Mixed Carbonates and Siliciclastics in the Quaternary of Southern Belize: Pleistocene Turning Points in Reef Development Controlled by Sea-Level Change*

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Abstract

The southern shelf of Belize (Central America) is a classic location of a mixed carbonate-siliciclastic system. Whereas the knowledge of the Holocene deposits in the area is extensive, data on the Pleistocene system are fragmentary. Open questions include the nature of the reef foundations (carbonate versus siliciclastics), the ages of the deposits including the initiation of the barrier reef, and the response of the mixed system to sea-level fluctuations. Six up to 105 m long borings were made on the southern Belize shelf in order to better understand the history of this mixed system. U-series dating in the Pleistocene was not possible due to diagenetic alteration, however, lithostratigraphy, strontium isotopes and calcareous nannofossil biostratigraphy were used to constrain stratigraphic ages. Our results support the contention that the Quaternary development in Belize was quite similar to that of other major barrier reefs where significant reef growth only began after the onset of high-amplitude, eccentricity-controlled sea-level changes and as late as during the long and warm marine isotope stage (MIS) 11, some 400 ka ago. In Belize, early Pleistocene sections include mollusc-rich wackestones, rare coral packstones, and marls, which were deposited under low to moderate energy conditions in a ramp setting around 1 Ma, during high sea levels of marine isotope stage (MIS) 25 and possibly earlier (MIS 31, 37). The Belize shelf was subaerially exposed for most of the mid Pleistocene and dominated by siliciclastic sedimentation, possibly during MIS 24-12 when highstands were comparatively low. Continuous reefs at the shelf margin were developing during highstands. In the late Pleistocene, beginning with MIS 11, the southern shelf was entirely flooded and carbonates started to dominate once more. Reefs developed on top of siliciclastic deposits on the shelf. A continuous barrier reef came into existence and largely developed on top of carbonates at the shelf margin. During late Pleistocene lowstands, siliciclastics presumably no longer reach the shelf margin anymore because of the topographic high of the barrier reef platform. The Quaternary Belize example may

serve as a model for reconstructing ancient mixed systems in icehouse worlds, however, any extrapolations are limited by the fact that fast-growing Scleractinian reef-builders had not yet evolved in the Paleozoic.

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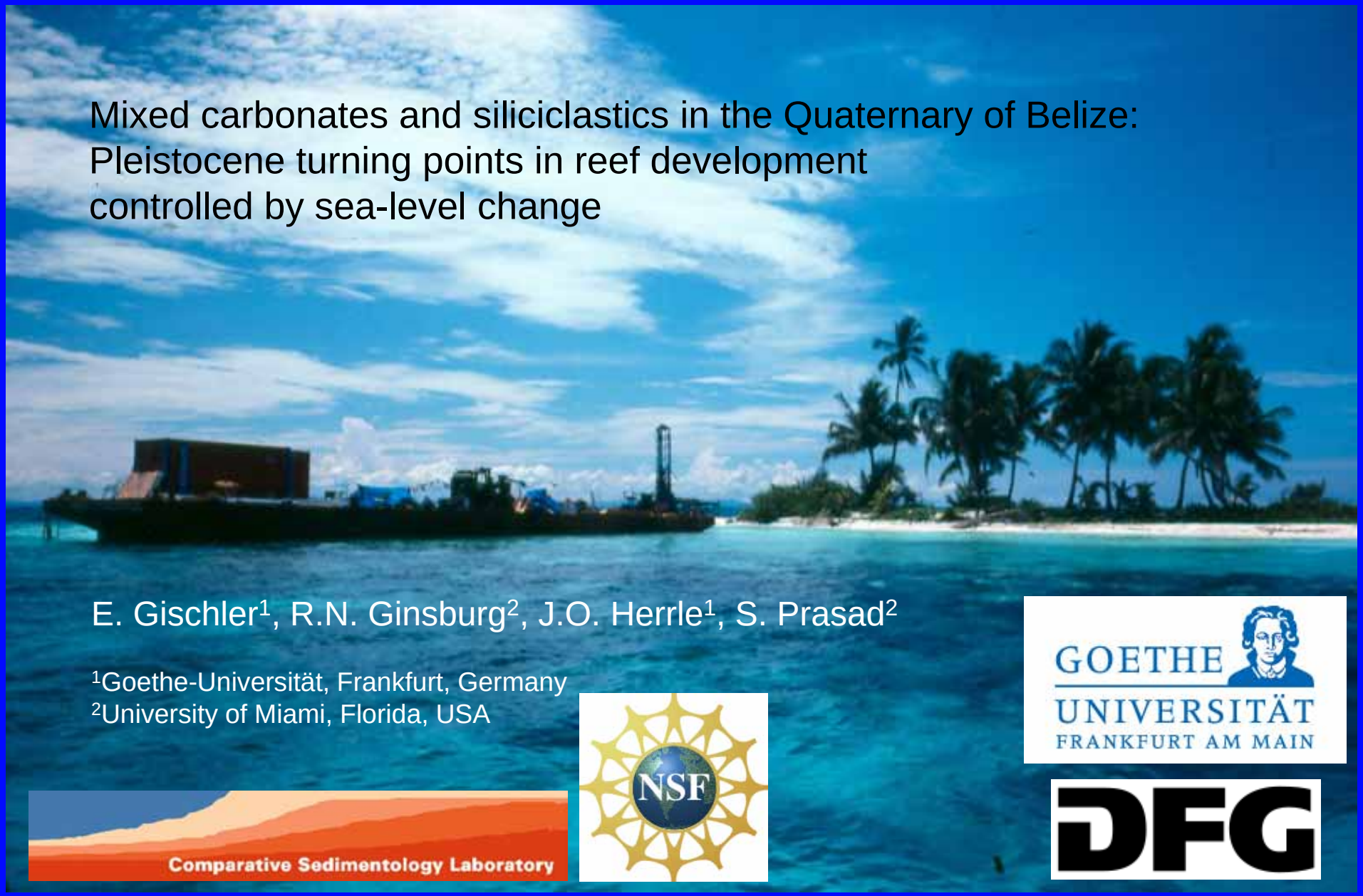

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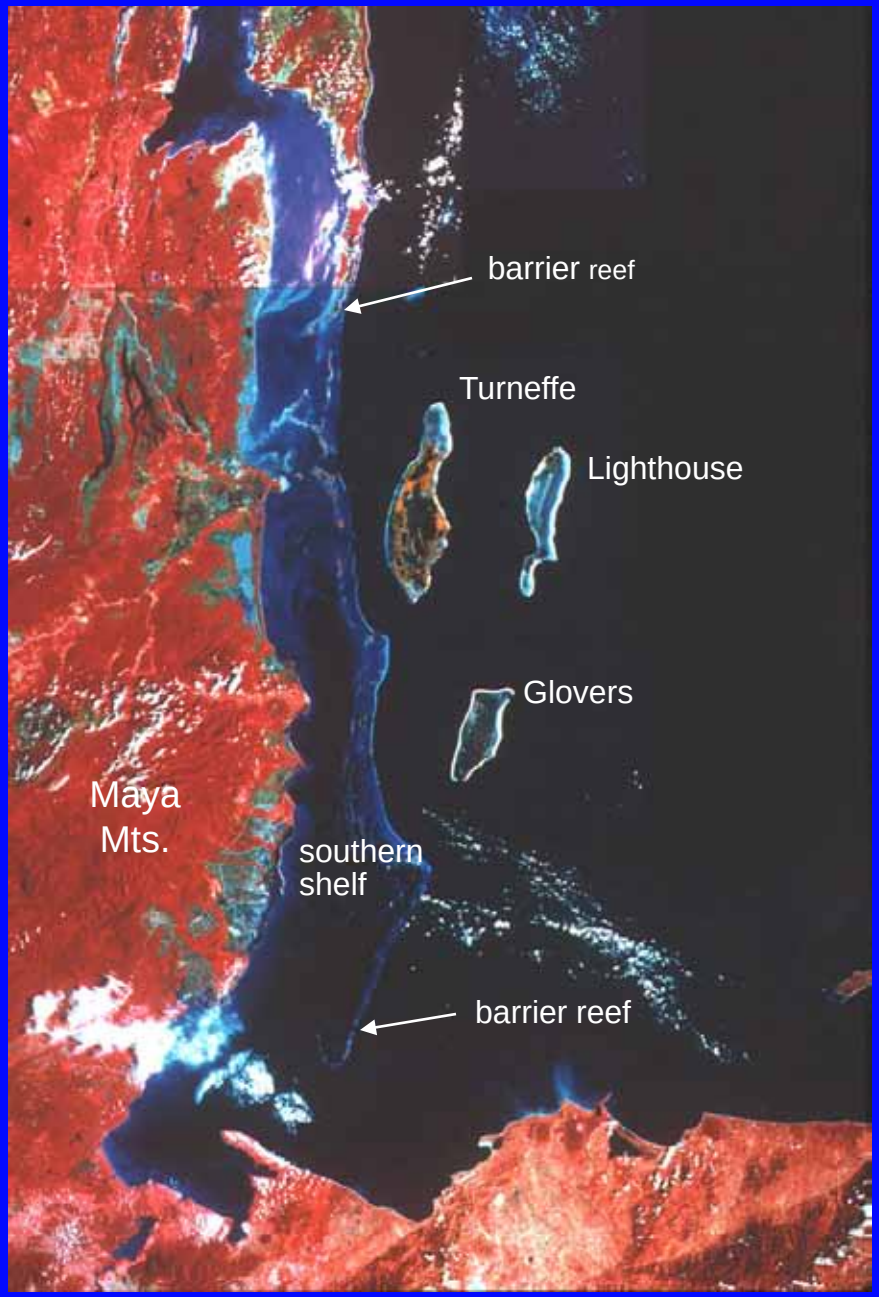
Annual Convention & Exhibition AAPG, New Orleans 2010: Session on "Mixed Systems (SEPM)"

Background / Objectives

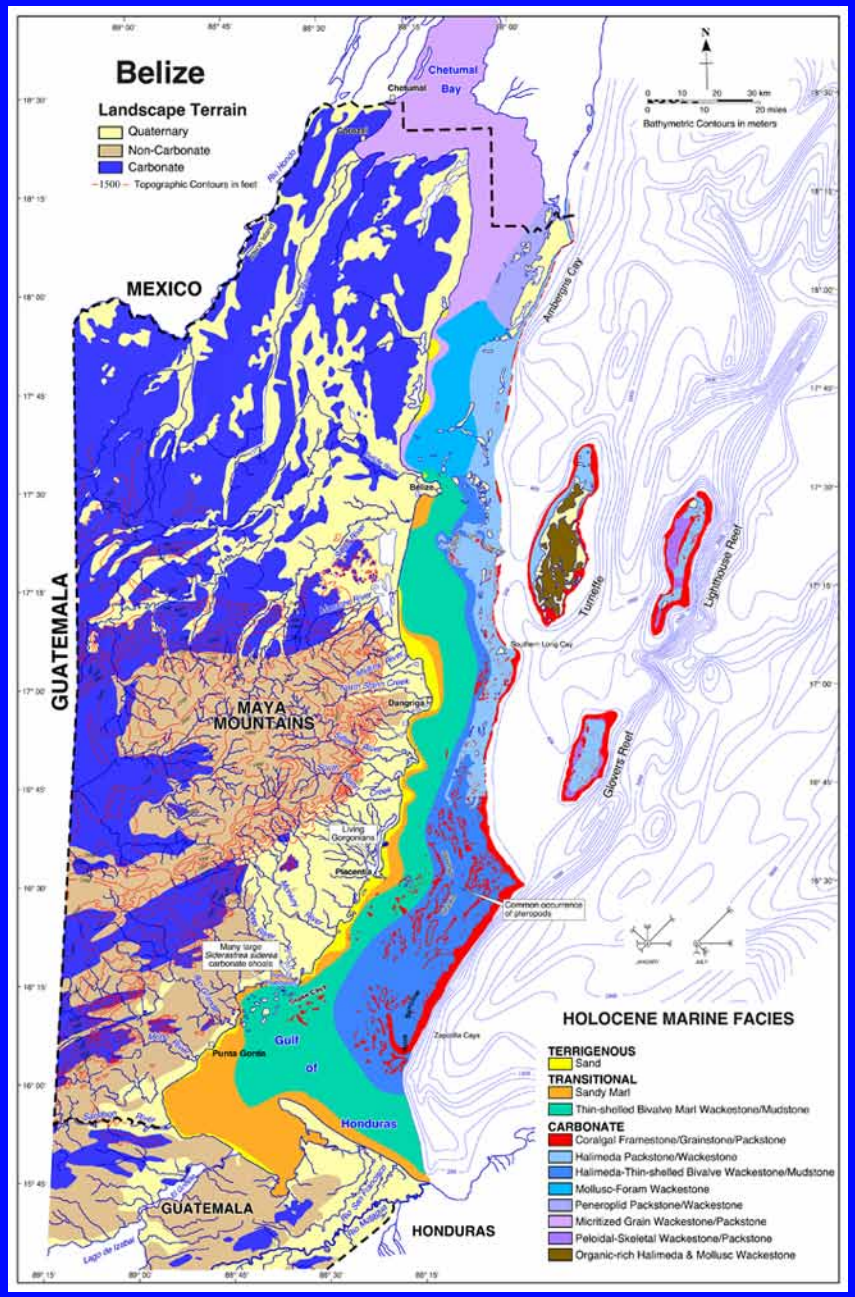
- knowledge on Belize Holocene comprehensive, data on Pleistocene fragmentary
- response of mixed system to sea-level change
- initiation of reef accretion (MIS 11 question)
- controversy on the nature of reef foundation (carbonates *versus* siliciclastics)

study area

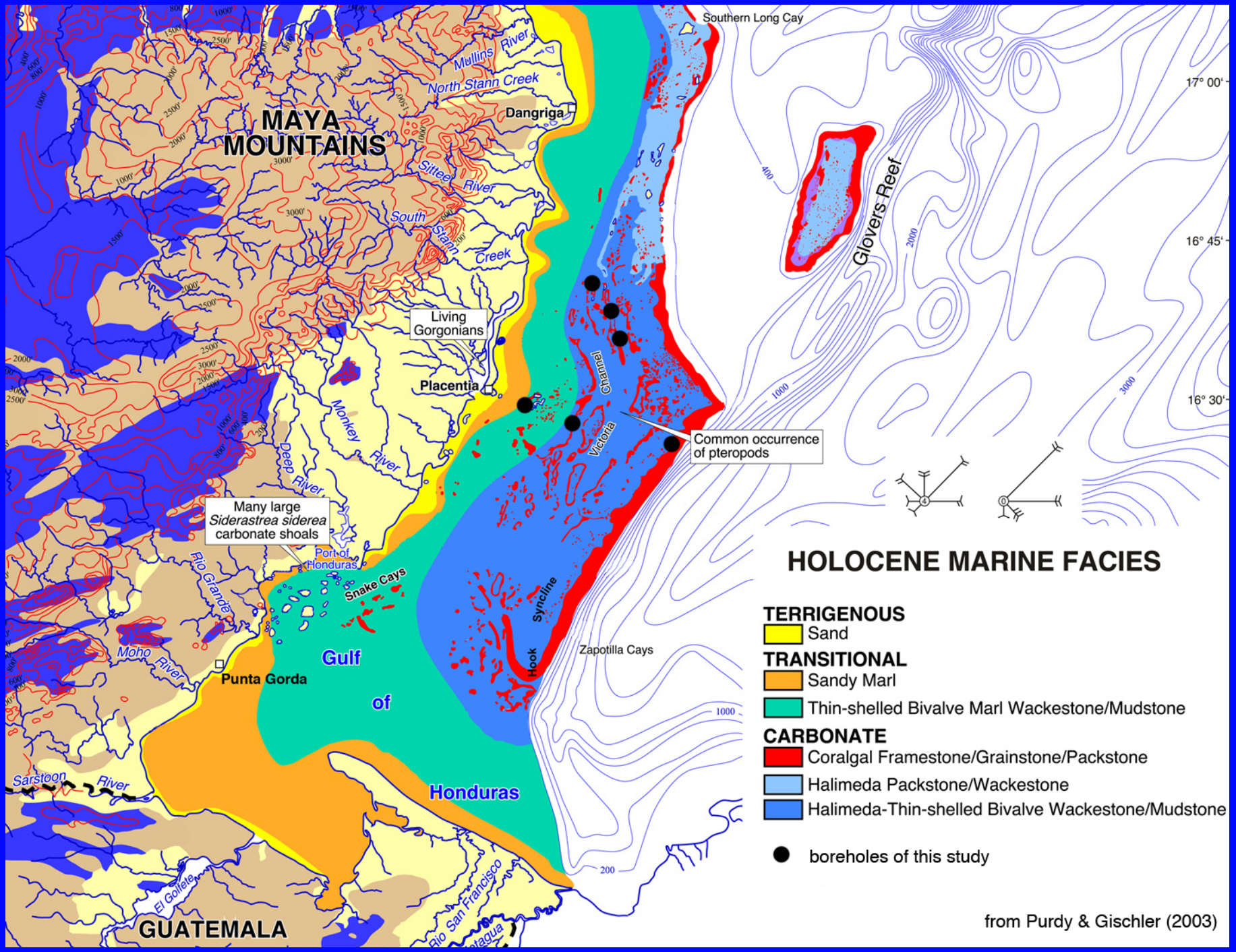
Study area

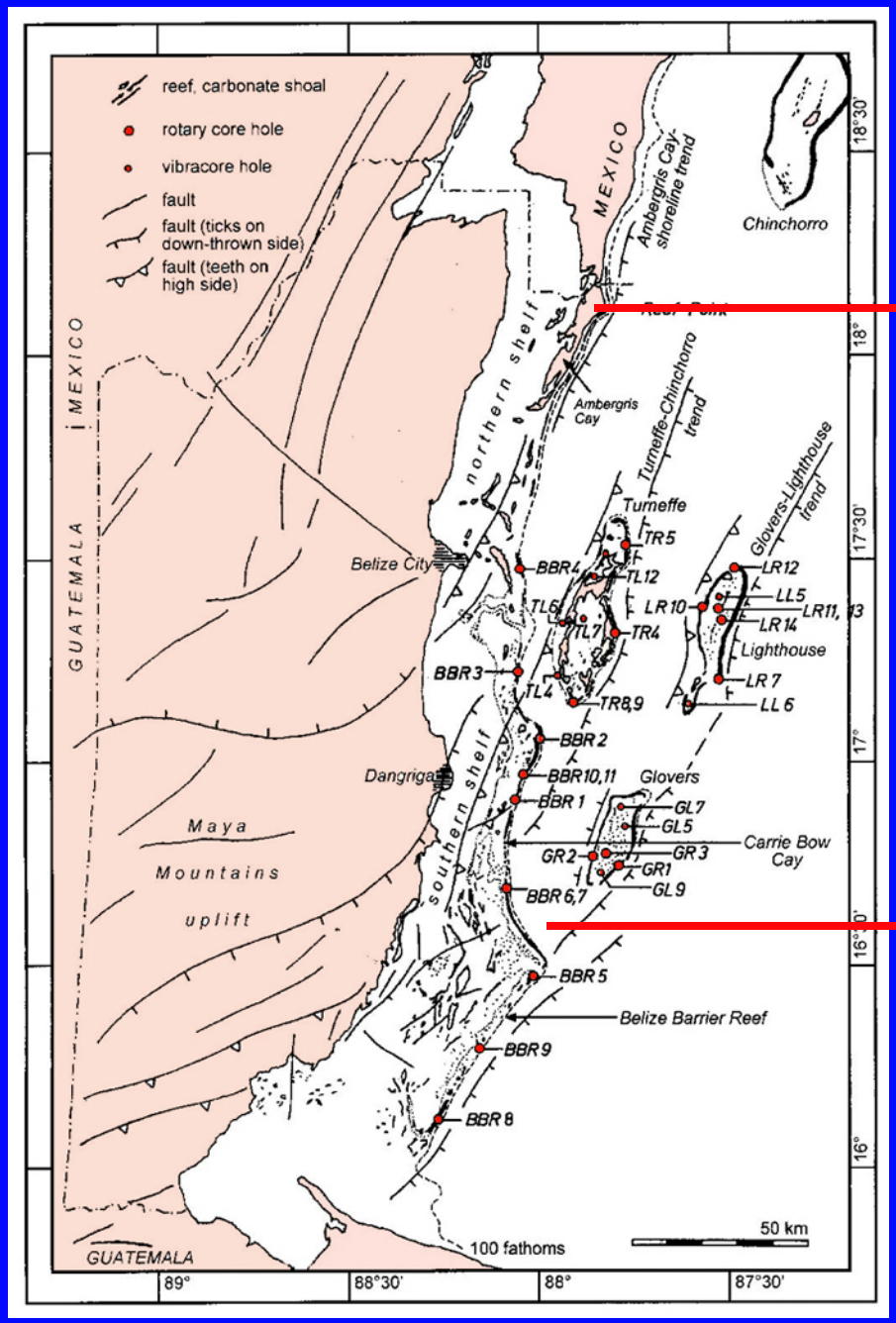


Holocene marine facies

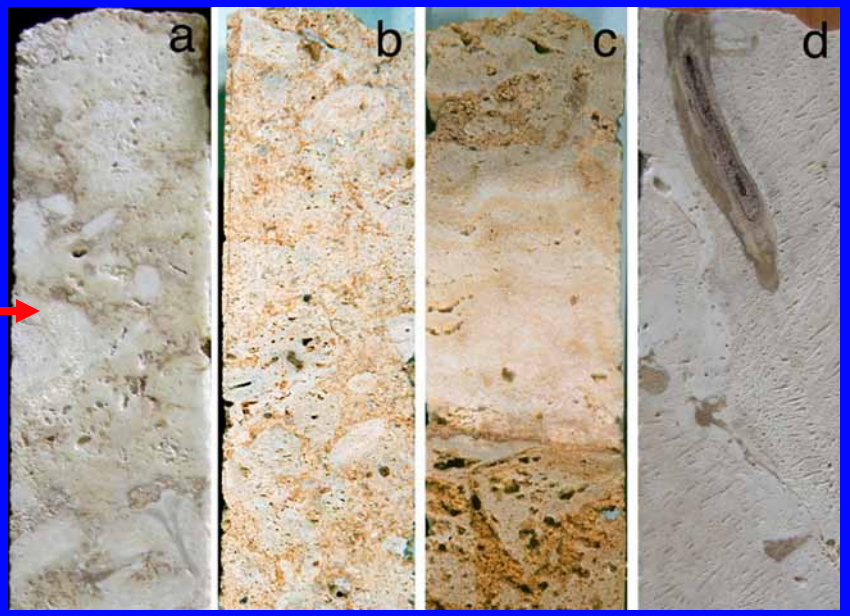


Purdy & Gischler (2003)

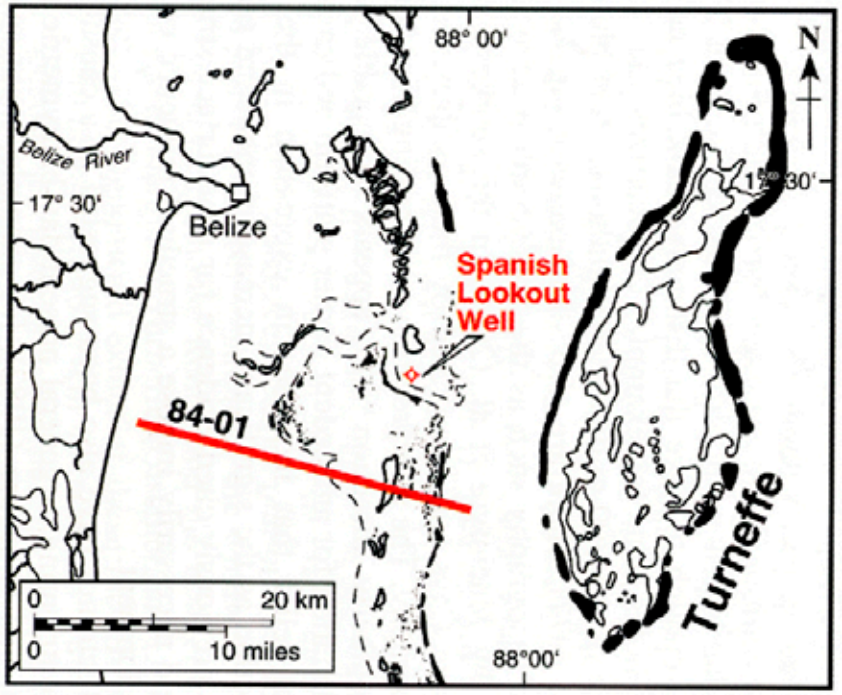

MAYA MOUNTAINS
Mullins River
North Stann Creek
Dangriga
Silitee River
South Stann Creek
Living Gorgonians
Placentia
Monkey River
Deep River
Many large Siderastrea siderea carbonate shoals
Port of Honduras
Rio Grande
Snake Cays
Moho River
Punta Gorda
Gulf of Honduras
Sarstoon River
El Golfete
GUATEMALA
Rio San Francisco
Channel
Victoria
Syncline
Hook
Zapotilla Cays
Common occurrence of pteropods
Southern Long Cay
Glovers Reef
17° 00'
16° 45'
16° 30'
400
1000
2000
3000
200
HOLOCENE MARINE FACIES
TERRIGENOUS
Sand
TRANSITIONAL
Sandy Marl
Thin-shelled Bivalve Marl Wackestone/Mudstone
CARBONATE
Coralgal Framestone/Grainstone/Packstone
Halimeda Packstone/Wackestone
Halimeda-Thin-shelled Bivalve Wackestone/Mudstone
boreholes of this study
from Purdy & Gischler (2003)

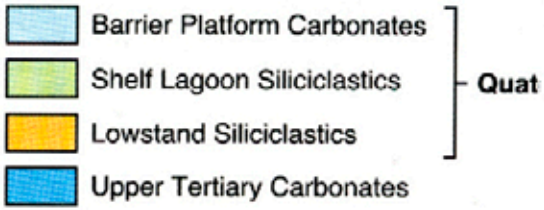


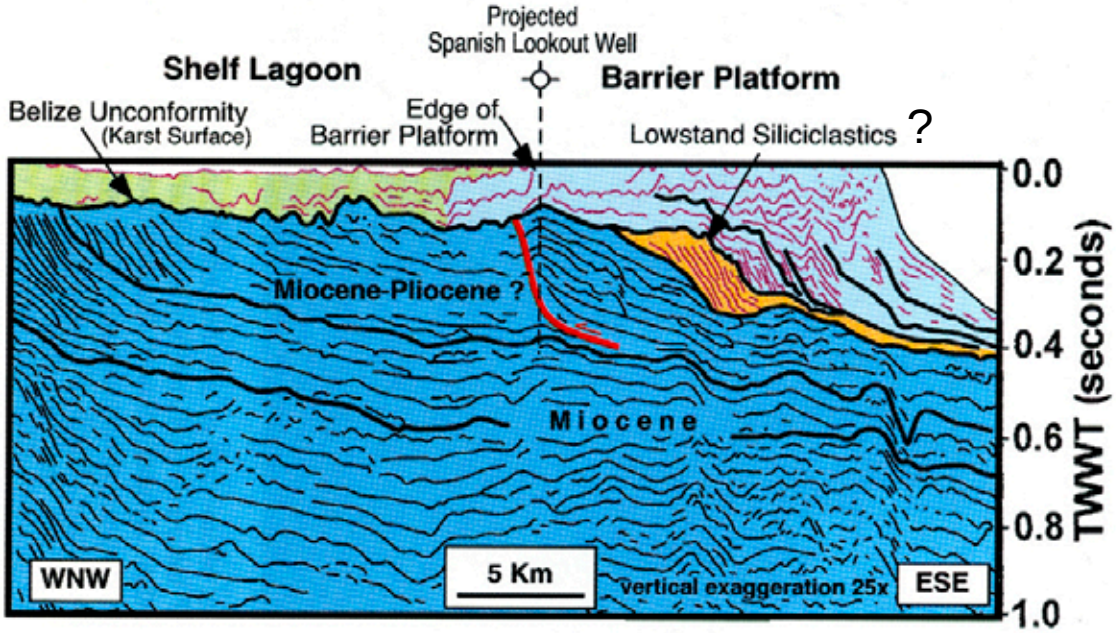
Gischler & Hudson (2004)



Pleistocene outcrop and core tops dated to 125 ka (Gischler et al. 2000)





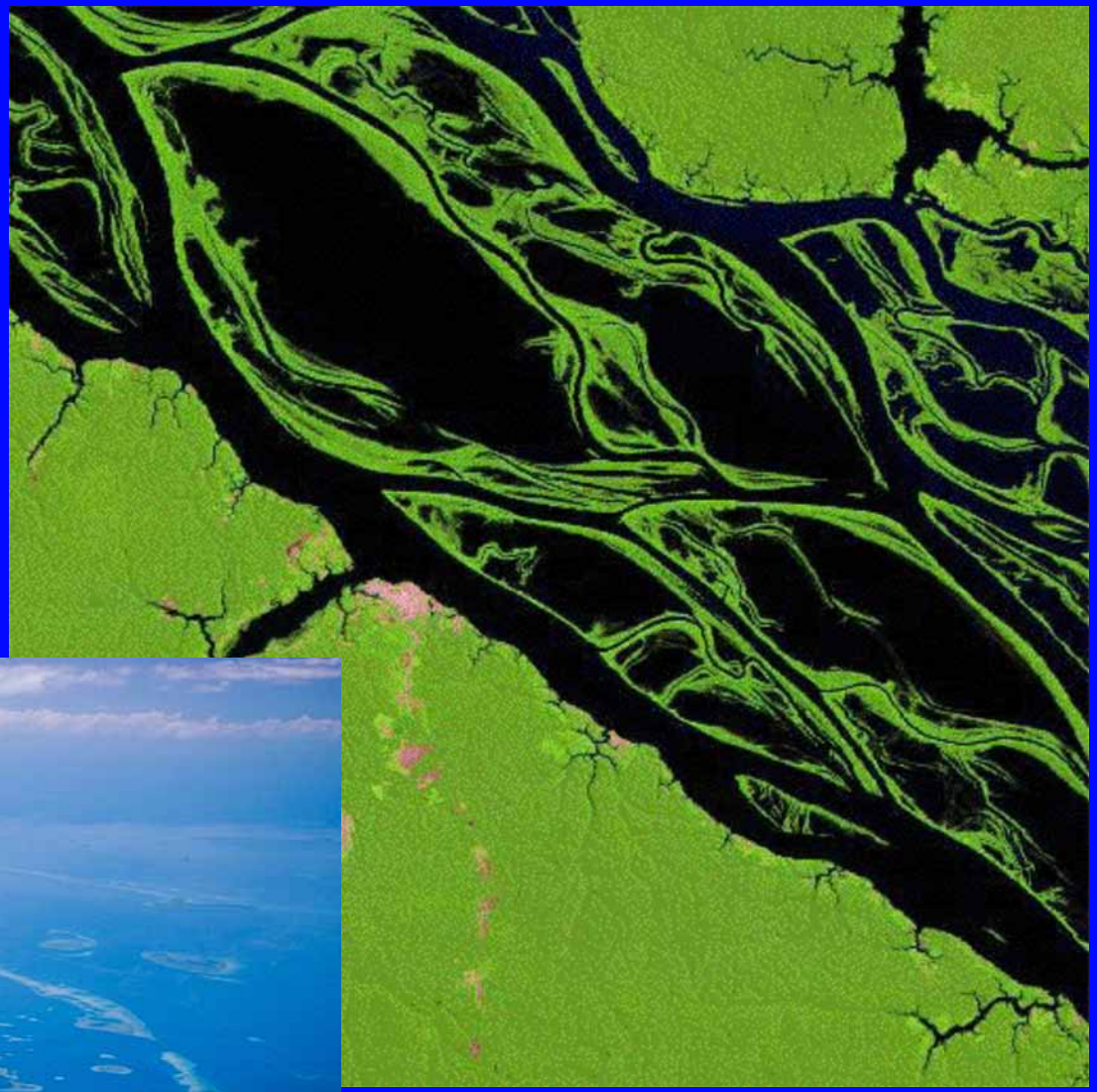


Seismics & exploration wells

indicate 100-120 m Pleistocene thickness

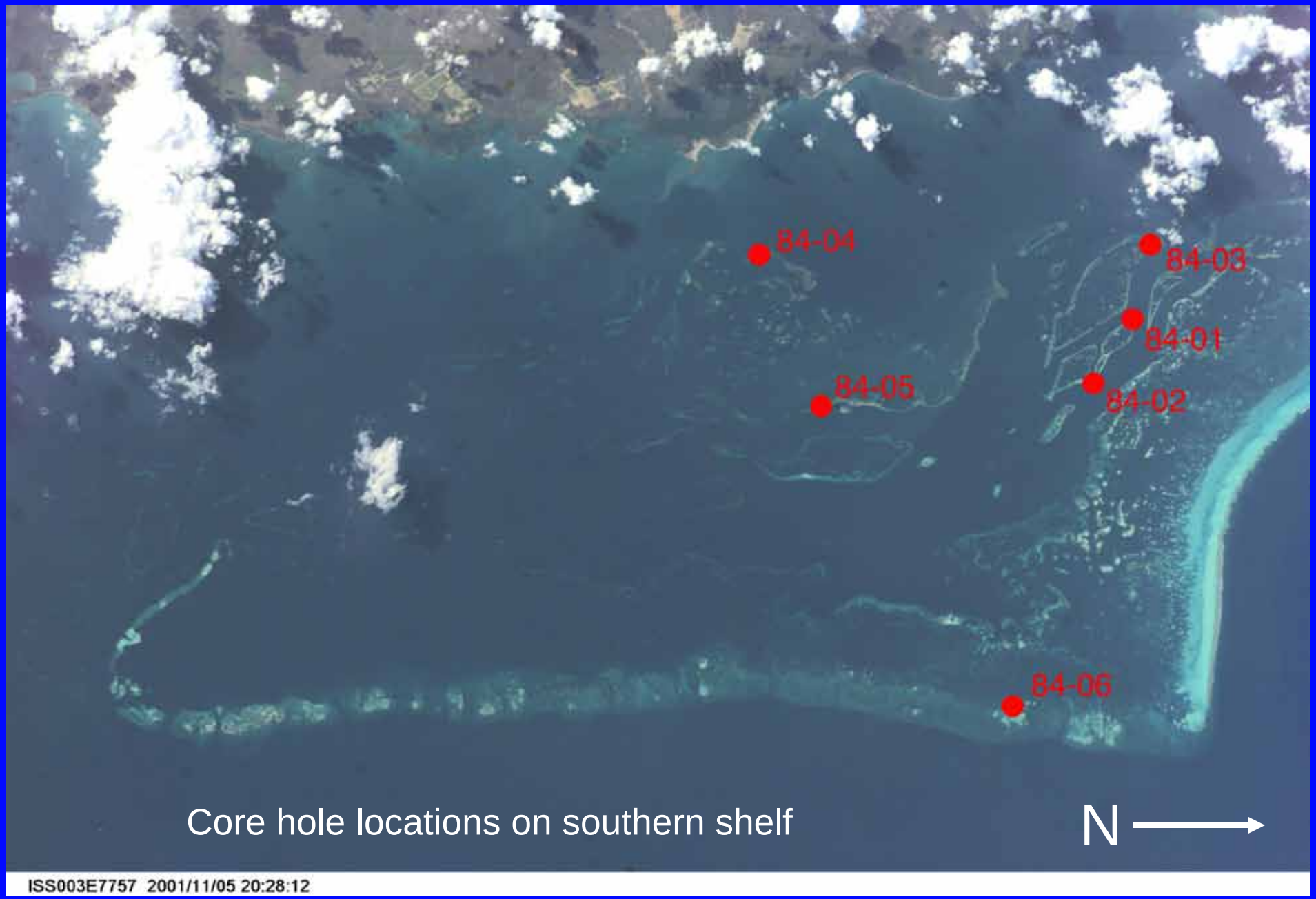
Purdy et al. 2003; Mazzullo 2006

rhomboid reef shapes
resemble
river channel bars



sat. image of channel bars,
Rio Negro, S' America

aerial, S' Belize reefs

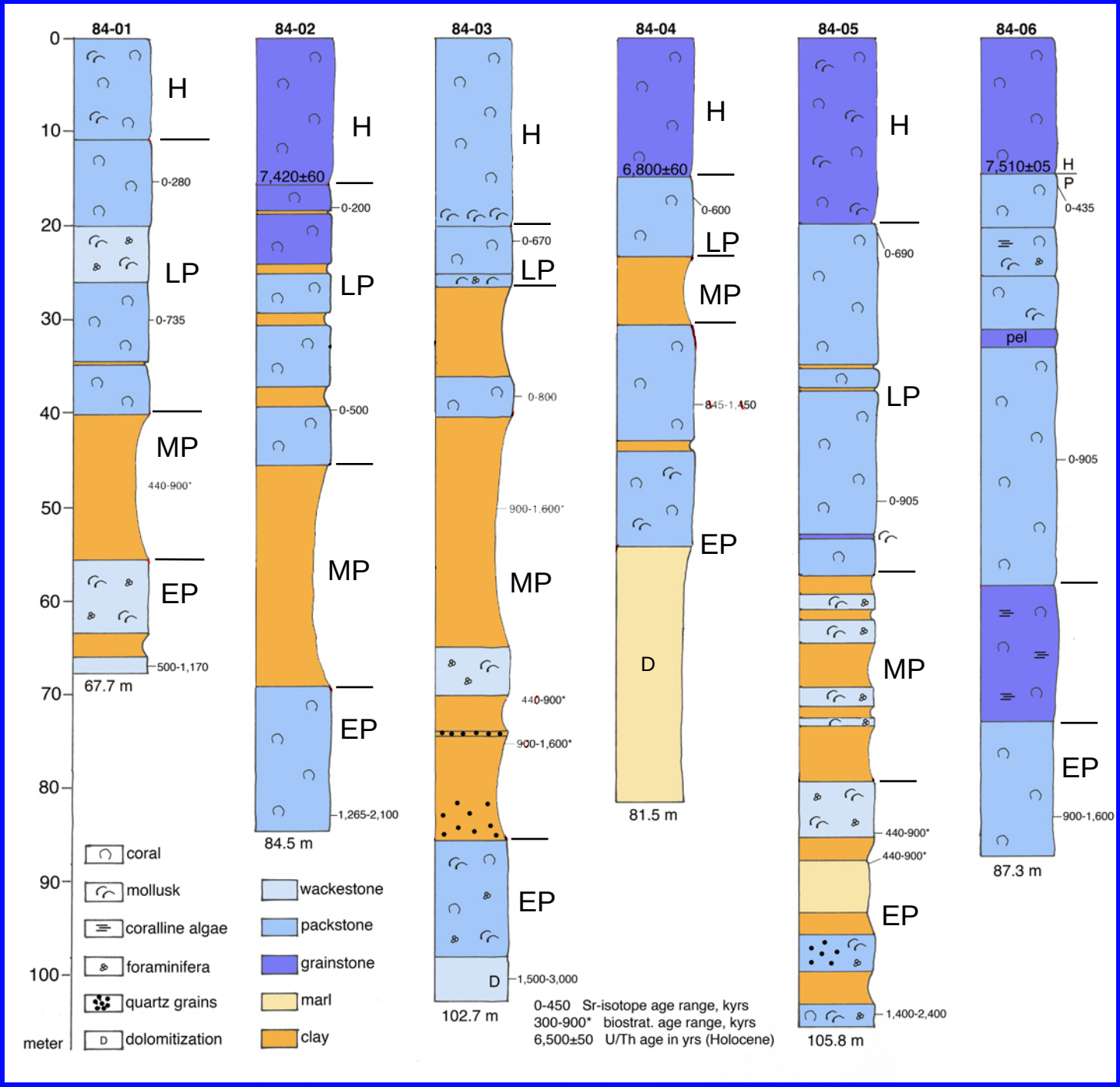


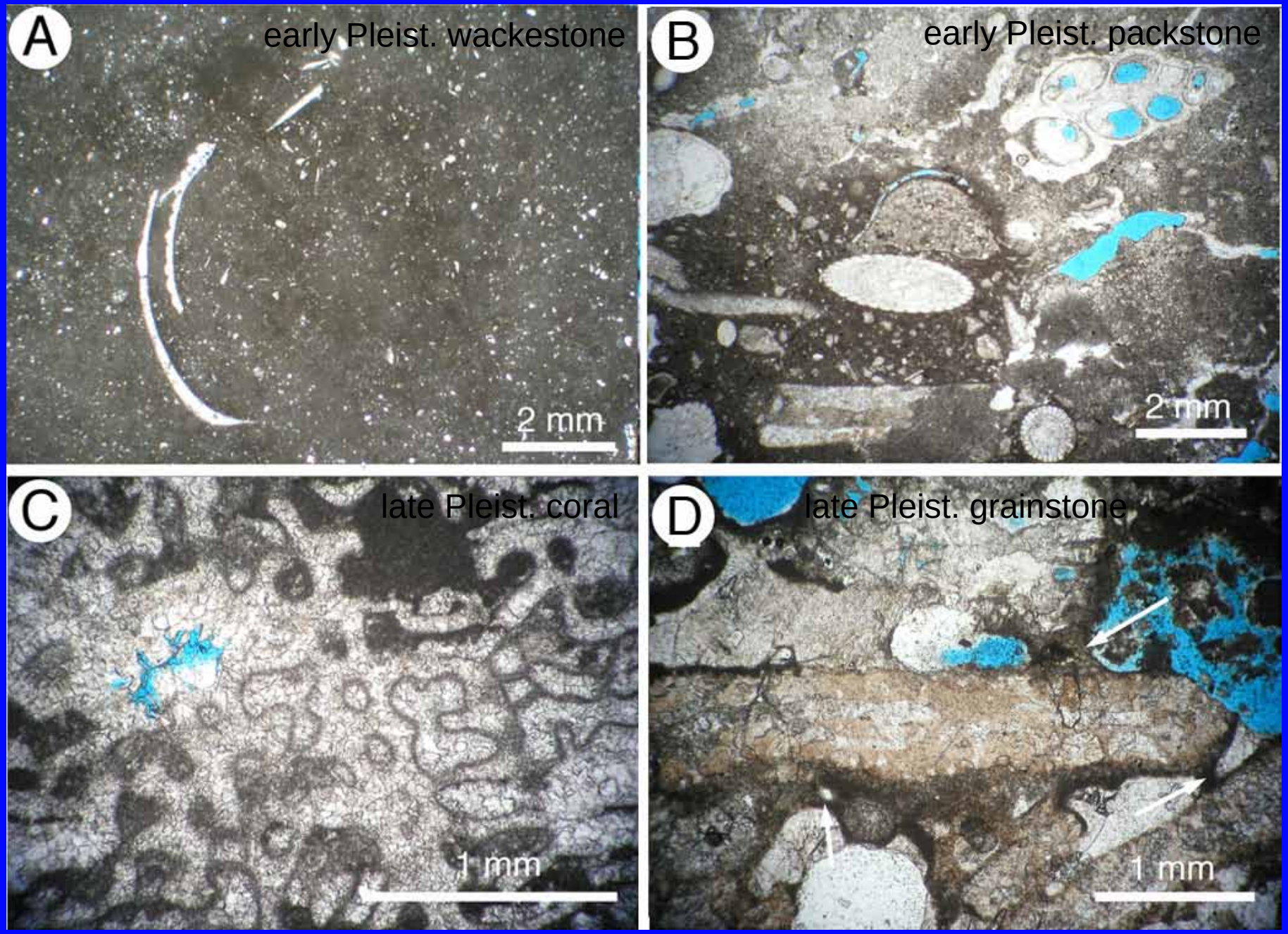
Core hole locations on southern shelf

ISS003E7757 2001/11/05 20:28:12

simplified core logs

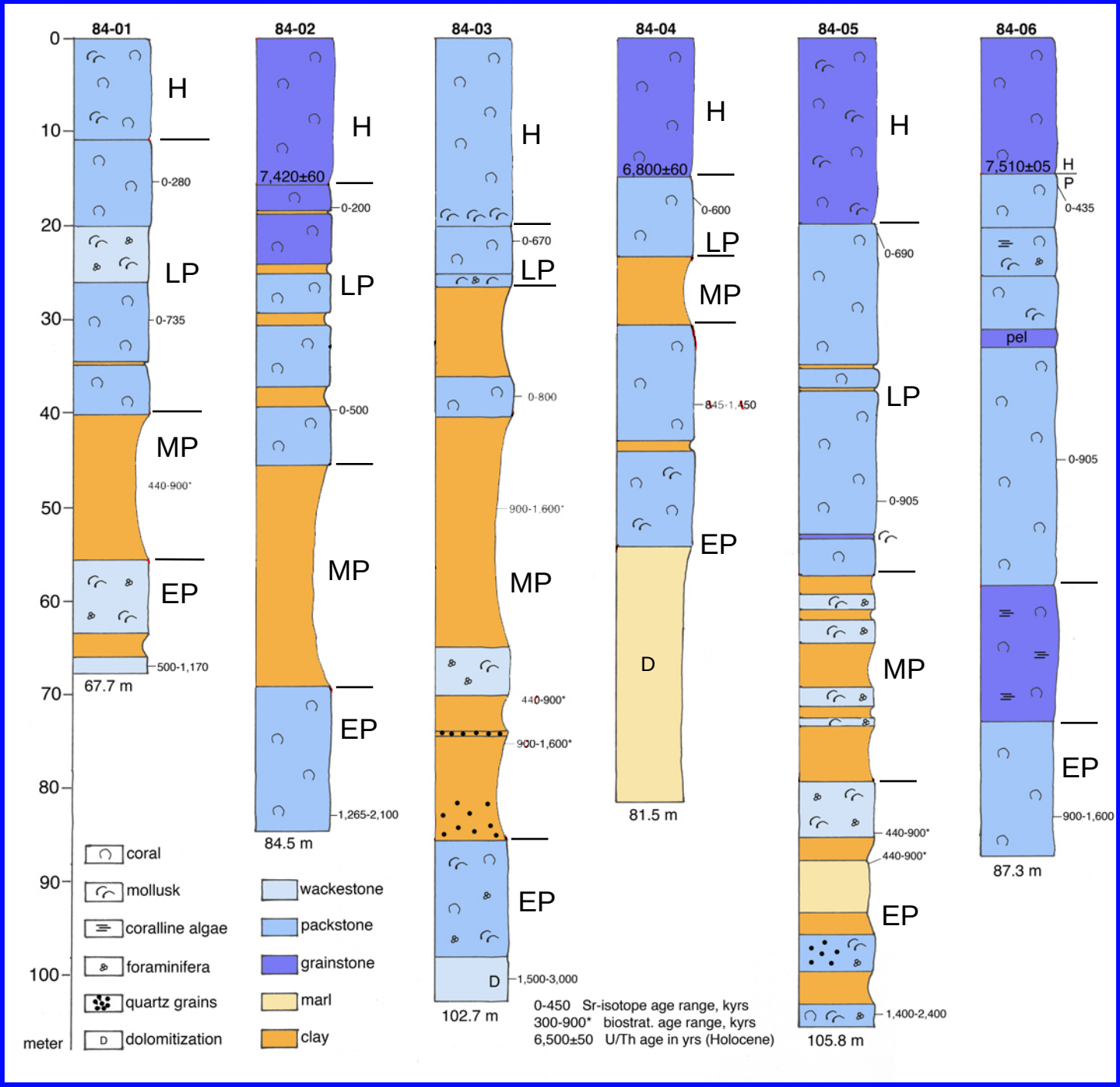
4 lithostrati-graphic units




A
early Pleist. wackestone
2 mm
B
early Pleist. packstone
2 mm
C
late Pleist. coral
1 mm
D
late Pleist. grainstone
1 mm

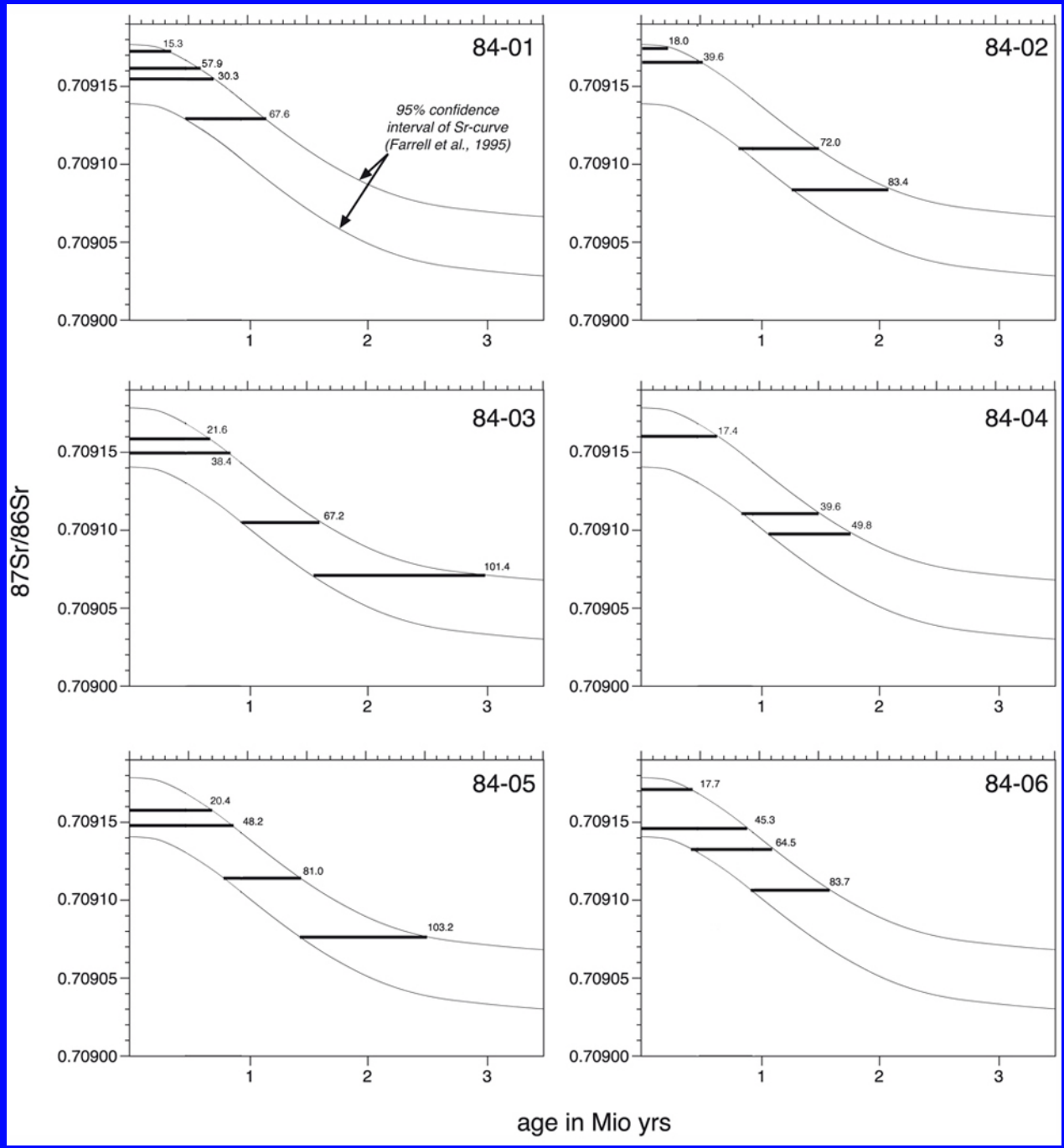
simplified core logs

4 lithostrati-graphic units



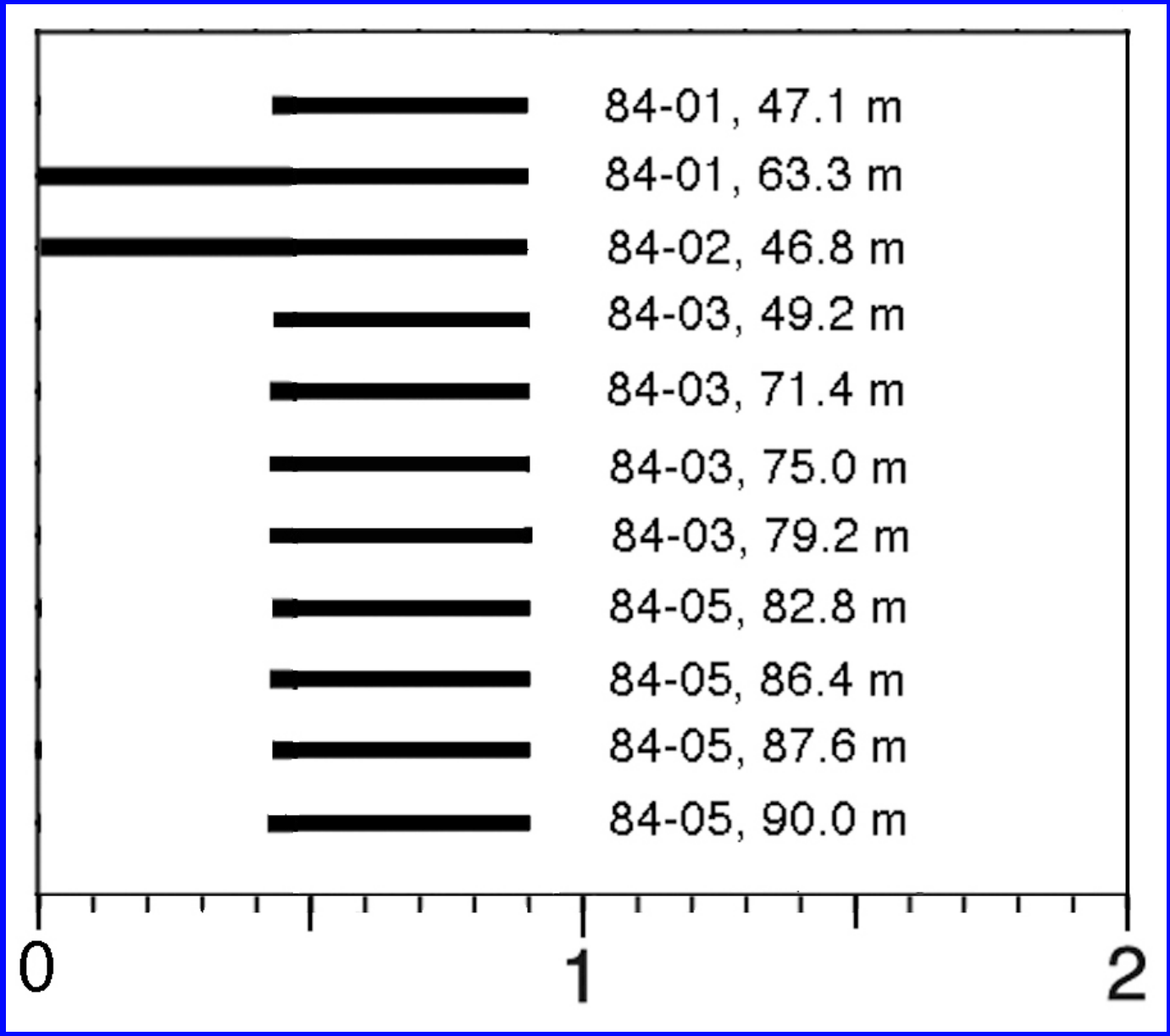
Strontium isotope stratigraphy

from late and early Pleistocene carbonate units



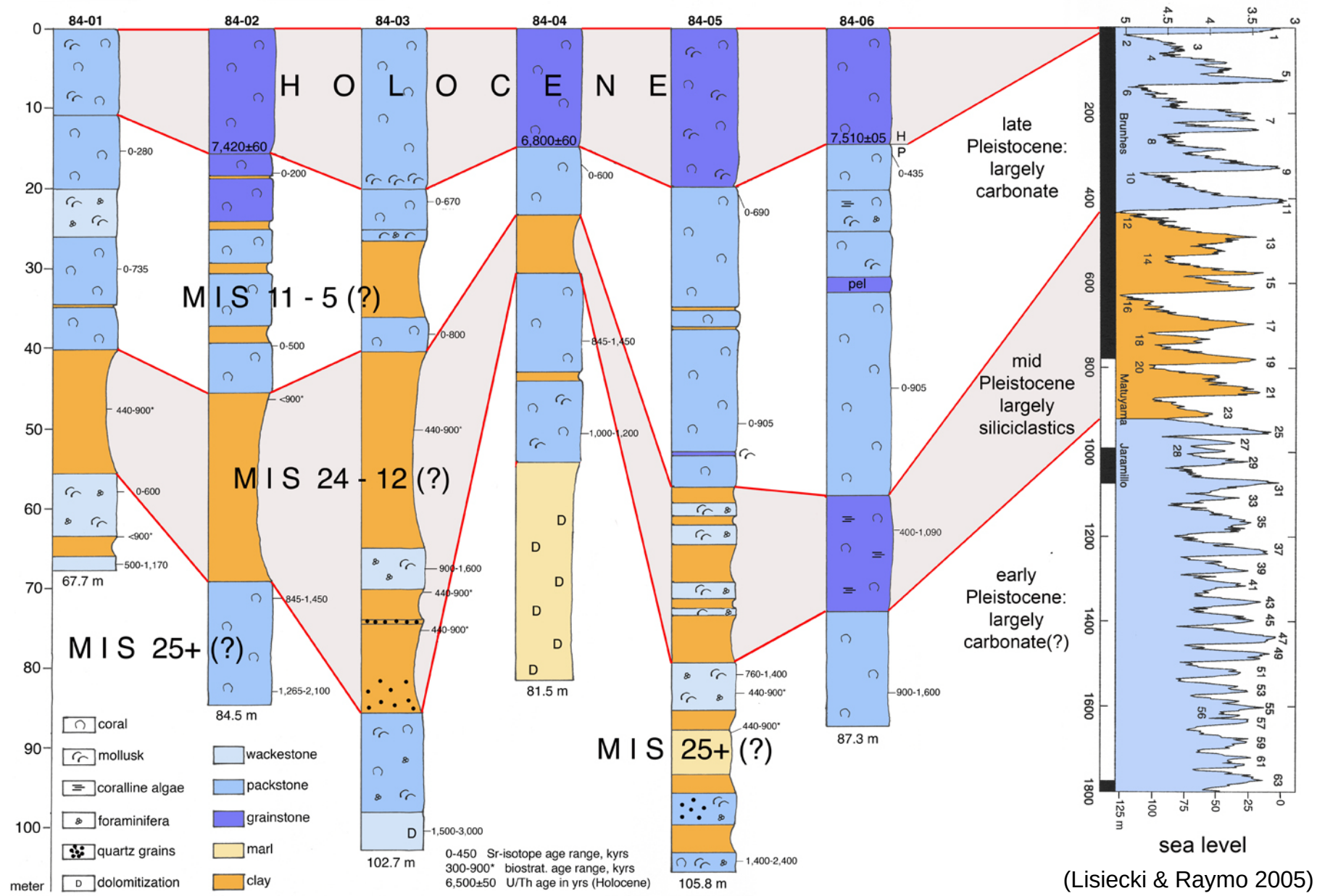
Sr-curve from Farrell et al. (1995)

Calcareous nannofossil stratigraphy from mid Pleistocene clays



Mio yrs. BP

Synthesis



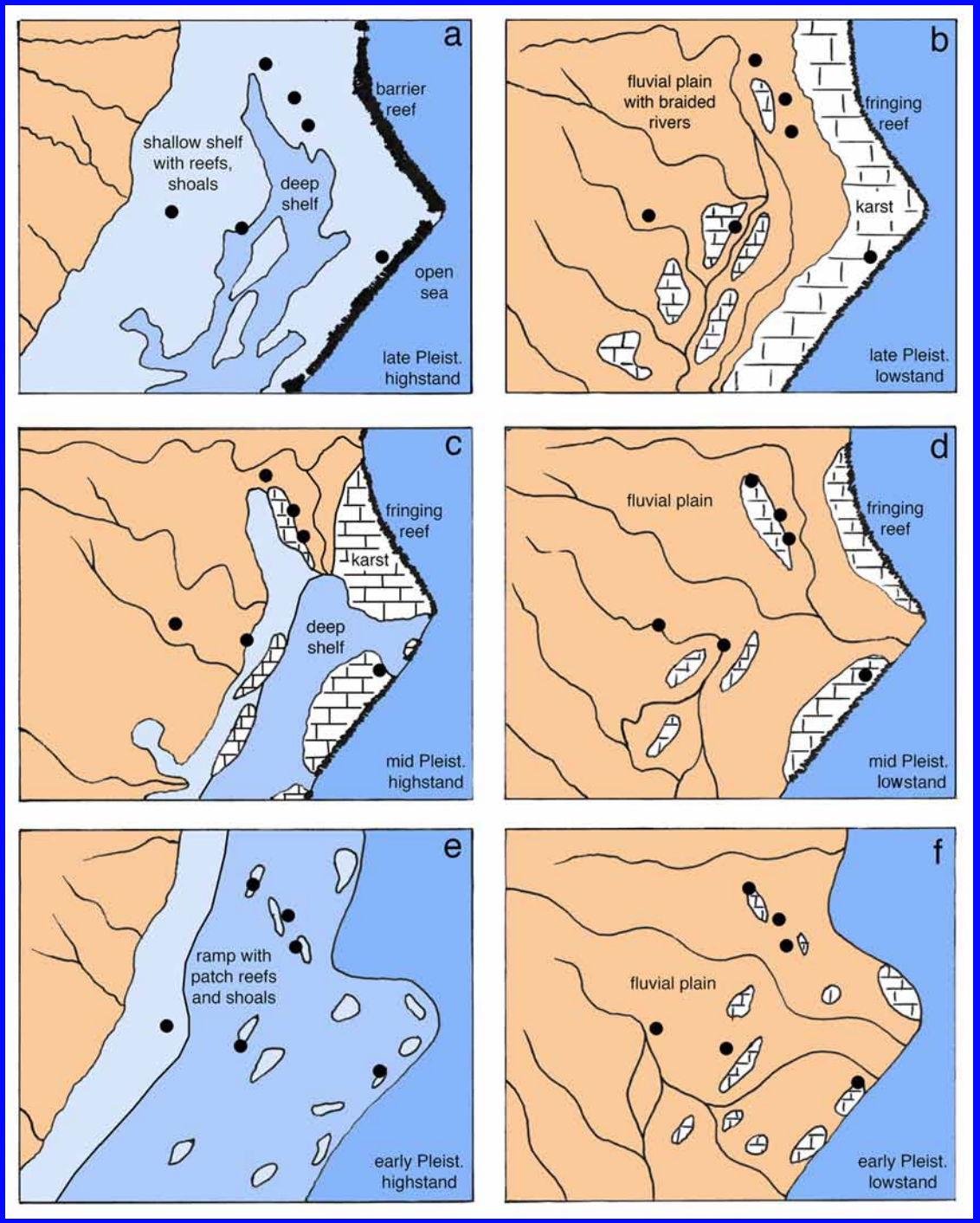
(Lisiecki & Raymo 2005)

Paleogeography

late Pleistocene

mid Pleistocene

early Pleistocene



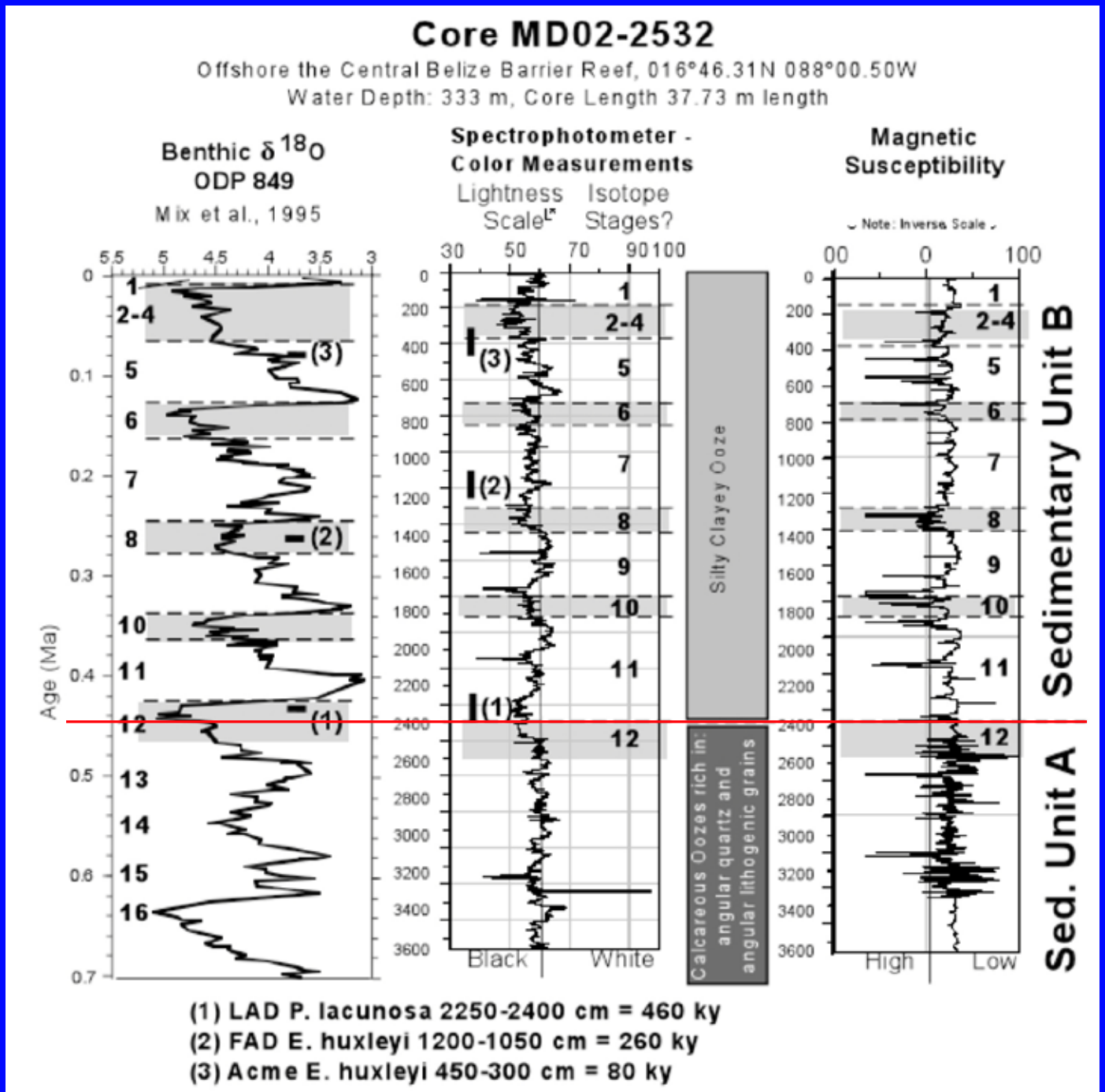
MIS 11-1

MIS 23-13

MIS 25+

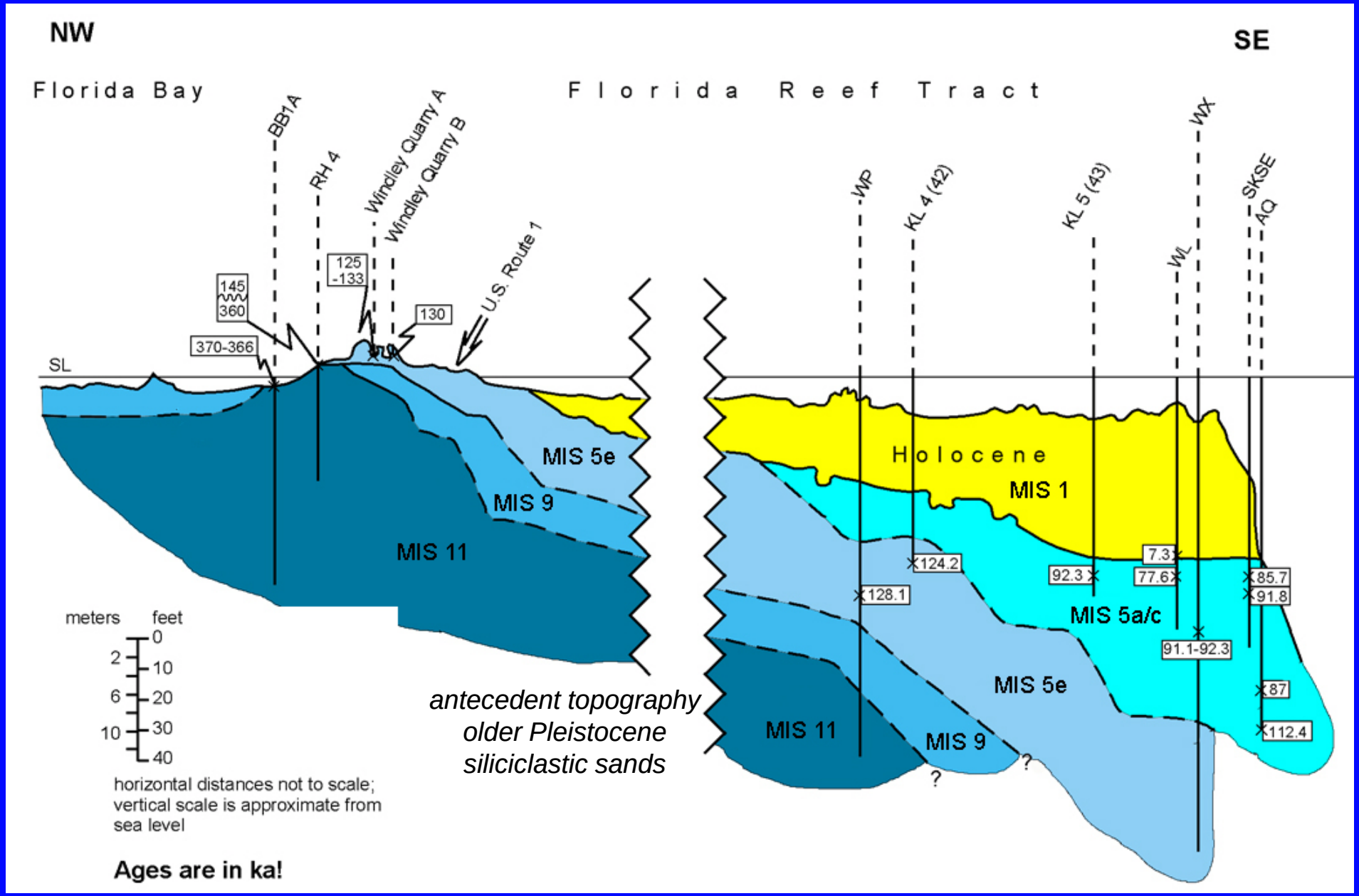
Off-reef core MD02-2532

taken 3 km east of Belize Barrier Reef



Droxler et al. (2003)

Comparison 1: Florida Reef Tract

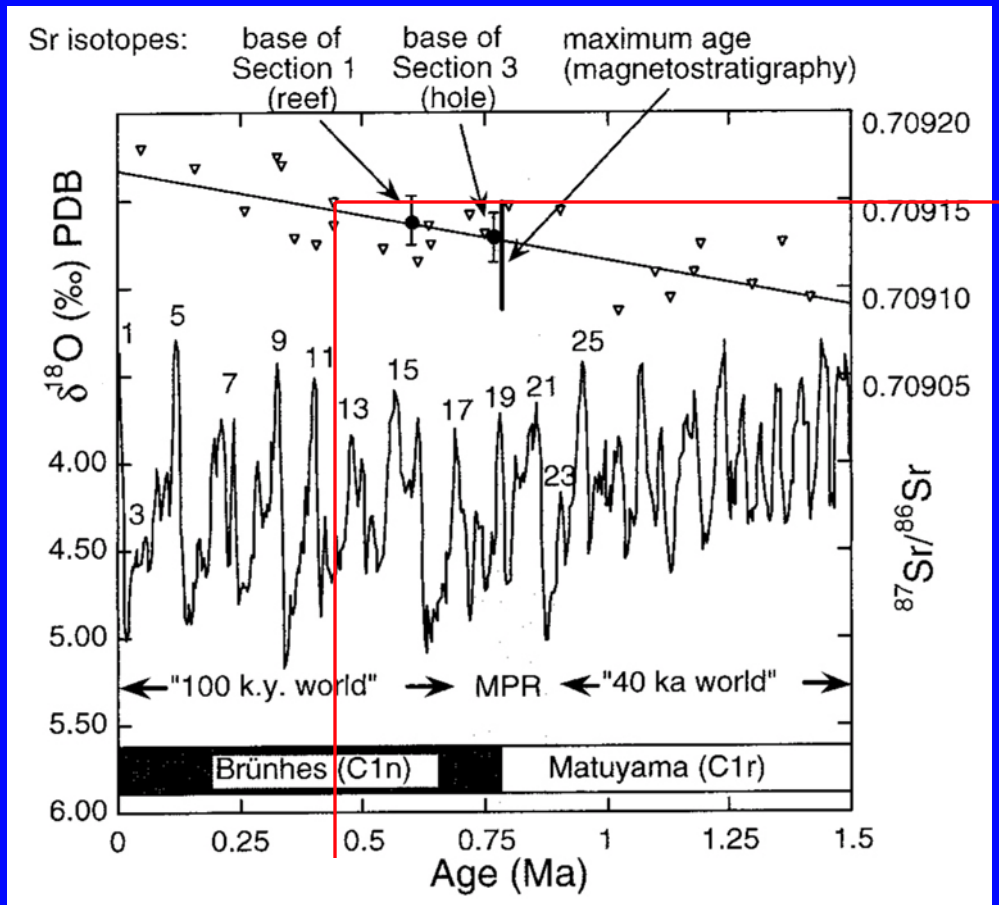


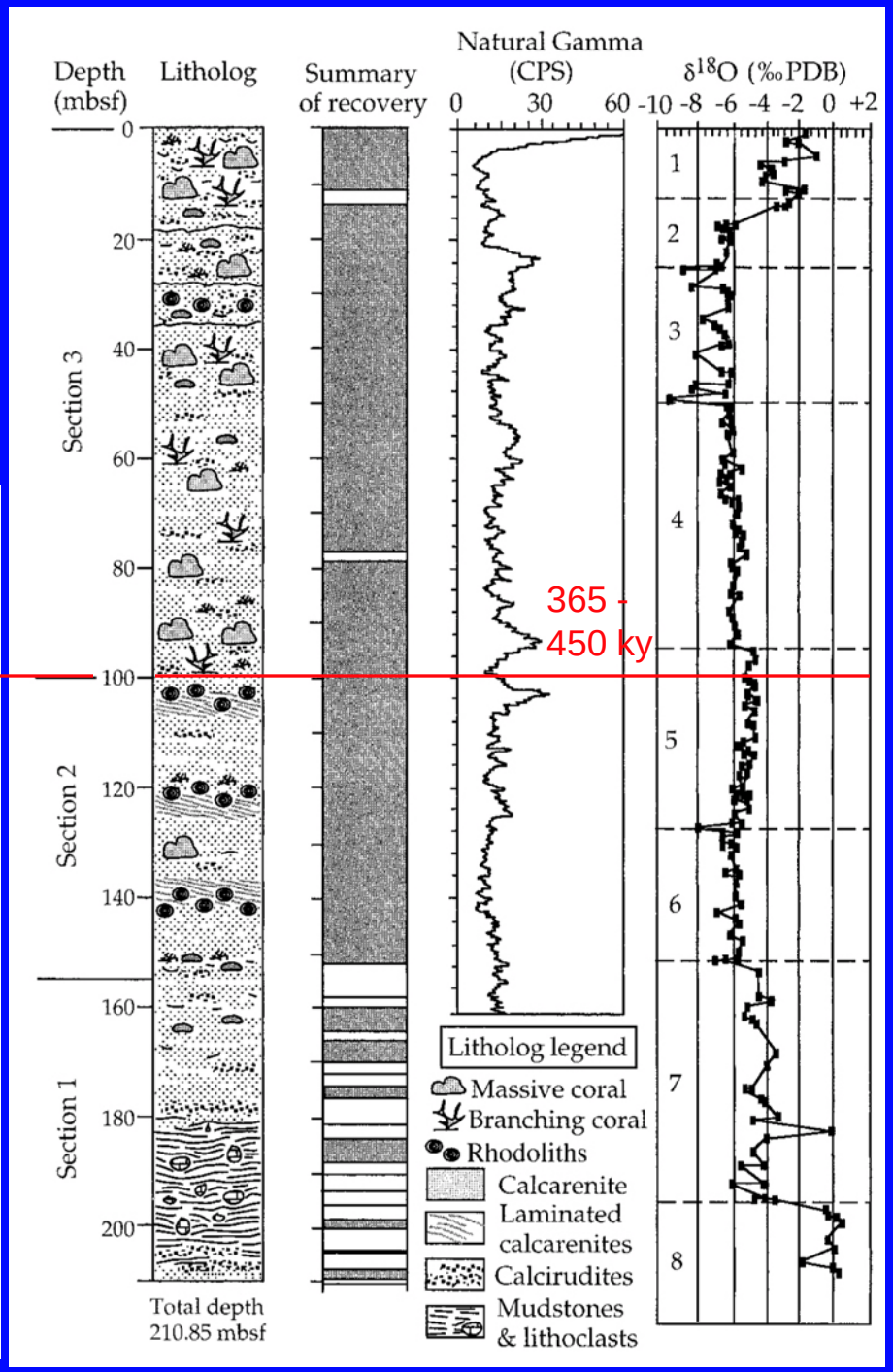
Multer, Gischler et al. (2002)

Comparison 2: Great Barrier Reef

Ribbon Reef 5

Int. Consort. GBR Drilling (2001)
Webster & Davies (2003)
Braithwaite et al. (2004)





Summary

- Quaternary successions in Belize include:
  late Pleistocene (and Holocene) coral packstone/grainstone (from MIS 11)
  mid Pleistcene clays (MIS 24-12)
  early Pleistocene biogenic wackestone, marl (before MIS 25)

- reefs on the shelf formed on siliciclastics
  barrier reef initiated on carbonates (older reef limestone)

- limitations: age model based on ranges

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Mixed carbonates and siliciclastics in the Quaternary of southern Belize: Pleistocene turning points in reef development controlled by sea-level change

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ABSTRACT

The Belize barrier and atoll reefs represent one of the largest reef structures in the Atlantic Ocean. The southern shelf of Belize is a classic location of a modern mixed carbonate–siliciclastic system. Whereas knowledge of the Holocene deposits in the area is extensive, data on the Pleistocene system are fragmentary. Open questions include: (i) the nature of the reef foundations (carbonate *versus* siliciclastics); (ii) the ages of the deposits including the initiation of the barrier reef; and (iii) the response of the mixed system to sea-level fluctuations. The results of a study of borings on the southern Belize shelf are presented here. Six, up to 105 m long borings were made to better understand the history of this important mixed system.