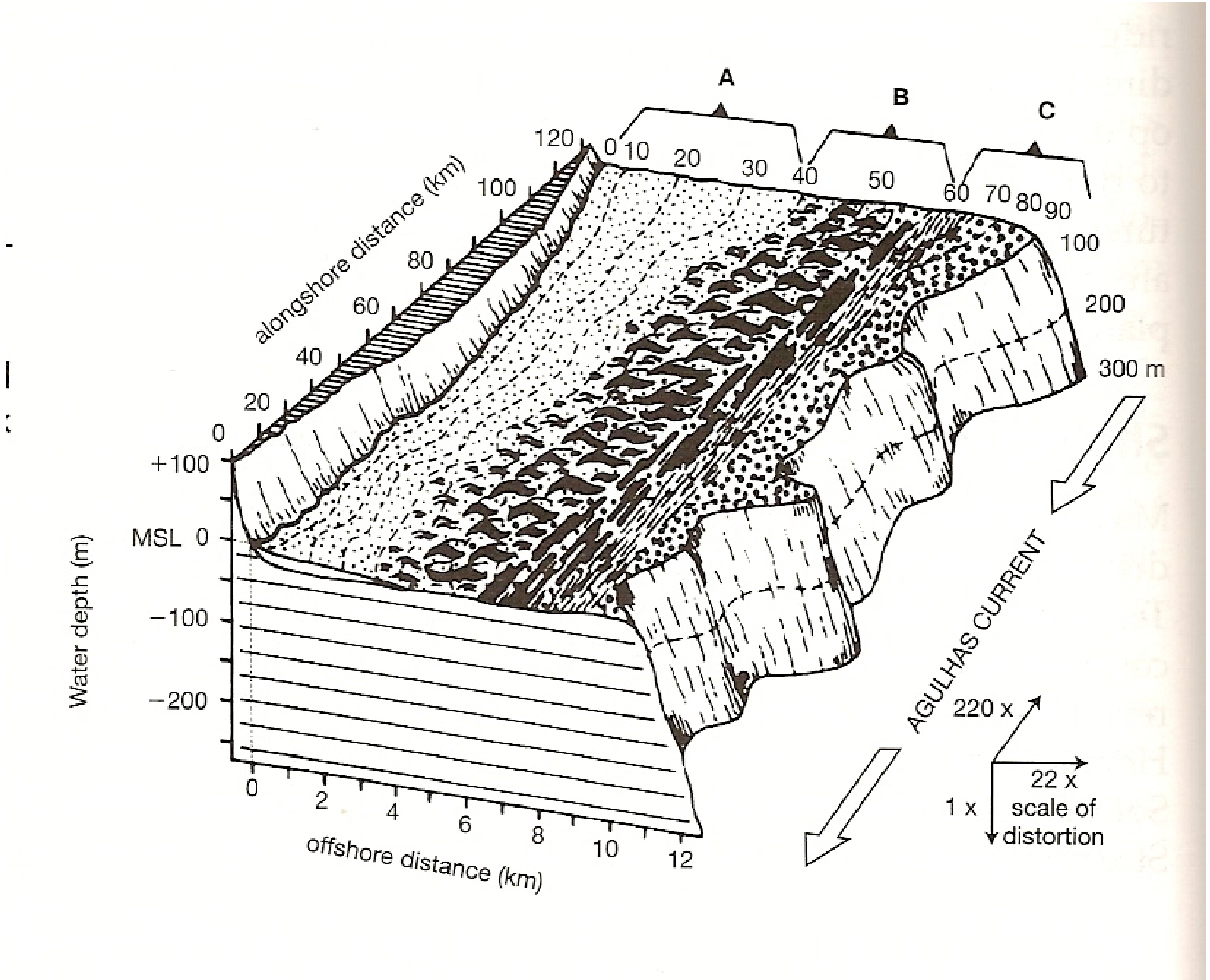




Seafloor Character, Offshore of San Francisco Map Area, California

By
Mercedes D. Erdey and Guy R. Cochrane
2015

Shelves affected by ocean currents

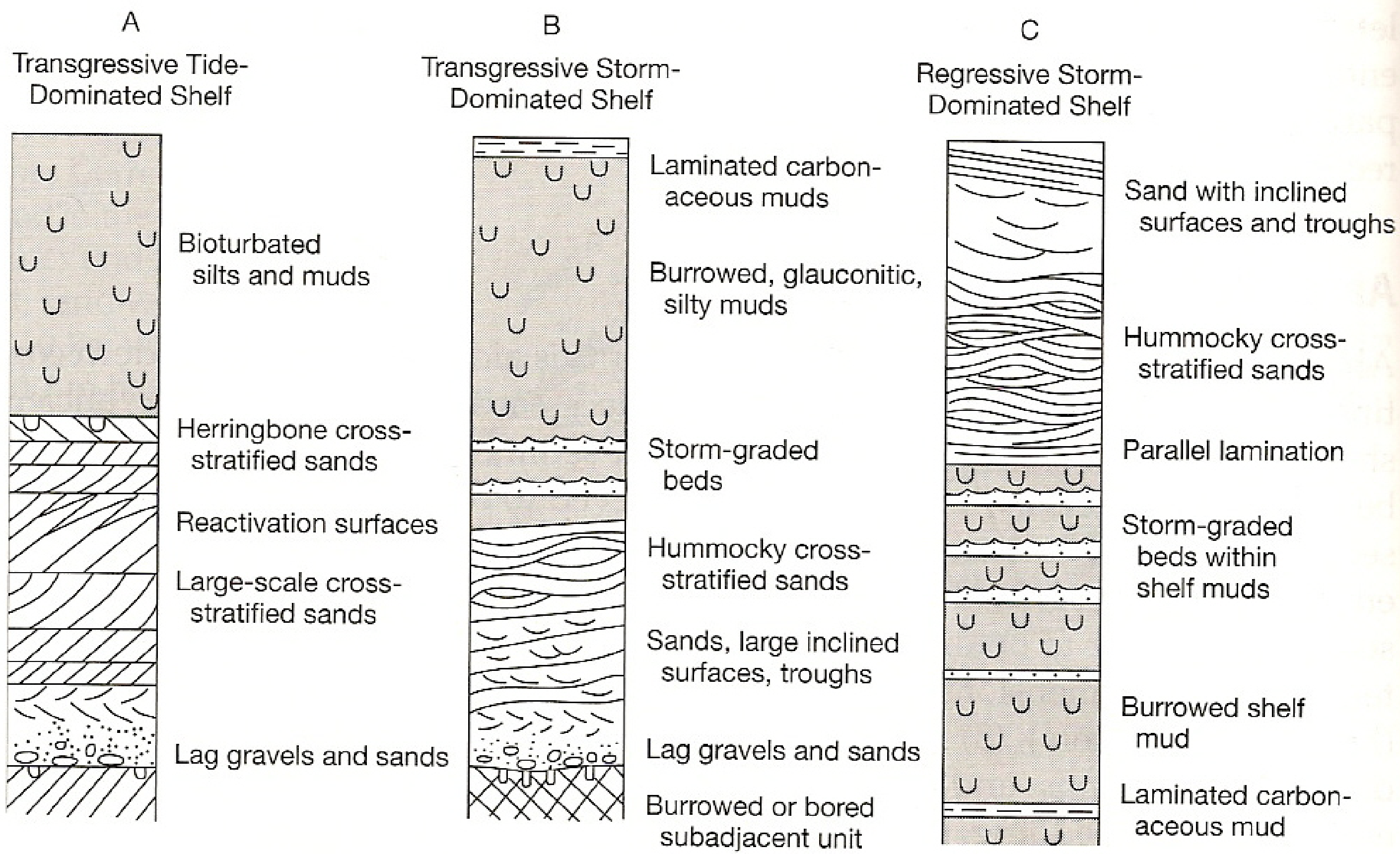


Ancient siliclastic shelf sediments

- Distinguishing characteristics:
  - Sheet-like (tabular) sandstones, sandy siltstones, and mudstones
    - Well-developed, even bedding
    - Cross-bedded sandstone (tide-dominated shelf)
    - Reactivation surfaces
    - Storm beds and hummocky xs-beds or HCS (storm-dominated shelf)
  - Extensive lateral dimensions (> 1000 km^2) and great thickness (> 100 m)
  - Moderate compositional maturity (QFR)
  - Diverse and abundant marine fossil organisms
  - Bioturbation; trace fossils (e.g. *Cruziana*)
  - Well-exposed examples in the Rocky Mtns foothills (Cretaceous); **hydrocarbon reservoirs…**

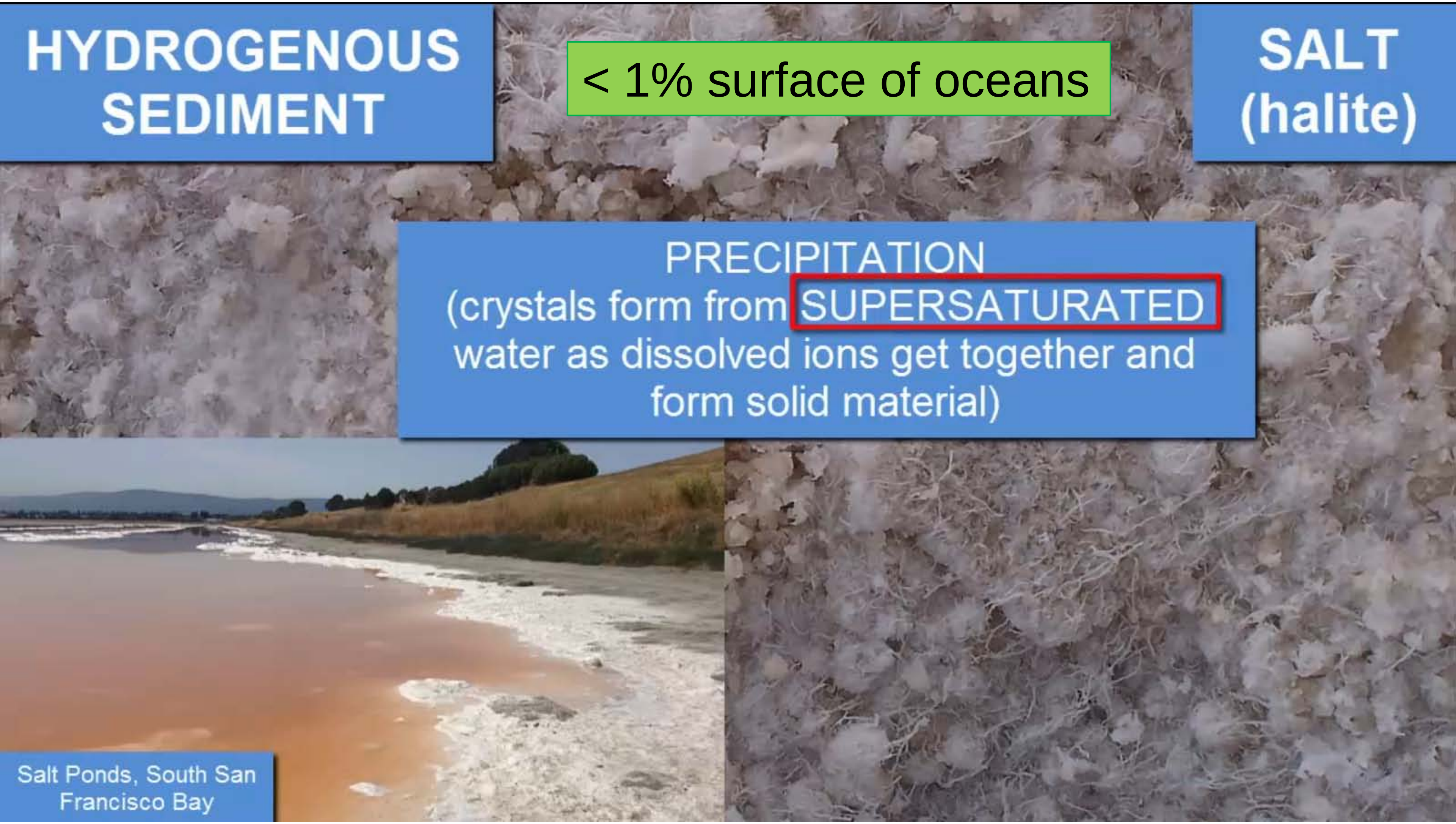
Ancient siliclastic shelf sediments

"idealized" profiles

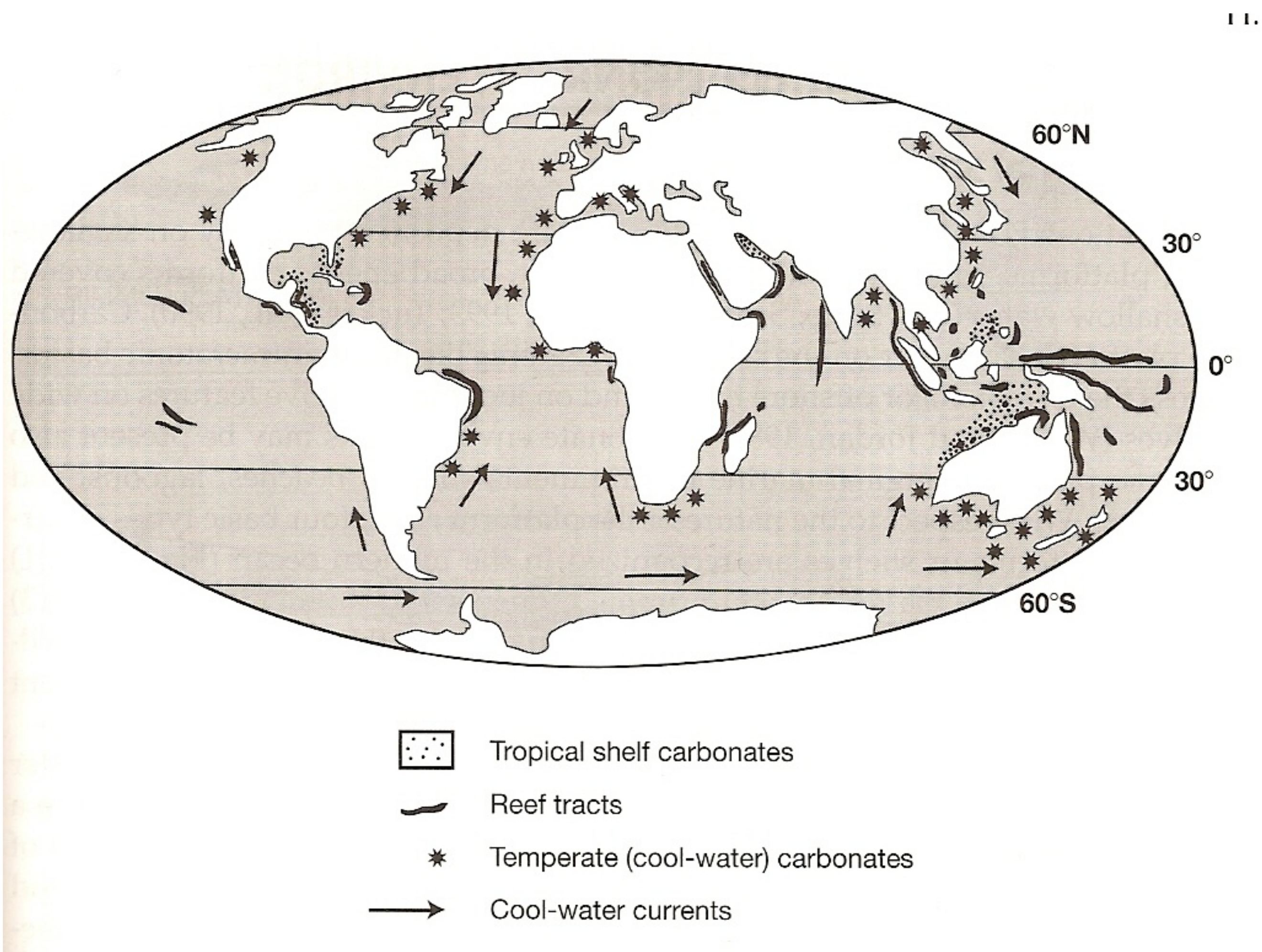


Transgression tends to produce fining-upward successions
Regression produces coarsening-upward successions

Hydrogenous sediment (shallow seas)



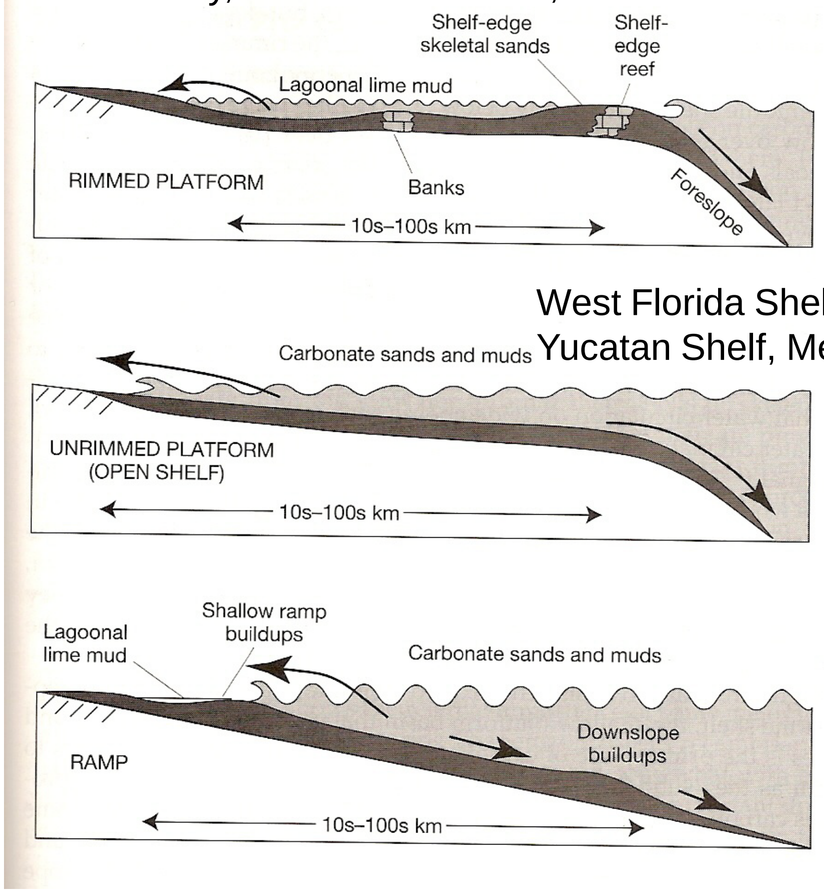
Carbonate environments



Carbonate shelf

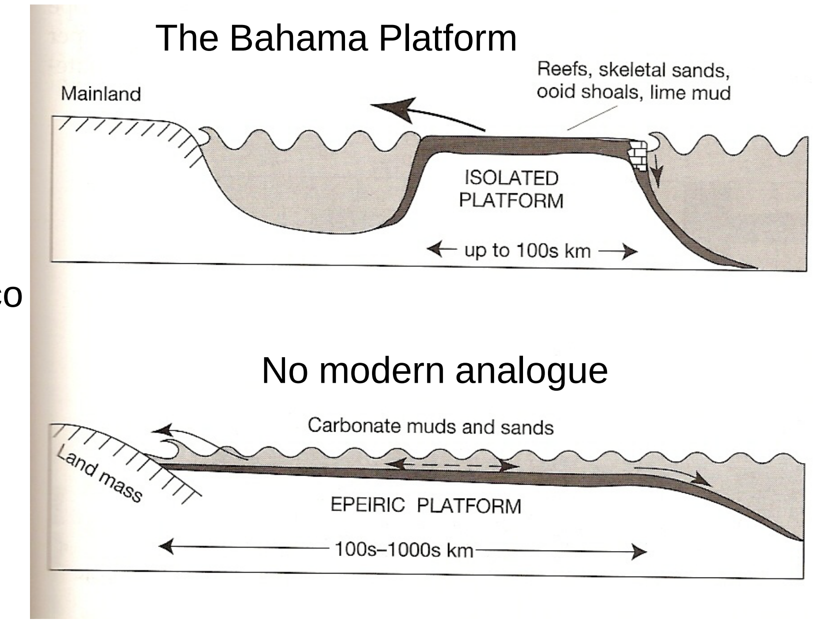
Florida Bay, Great Barrier Reef, Australia

West Florida Shelf; Yucatan Shelf, Mexico

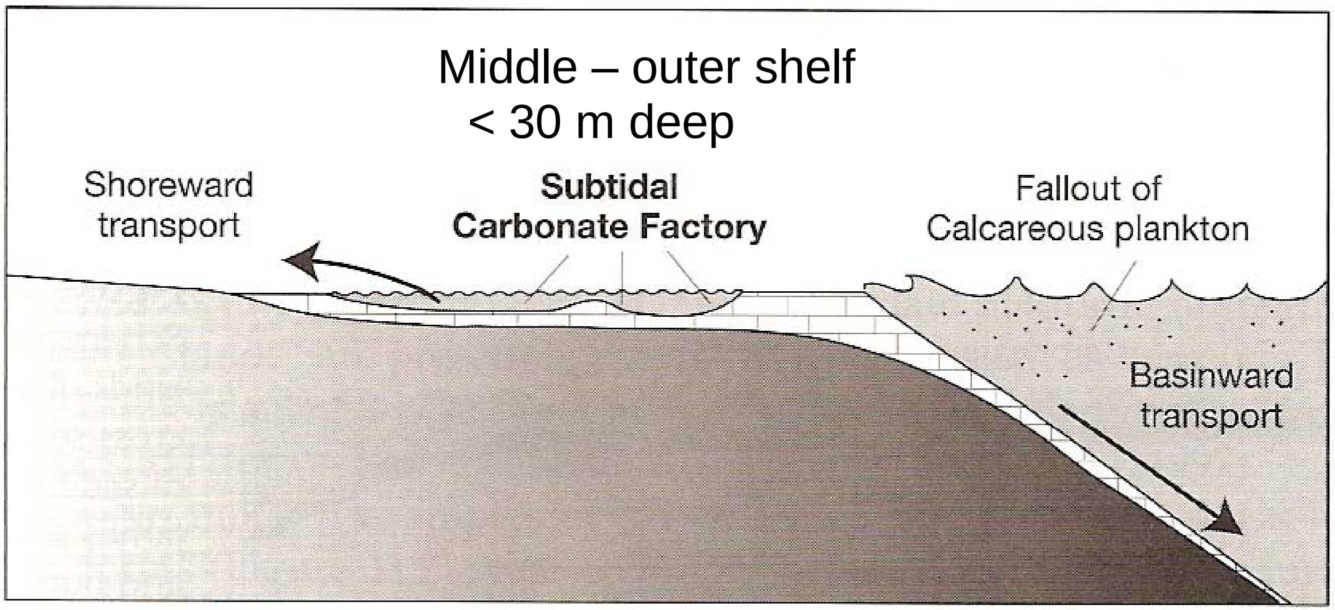


The Bahama Platform

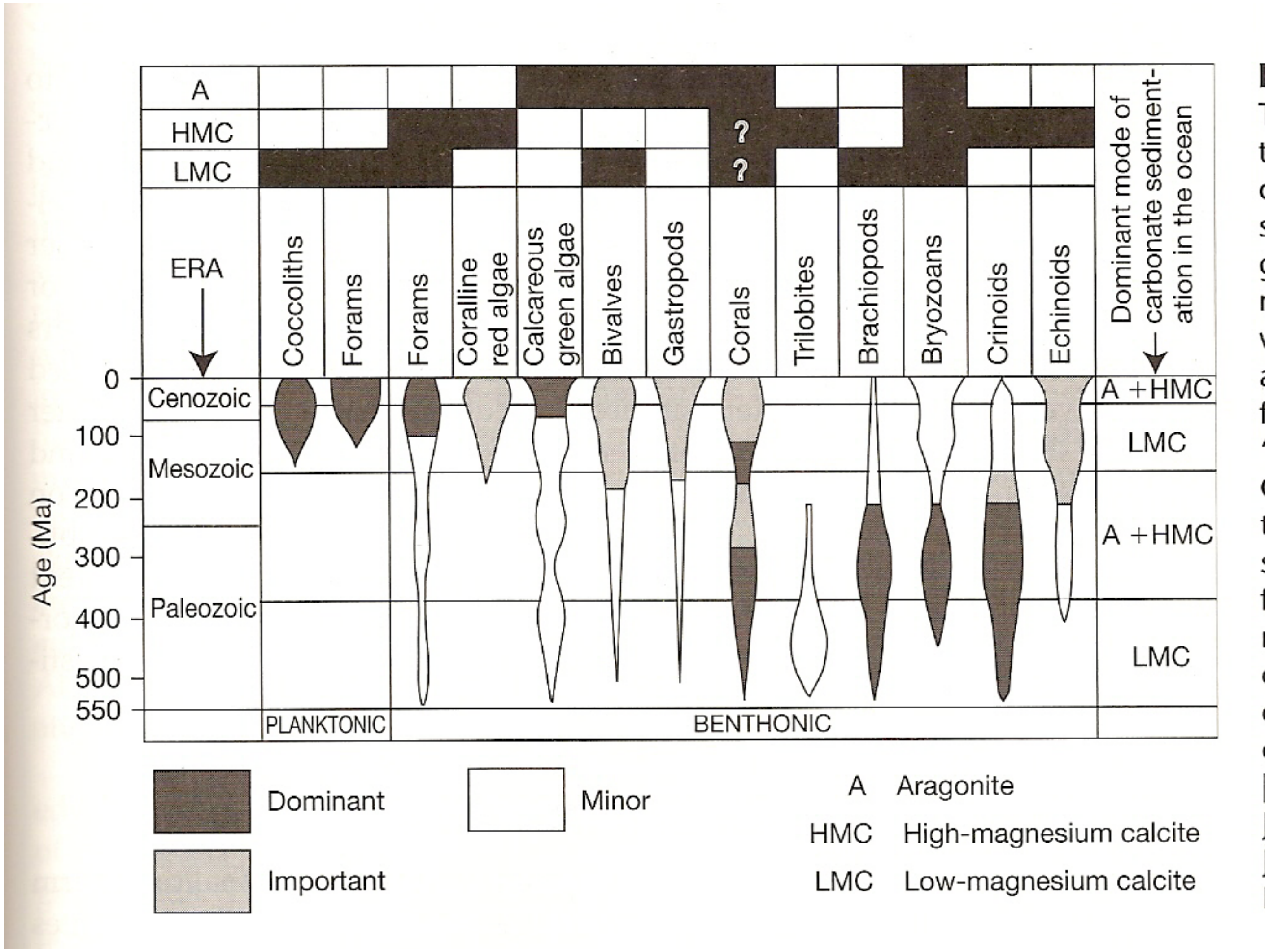
No modern analogue



Marine carbonate production



Marine organisms as sediment producers

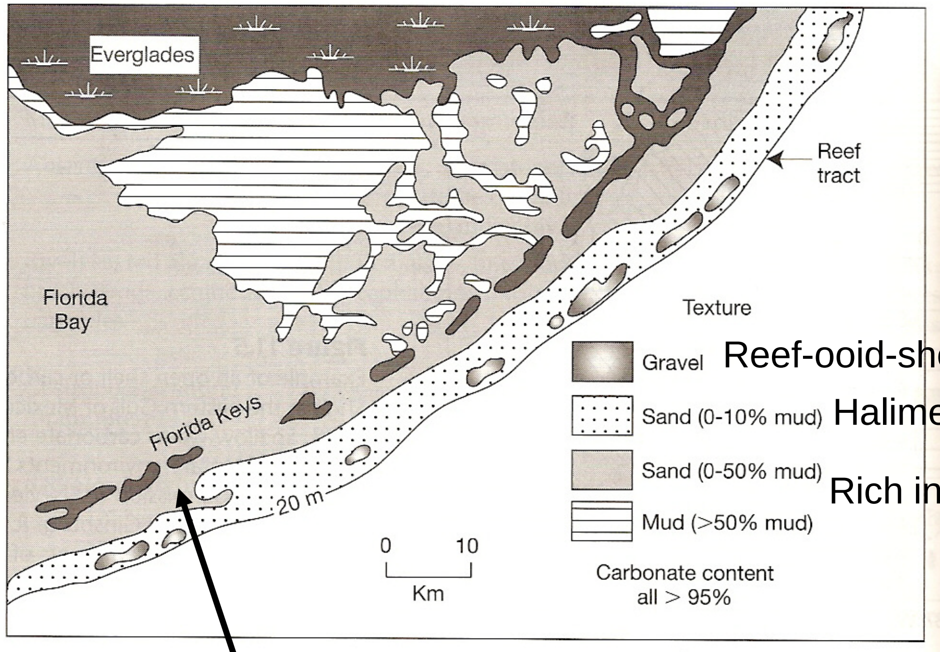


Warm-water vs. cool-water assemblages

- Cool-water assemblages
  - **Heterozoan** associations: Foraminifers and molluscs
- Warm-water assemblages
  - **Photozoan** associations
    - Reef-building corals
    - Calcareous green algae

Florida Bay – a rimmed shelf

Coastal swamps



Reef-ooid-shoal complex

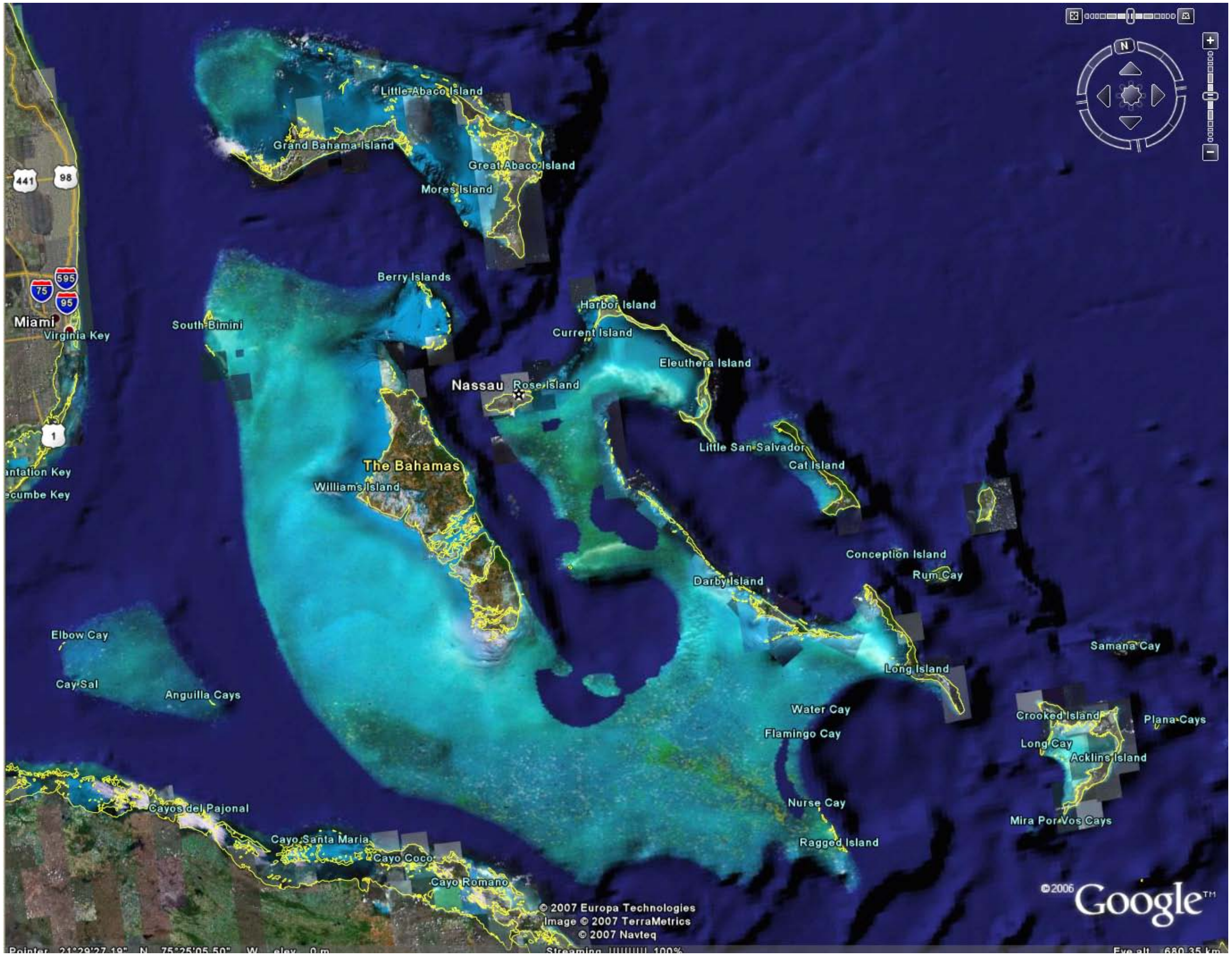
Halimeda, coral, and corraline algae

Rich in molluscs and forams

Muddy carbonate sands
Rich in calcareous algae (*Halimeda*)
and molluscs

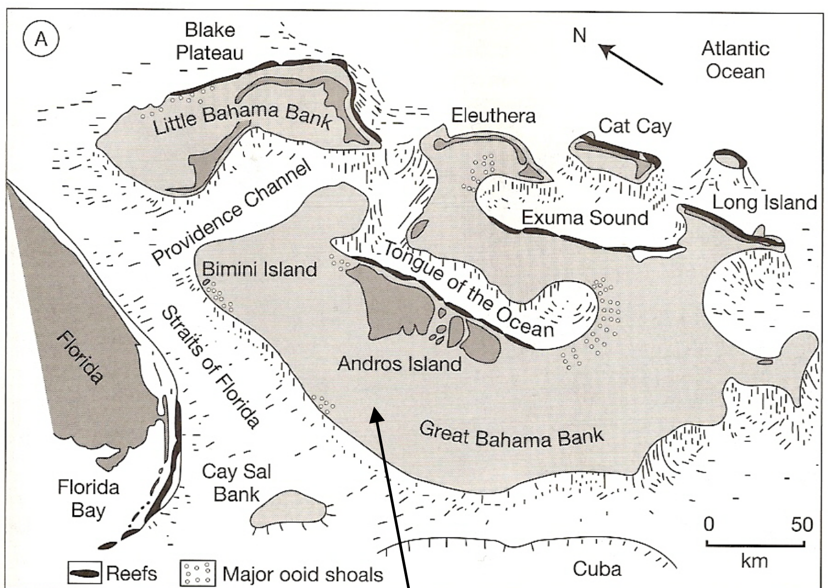
Great Barrier Reef

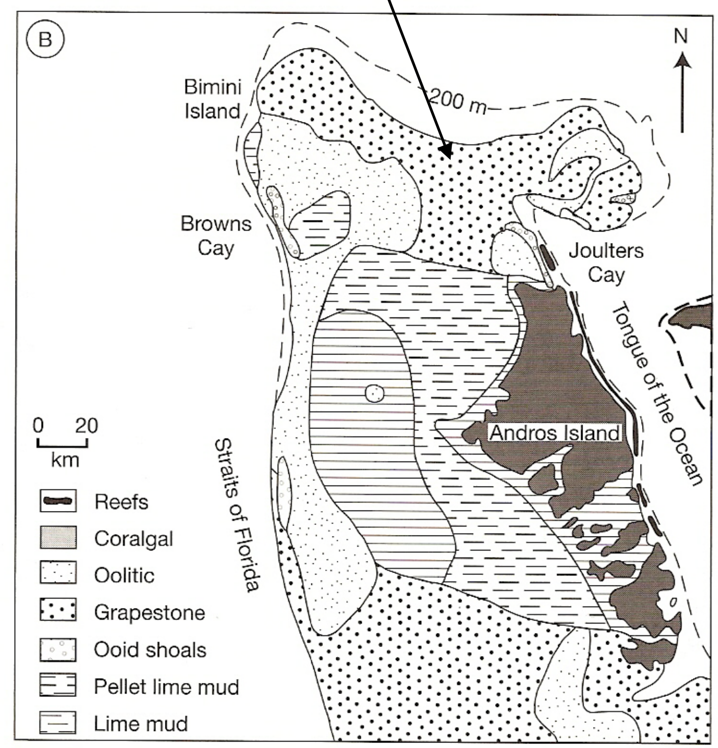
The Bahama Platform



The Great Bahama Banks

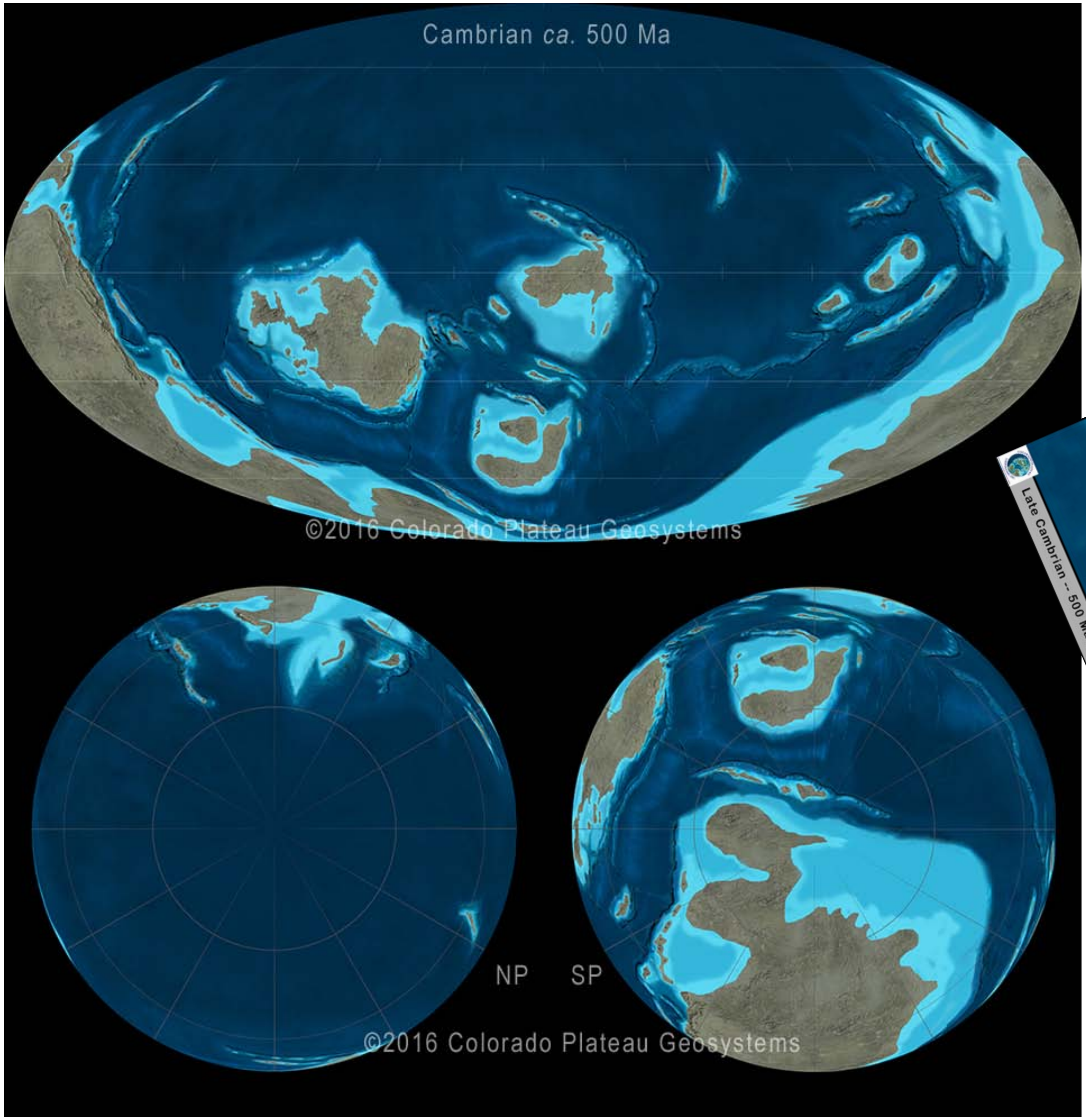
Cluster of sand-size calcareous pellets stabilized by organisms (9-10 m)

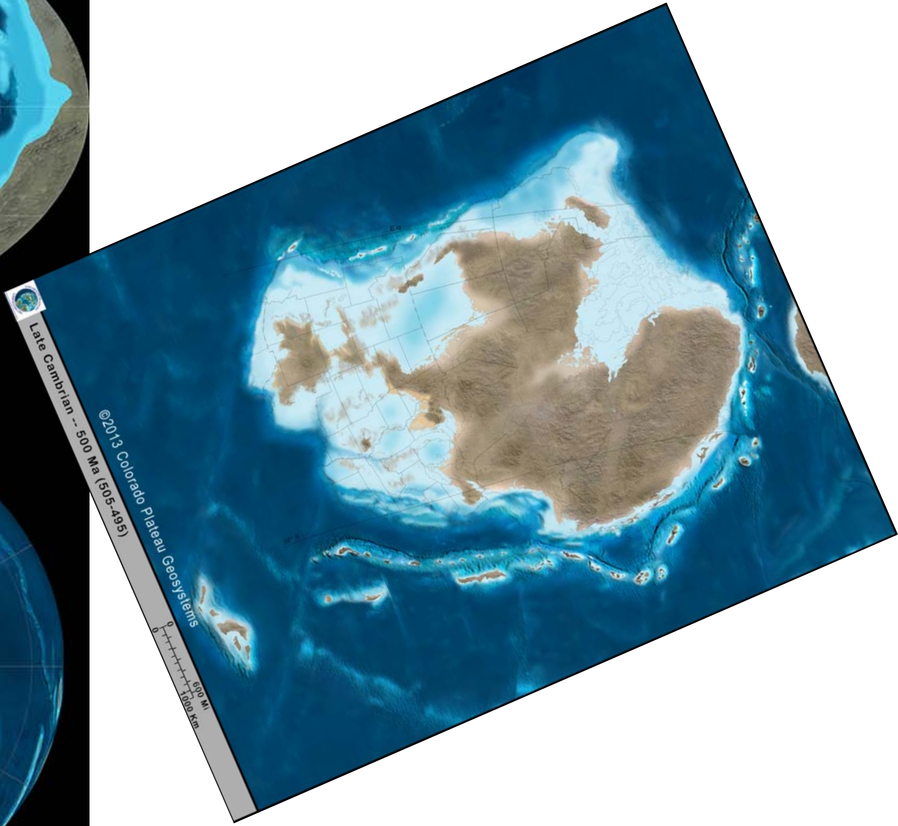




Mud facies (aragonite mud, fecal pellets)
Low energy part of the platform (water depth < 4 m)

Ancient example





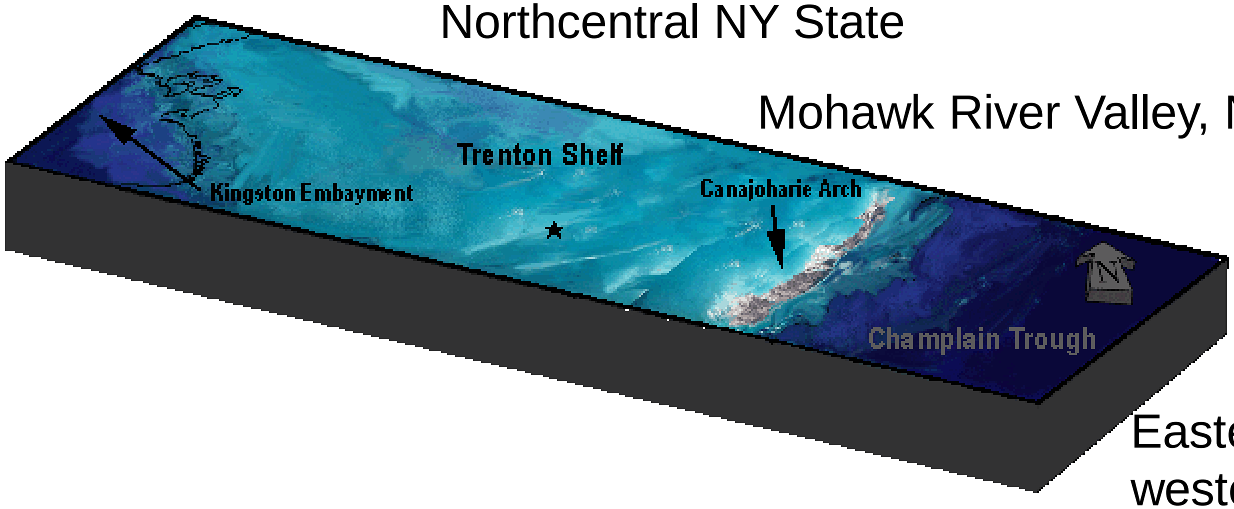
http://deeptimemaps.com/

The Trenton Shelf

Present day Lake Ontario –
St. Lawrence River

Northcentral NY State

Mohawk River Valley, NY



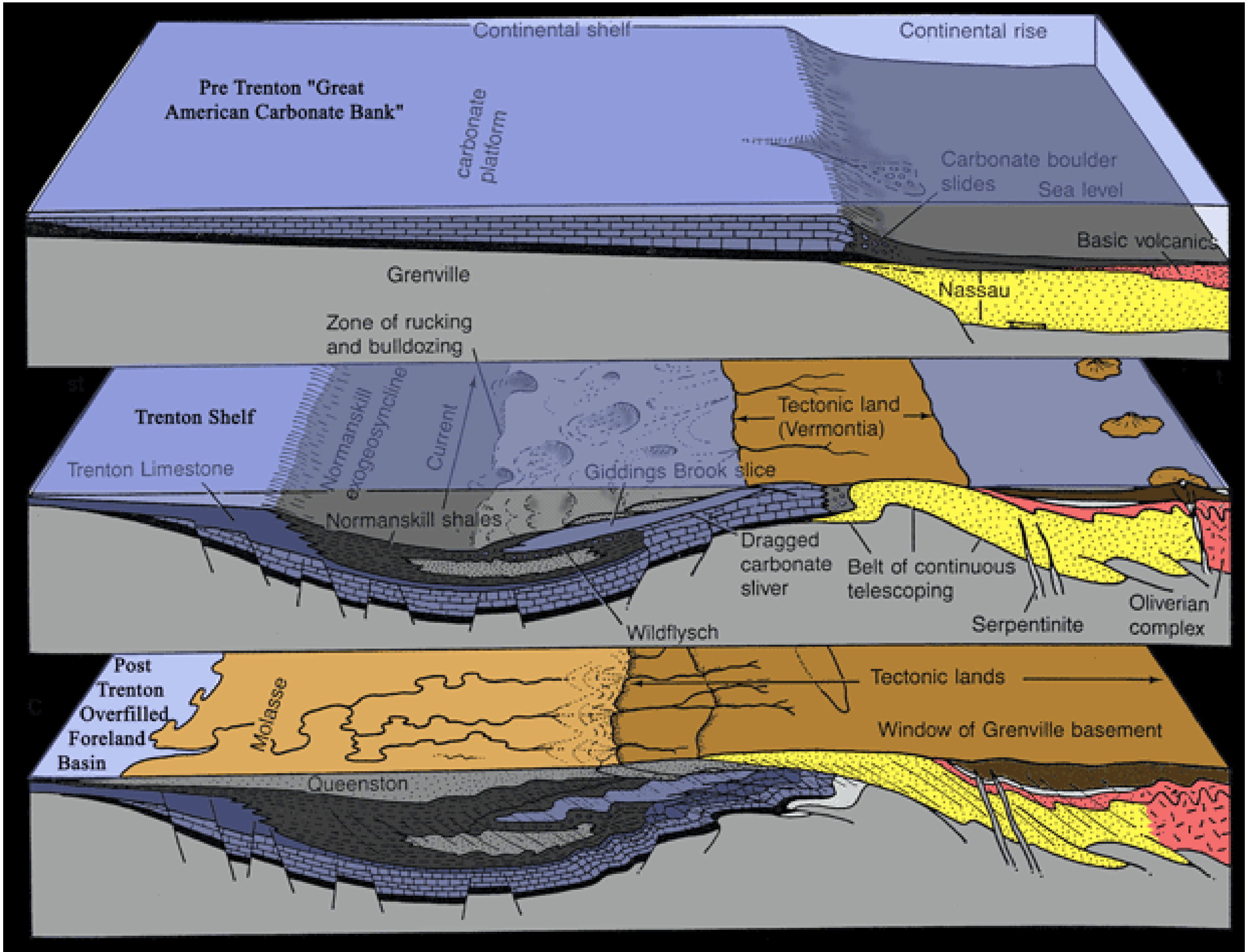
Eastern NY and
western Connecticut

Taconic peripheral foreland basin

Early to Mid-Trenton configuration

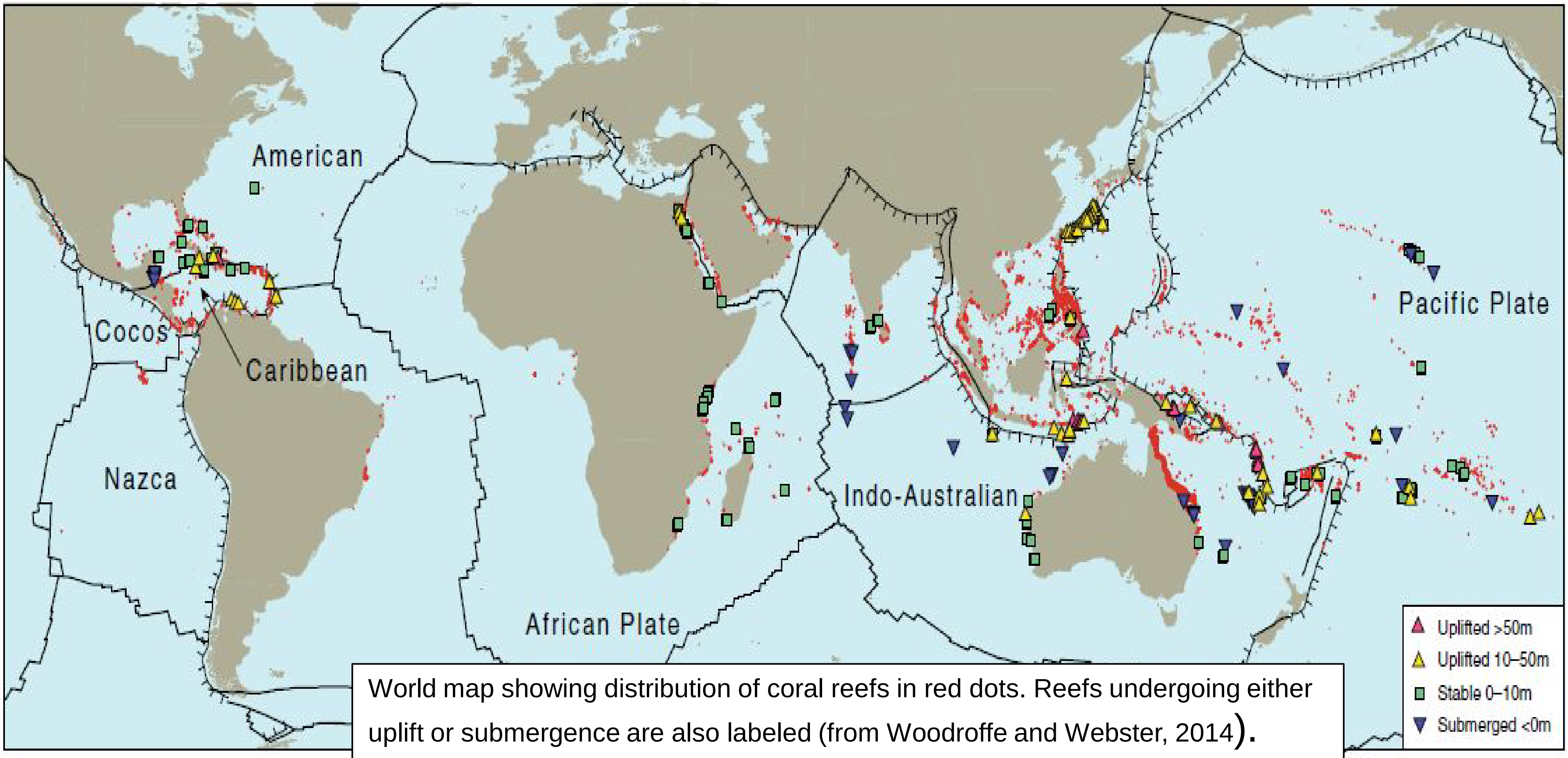
Early to Mid Ordovician

Ancient carbonate shelf – Trenton shelf



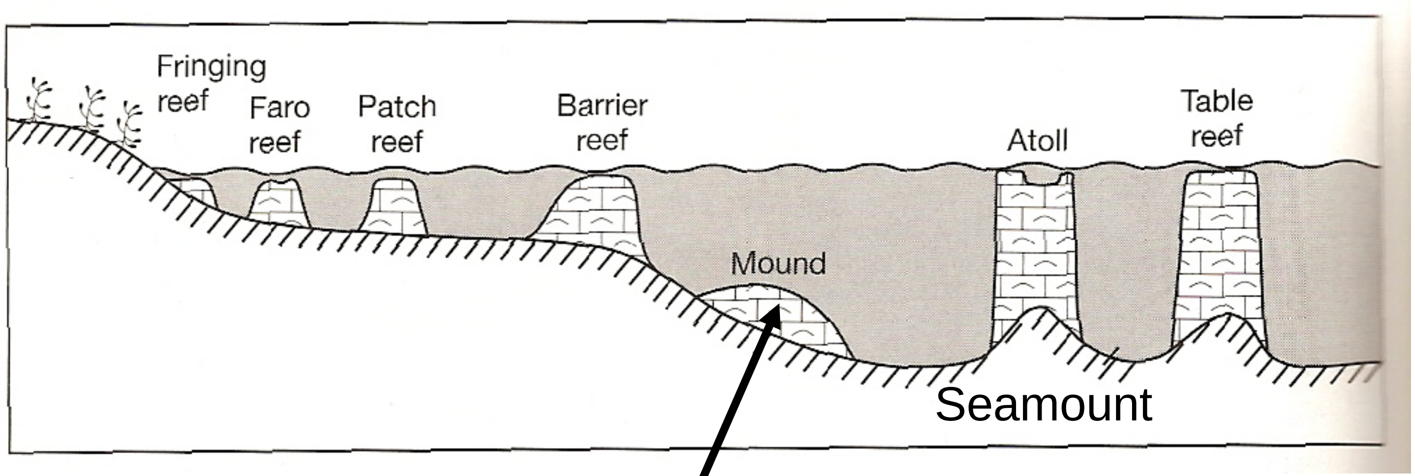
Coral reef environment

Coral reefs cover 250,000 km^2
Typically grow in upper 0-30 m of water where temperatures >18 C (1-25mm/yr)



World map showing distribution of coral reefs in red dots. Reefs undergoing either uplift or submergence are also labeled (from Woodroffe and Webster, 2014).

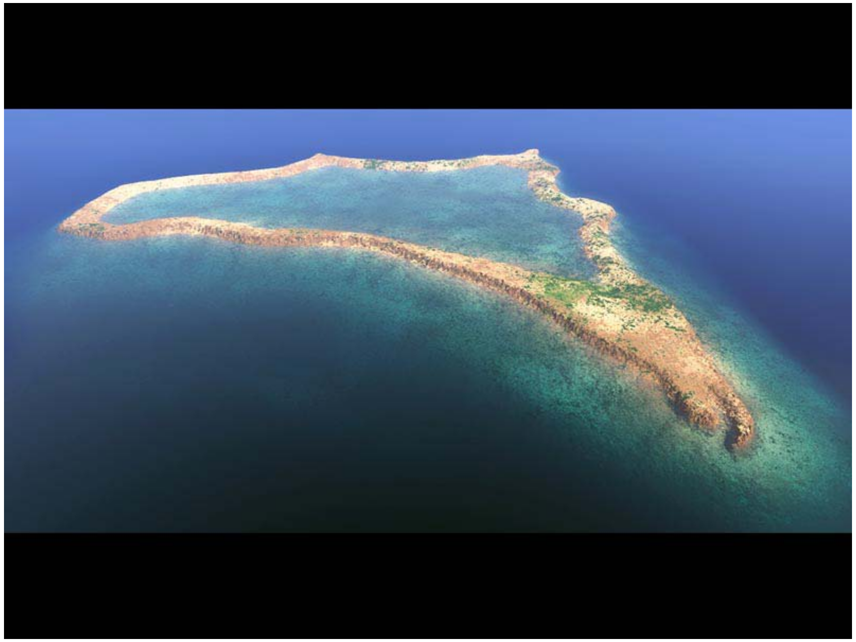
Organic reef environments



Structures built by small delicate organisms
in low energy env. (shallow or deep water)

- Microbial mounds (stromatolites)
- Skeletal mounds (reef-building organisms)
- Mud mounds
- Occur at various scales

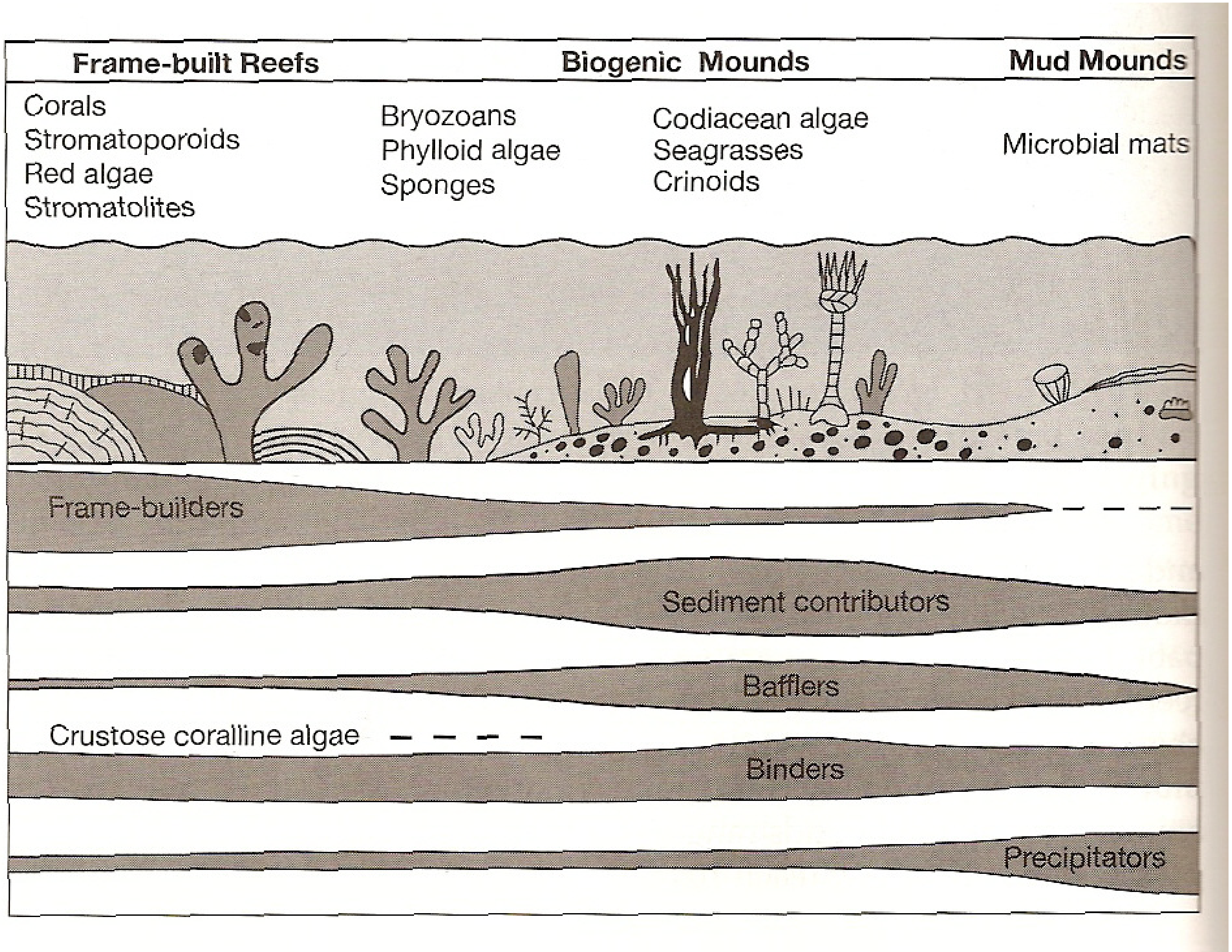
Atolls



Patch reef

Fringing reef

Reef organisms



Frame builders and binders

Plate corals

Hard corals and
giant limpet (gastropod molluscs)

Frame builders and binders

Hard corals and short red algae (2 – 6 m)

Encrusting red algae

Bafflers and binders

Green seaweeds

Encrusting
Yellow coral

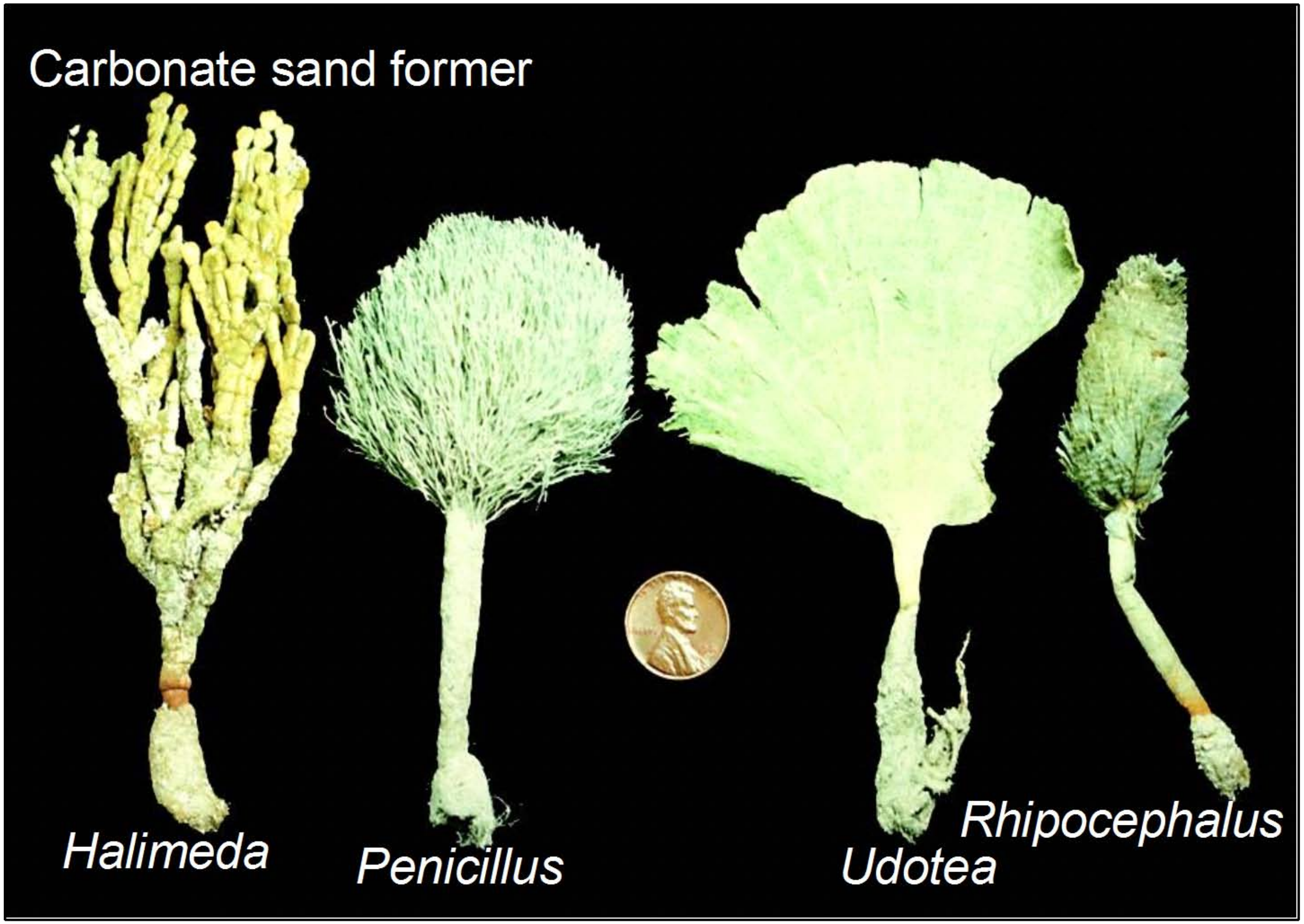
Soft corals

Bafflers and binders

Bowl coral, soft corals and red algae (6 – 8 m)

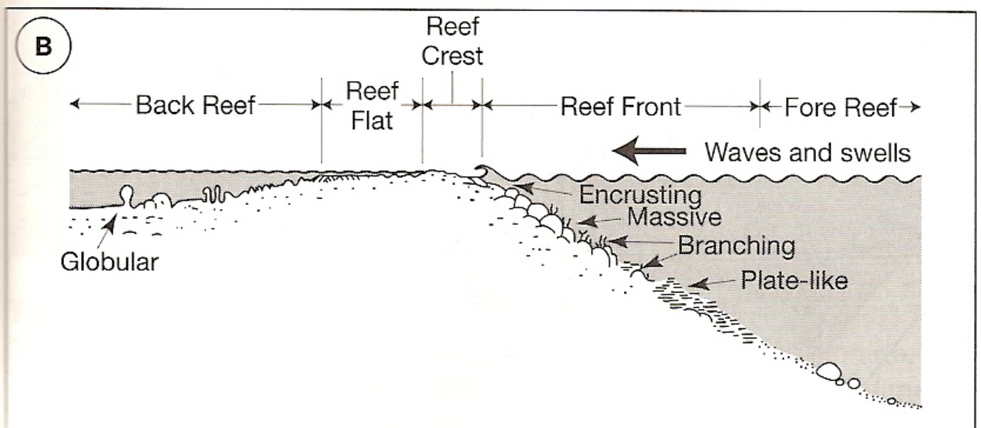
Green seaweeds and red algae (6 m)

Sediment producer

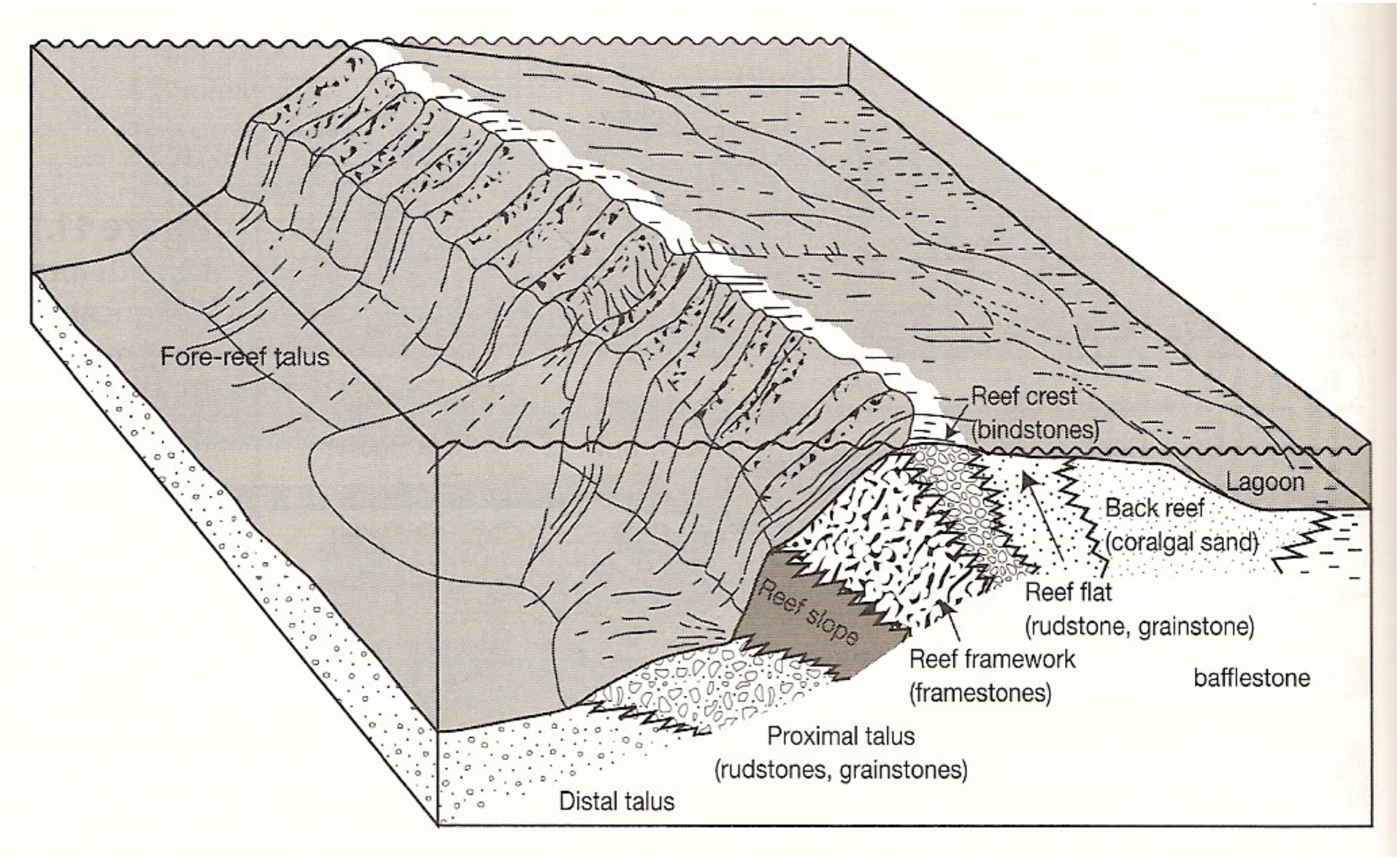


Growth forms

A	Growth Forms	Environment	
		Wave Energy	Sedimentation
	Delicate, branching	low	high
	Thin, delicate, plate-like	low	low
	Globular, bulbous, columnar	moderate	high
	Robust, dendroid, branching	moderate-high	moderate
	Hemispherical, domal, irregular, massive	moderate-high	low
	Encrusting	intense	low
	Tabular	moderate	low



Facies of reef complexes



Embry& Klovan (1971) Limestone Classification

Original Components Not Organically Bound During Deposition		Original Components Organically Bound During Deposition		
> 10% grains >2 mm		Organisms acted as baffles	Organisms encrusted and bound	Organisms built a rigid framework
Matrix-supported	Supported by components larger than 2 mm			
Floatstone	**Rudstone**	**Bafflestone**	**Bindstone**	**Framestone**