Paleocene-Eocene Drawdown and Refill of the Gulf of Mexico*

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Search and Discovery Article #30455 (2016)**
Posted May 16, 2016

*Adapted from oral presentation given at AAPG Geosciences Technology Workshop, Seventh Annual Deepwater and Shelf Reservoir, Houston, Texas, January 26-27, 2016

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Abstract

Rosenfeld and Pindell (2002, 2003) hypothesized that Late Paleocene-Early Eocene docking of the northward migrating Caribbean Plate blocked the 200 km strait between the Florida/Bahamas Block and Yucatan, thereby isolating the Gulf of Mexico basin from the world ocean. Within several thousand years, net evaporation in the Gulf lowered its level by about 2,000 meters forming a land bridge across the eastern Gulf that encompassed Yucatan, Florida, Cuba, and the Bahamas. The land bridge was enhanced by isostatic uplift of the basin's margins as sea level dropped. After 1 Ma of isolation, reconnection with the world ocean and energetic refill of the basin cut a deep thalweg between Florida and Cuba. This relatively short duration drawdown explains many phenomena unique to this period of Gulf history, including:

- the excavation of deep canyons across contemporary continental shelves and slopes: (*e.g.*, Yoakum, St. Landry, Chicontepec, Bejuco-La Laja), many canyons of subaerial aspect cutting the lower continental slopes west of Florida and north of Yucatan, and sinkholes in present day water depth exceeding 1,000 m.

- the sudden deposition, and equally sudden cessation of a thick and widespread high net sand blanket in the deep Gulf Basin hundreds of kms beyond the contemporaneous shelf edge;

- salt deposited in the Tertiary Veracruz Basin; and

- a regional unconformity in the carbonate-dominated eastern Gulf Basin.

The drawdown is coeval with, and may have triggered, the worldwide Paleocene-Eocene thermal maximum (PETM) through the release of voluminous methane from destabilized hydrates and breached conventional reservoirs as the water level dropped.

The drawdown profoundly affected the petroleum geology of the Gulf of Mexico by deposition of the Wilcox "Whopper Sand" reservoirs in U.S. and Mexican waters, and porosity enhancement by fresh water infiltration and leaching of Golden Lane Atoll and deep-water carbonates of the Poza Rica and Campeche Sound Trends.

Although general acceptance of the Paleocene-Eocene Gulf drawdown has met resistance, recently available bathymetry along the deep western Florida and northeastern Yucatan continental slopes provides convincing evidence in the form of sinkholes and steep-walled canyons. Moreover, detailed study of the Chicontepec Canyon leads to the conclusion that bathyal turbidite deposition was interrupted by subaerial erosion and oil seepage.

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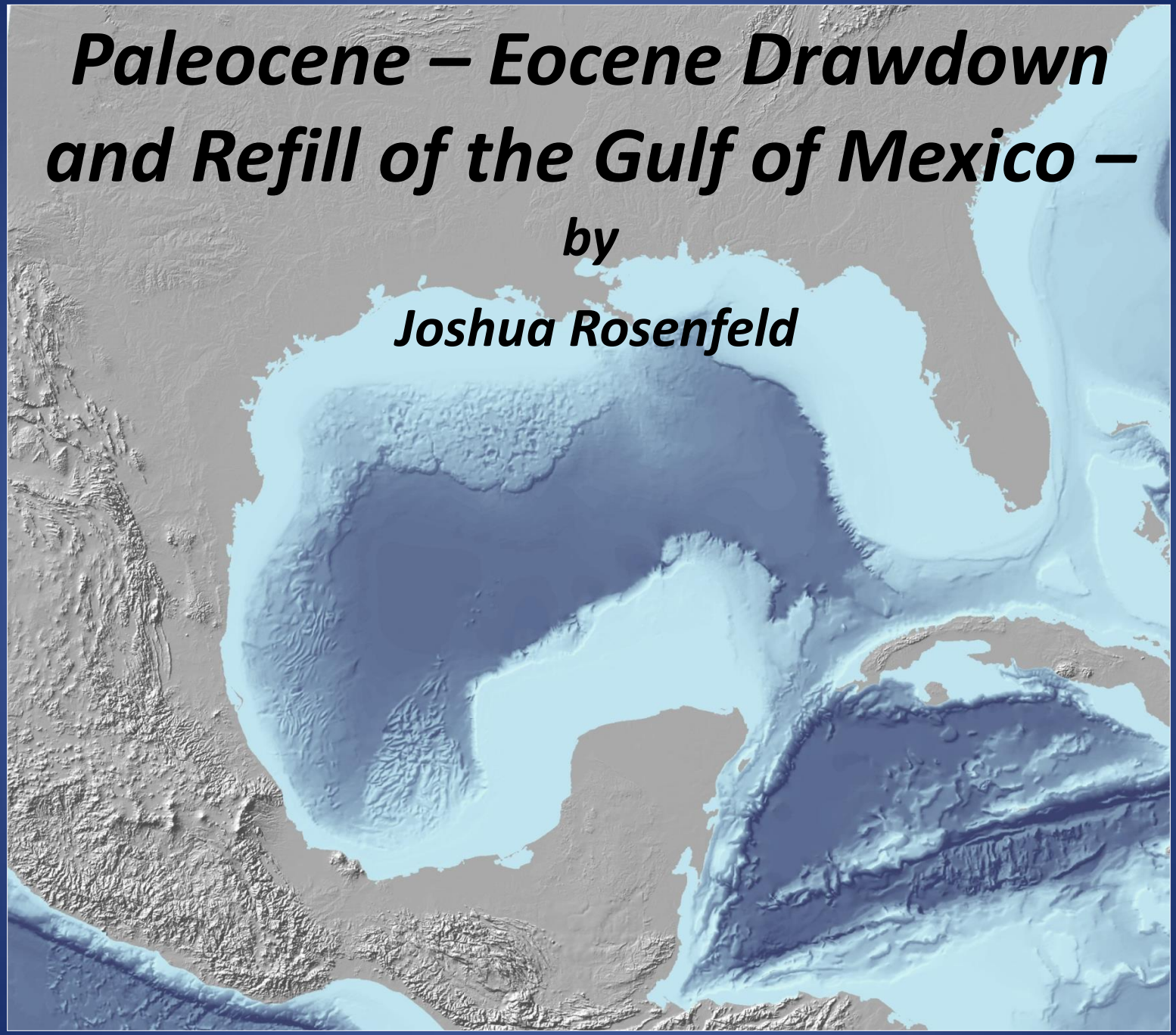
Paleocene – Eocene Drawdown and Refill of the Gulf of Mexico –

by

Joshua Rosenfeld



The Concept:

- *The Gulf was isolated from the world ocean at about the Paleocene-Eocene boundary as the Cuban Arc docked against the Florida/Bahamas Block*

- *Subsequently, evaporation lowered the level of the Gulf by some 2,000 meters within several thousand years .*

- *Isolation lasted about 1 million years.*

- *The Gulf refilled rapidly upon reconnection with the world ocean.*

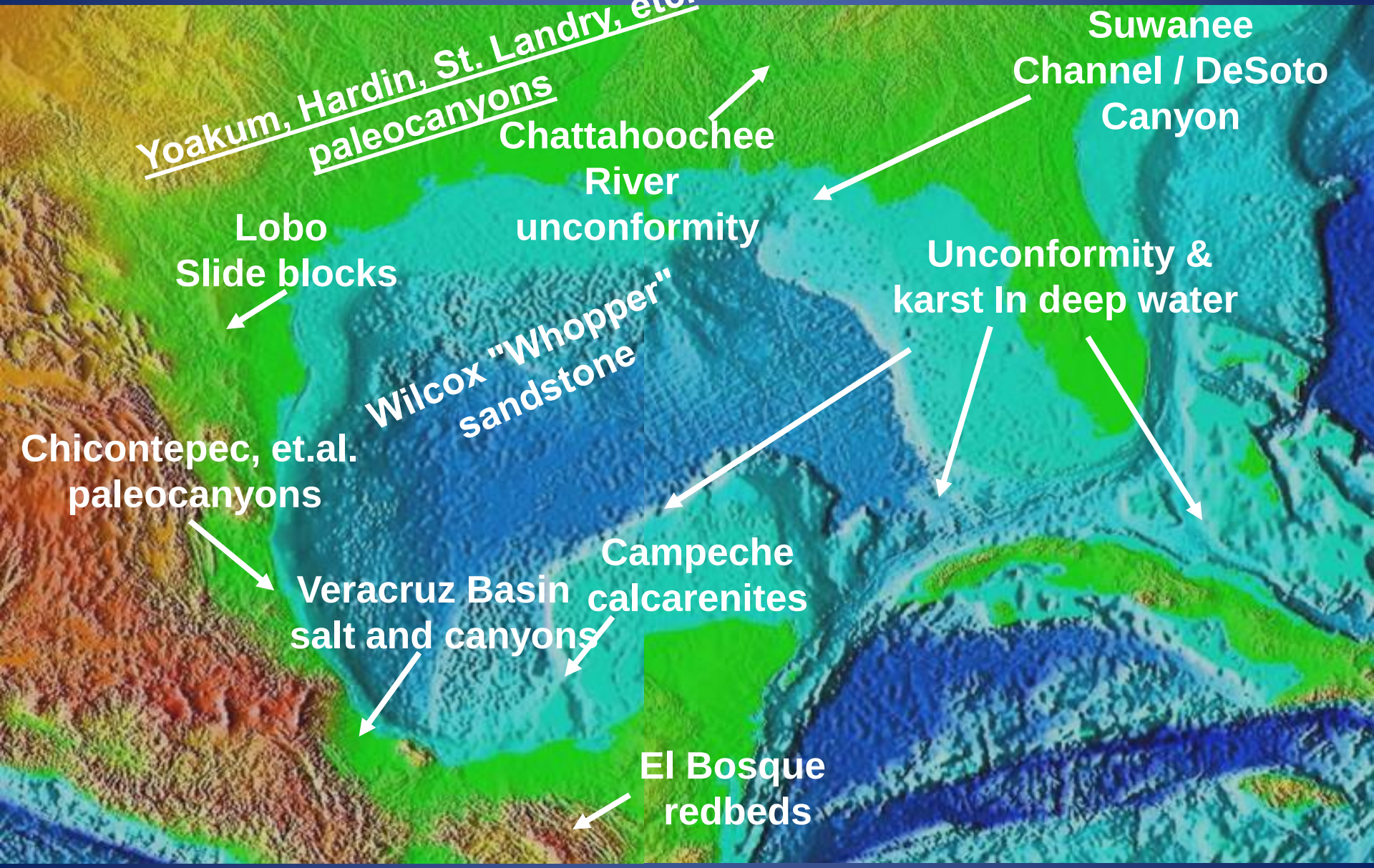
Concept History – Print References

- *Rosenfeld and Pindell: Offshore Magazine, January 2002*
- *Rosenfeld and Pindell: AAPG Memoir 79, 2003*
- *Berman and Rosenfeld: World Oil Magazine, July, 2007*
- *Berman and Rosenfeld: GCSSEPM Perkins Conf. Proceedings, 2007*
- *Rosenfeld: HGS Bulletin, October, 2008*
- *Rosenfeld: GCSSEPM Perkins Conf. Proceedings, 2014*
- *Cossey et al., in press*

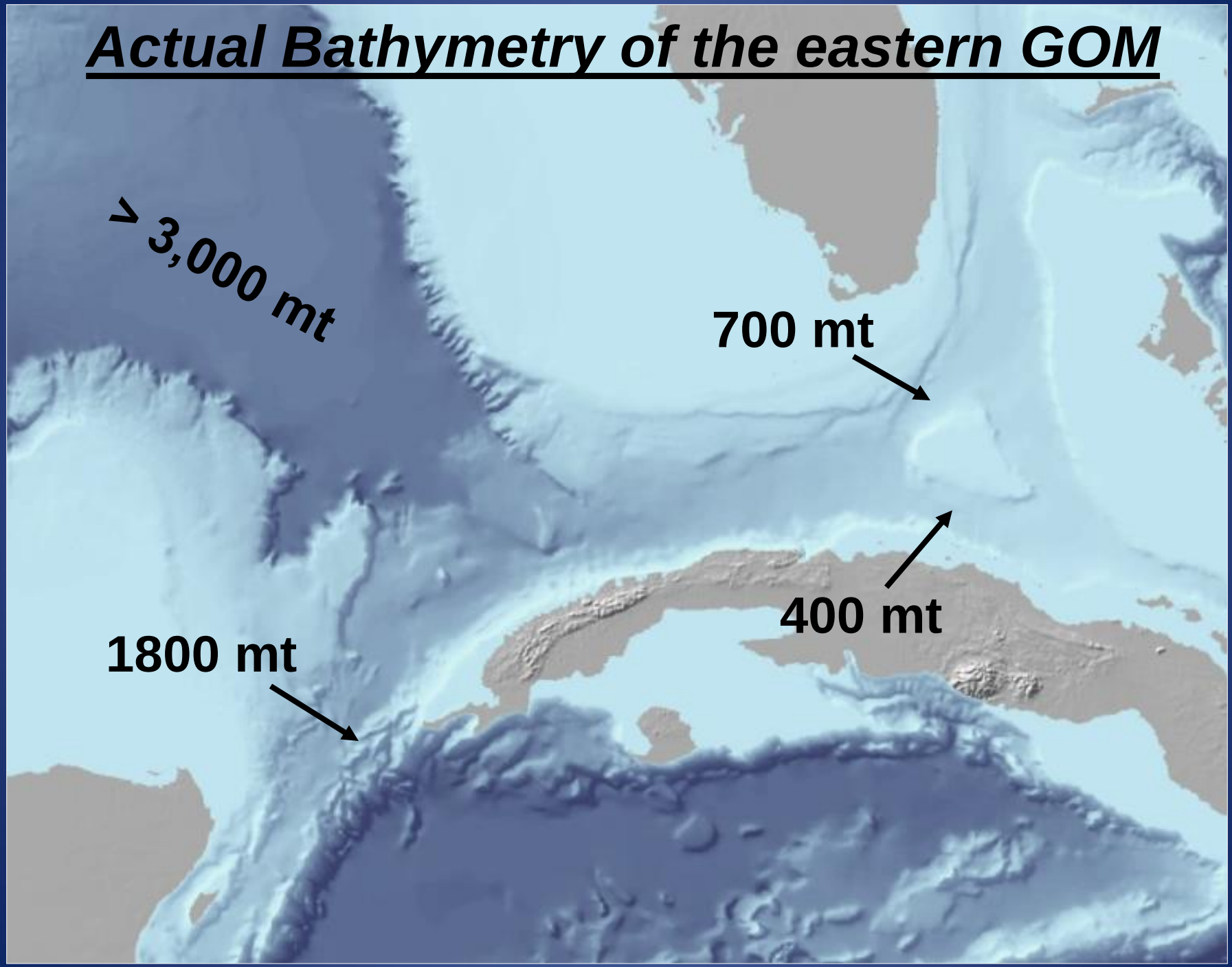
Beware of the "Semmelweis Reflex:

The reflex-like rejection of new knowledge because it contradicts entrenched norms, beliefs, or paradigms.

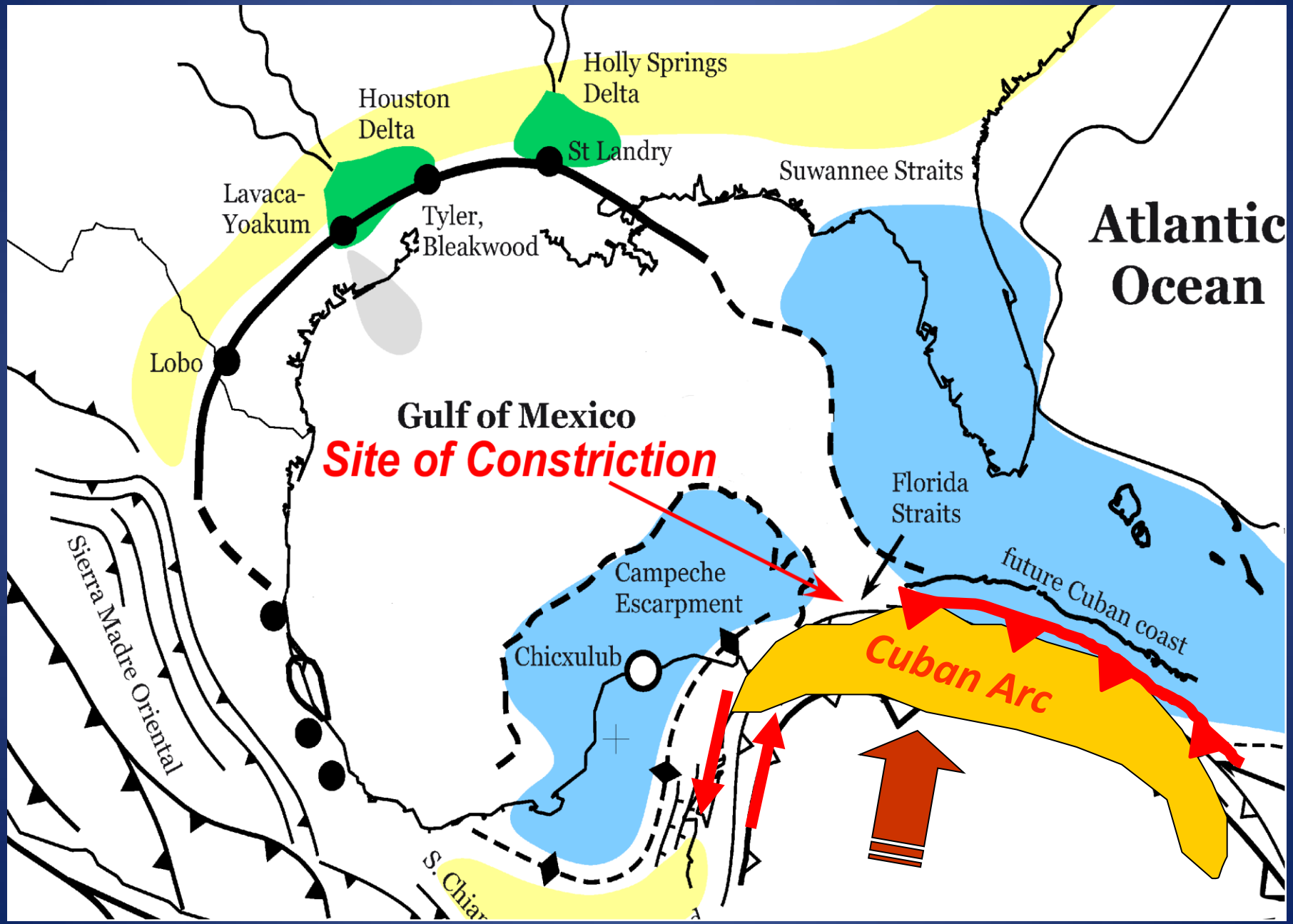
Paleocene - Eocene GOM Anomalies



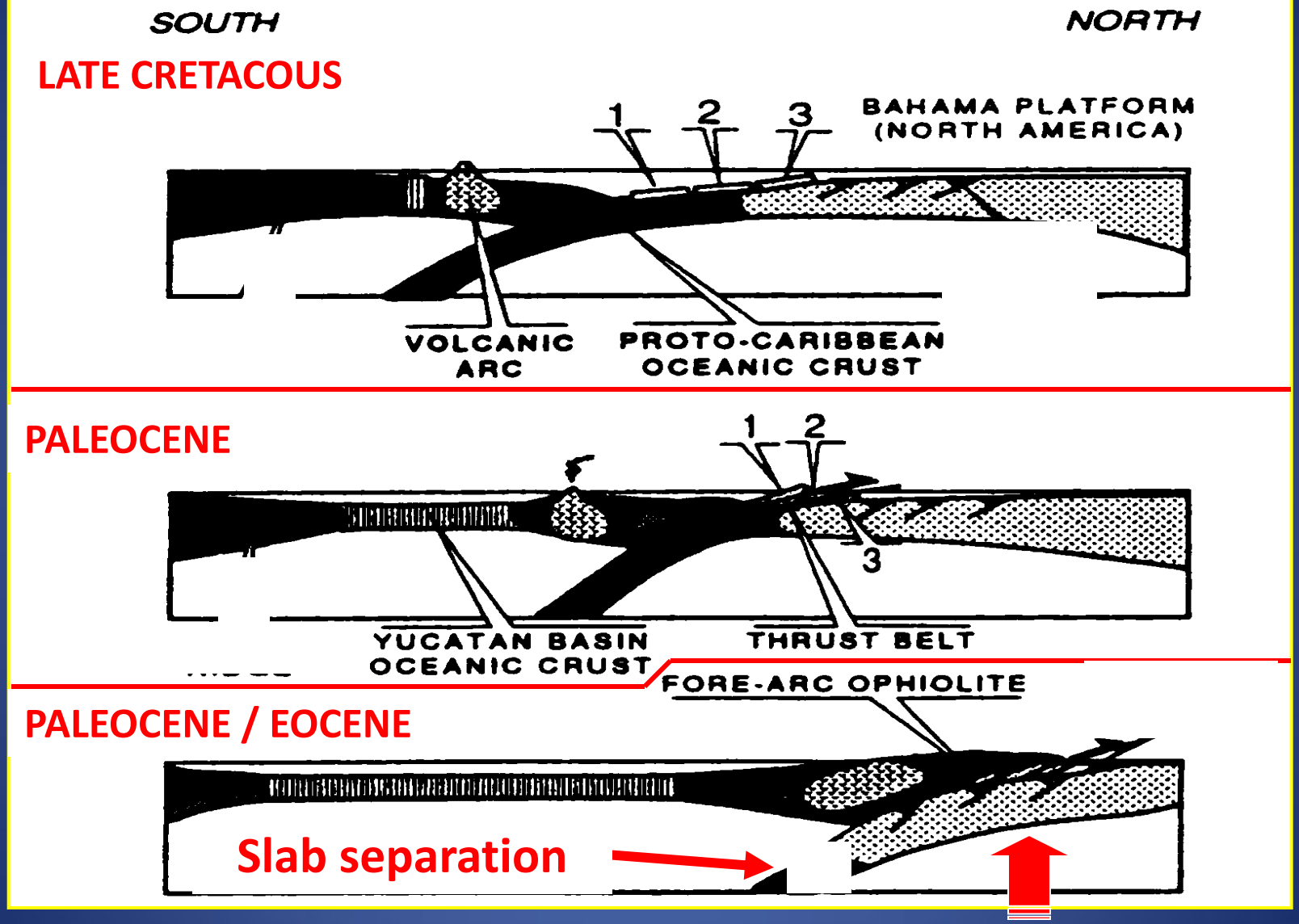
Actual Bathymetry of the eastern GOM



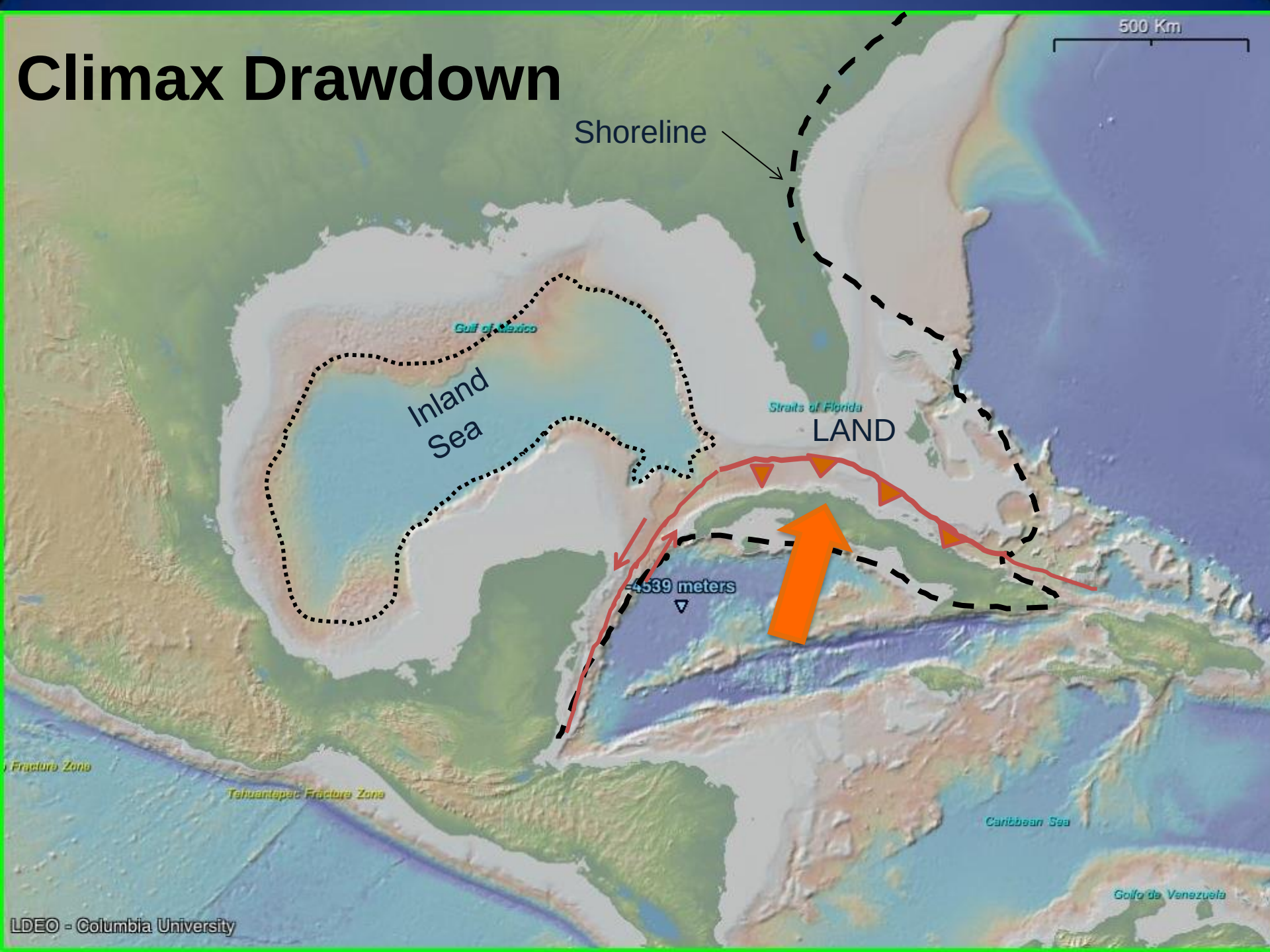
Isolation Mechanism



Cuba - Florida Collision



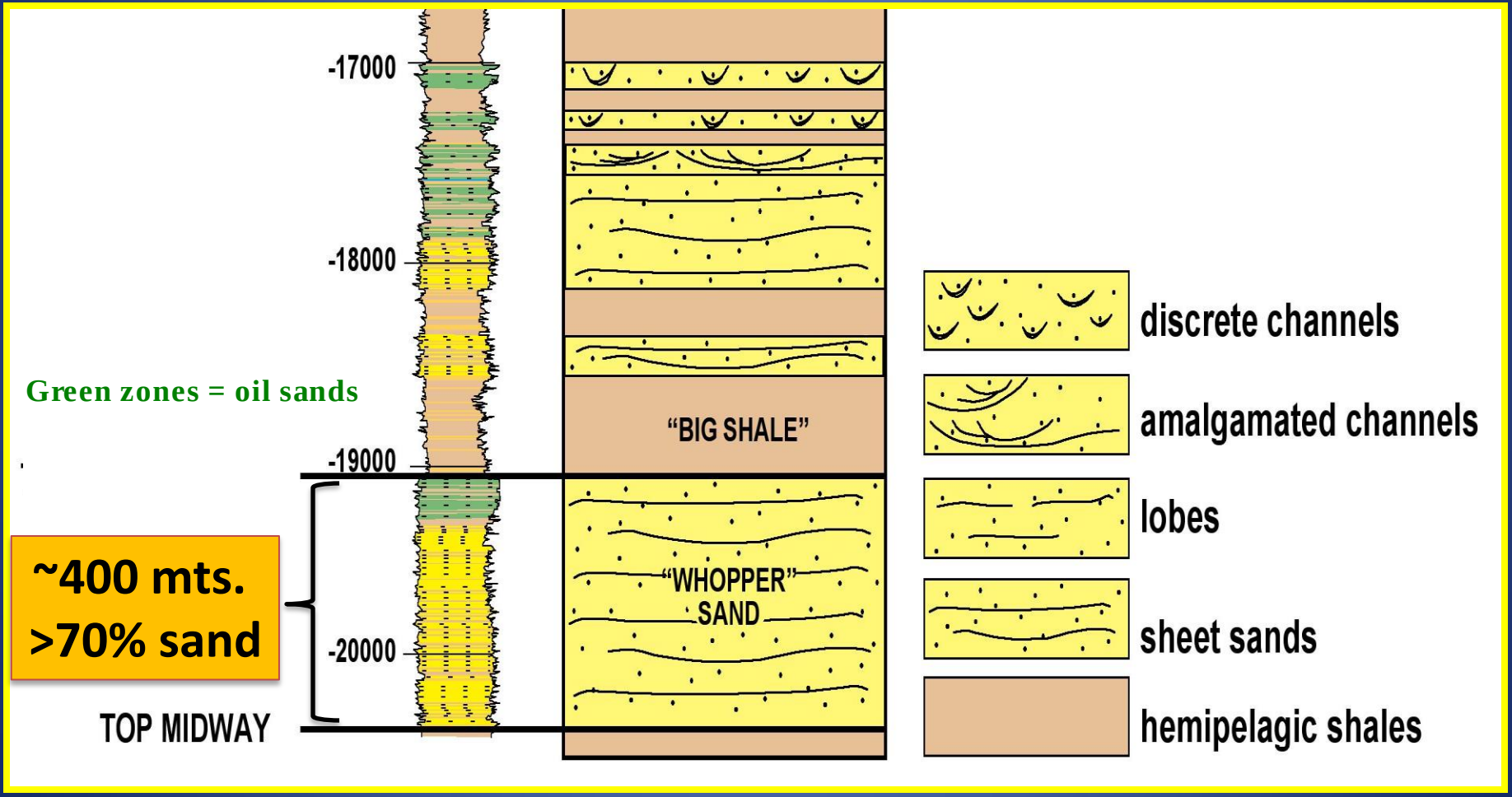
Adapted from Hutson, Mann and Renne, 1998


Climax Drawdown
Shoreline
500 Km
Inland Sea
LAND
-4539 meters
Gulf of Mexico
Straits of Florida
Tehuantepec Fracture Zone
Caribbean Sea
Golfo de Venezuela
LDEO - Columbia University

Isolation Effects

- *Rapid evaporative drawdown of the Gulf by ~2,000 m.*
- *Isostatic + tectonic uplift and land bridge across Florida, Cuba, the Bahamas and Yucatan*
- *Extensive slumping of clastic shelf edges and slopes*
- *Canyon incision across shelves and slopes*
- *Bypass and recycling of sediments into the central Gulf*
- *Karsting and fresh water diagenesis of shallow and deep basin carbonates*
- *Salt deposition in barred basins (i.e. Veracruz Basin)*
- *Massive hydocarbon release from hydrates and breached reservoirs possibly triggering the P/E Thermal Maximum*

Wilcox section – Union Oil Trident well (2001)



Blickwede et al., 2004

"Whopper" Sand in the Great White well

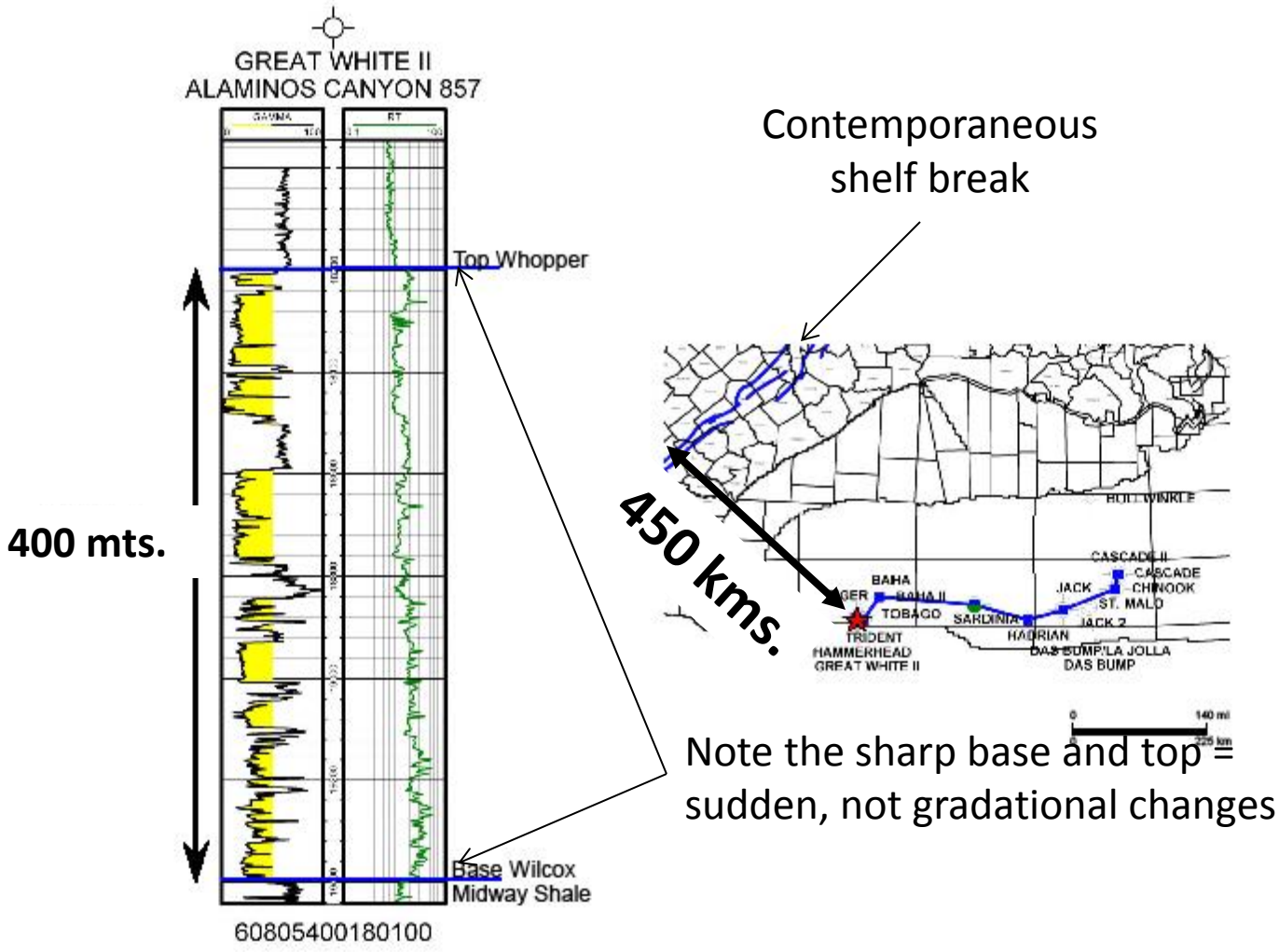
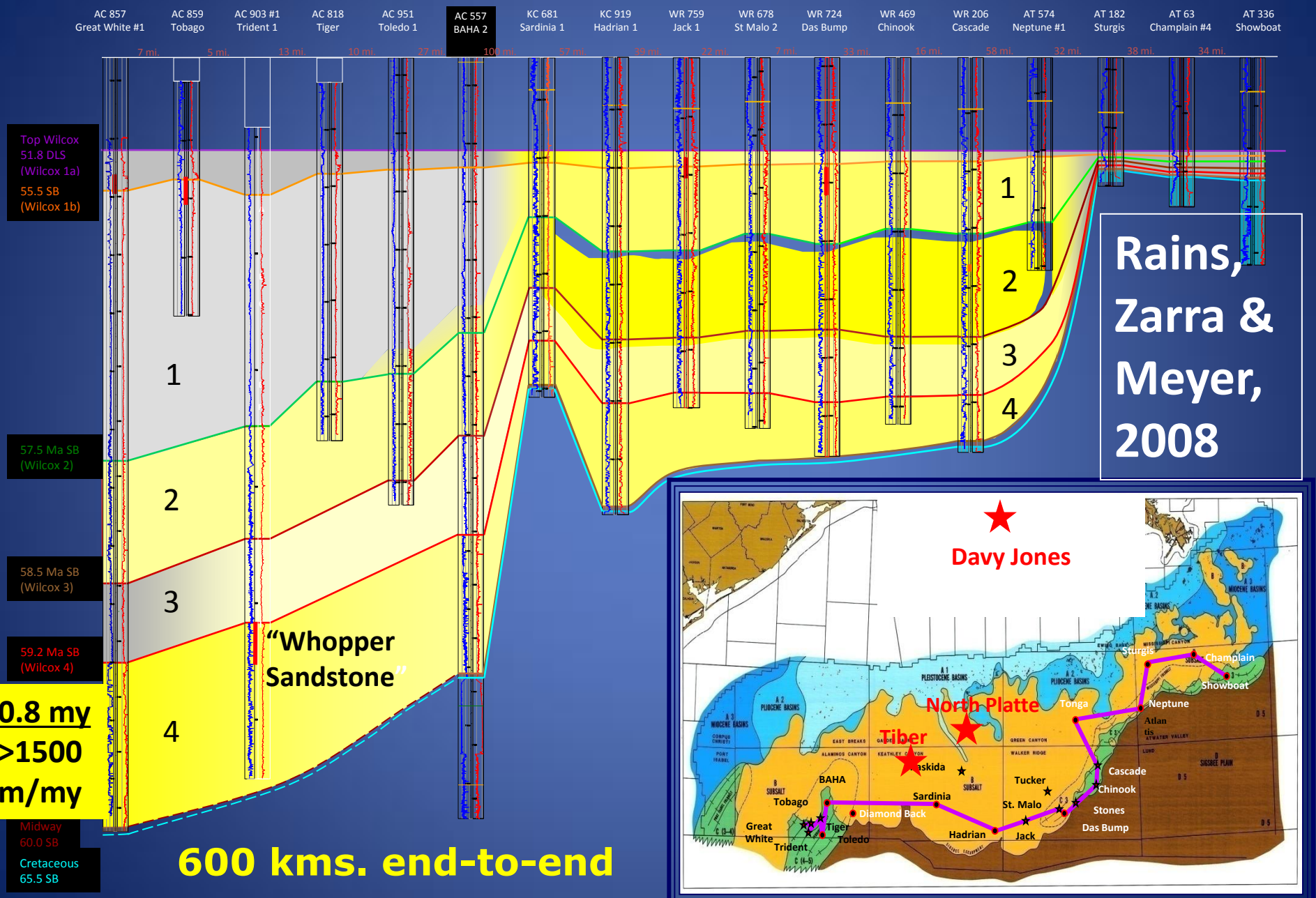


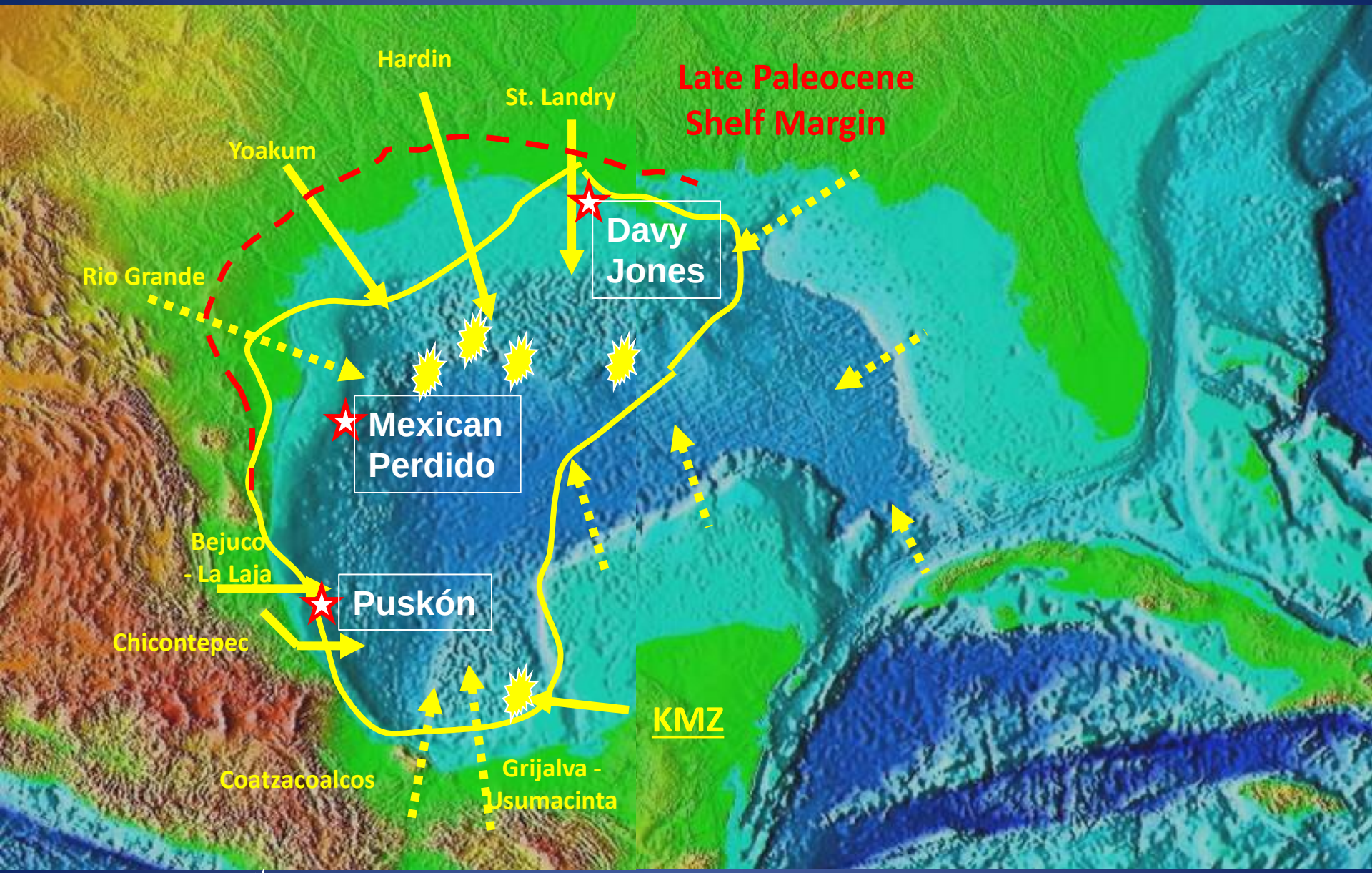
Figure 36. Wilcox section in Great Whilte well, Alaminos Canyon 857, API # 60805400180100. Gamma Ray curve is normalized with other deep Gulf Wilcox wells and re-scaled, shading less than 50 API Units. Data from IHS Energy.

Berman and Rosenfeld, 2008

Wilcox Regional Cross Section

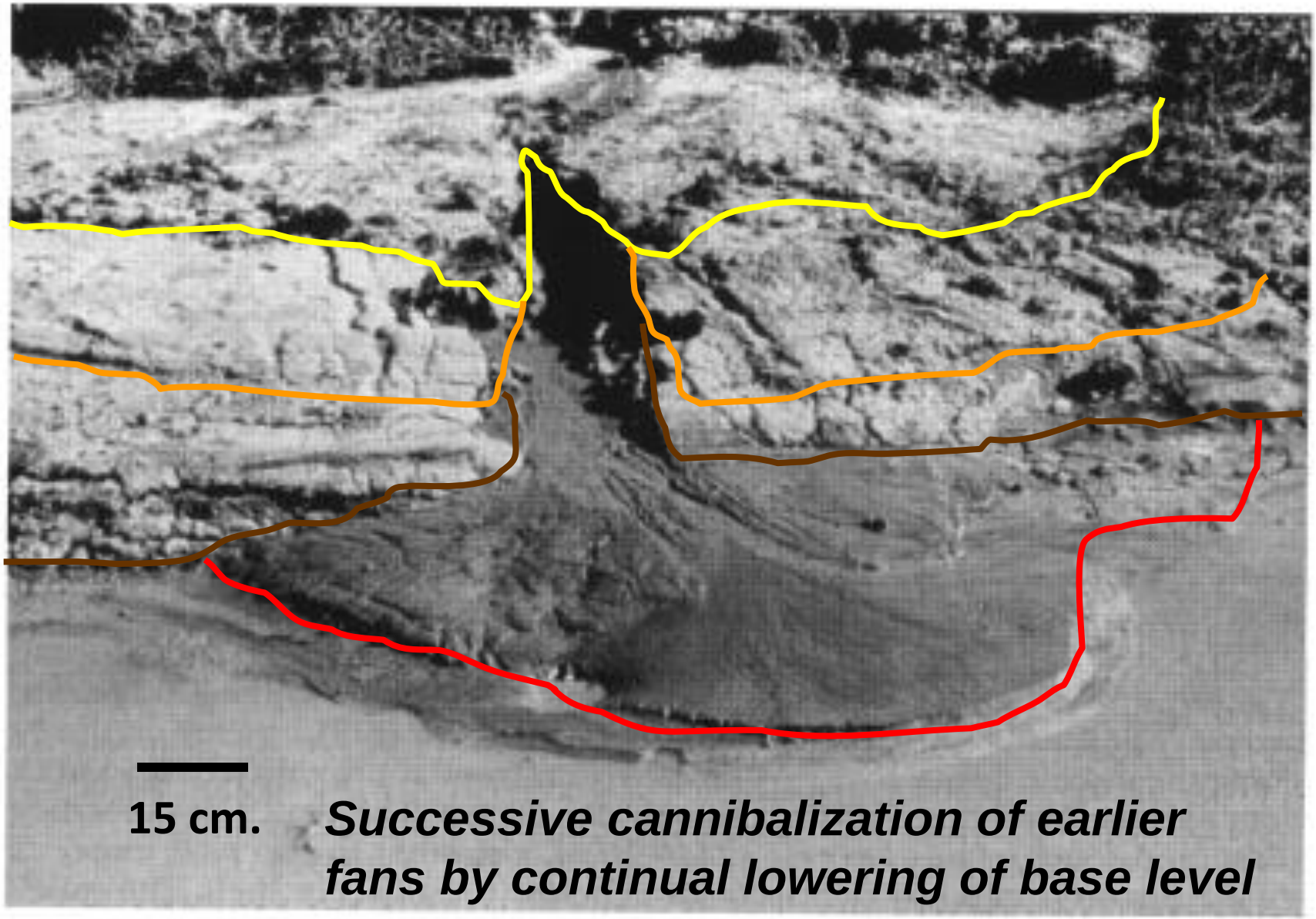


Deep Water Wilcox Sandstone Trend



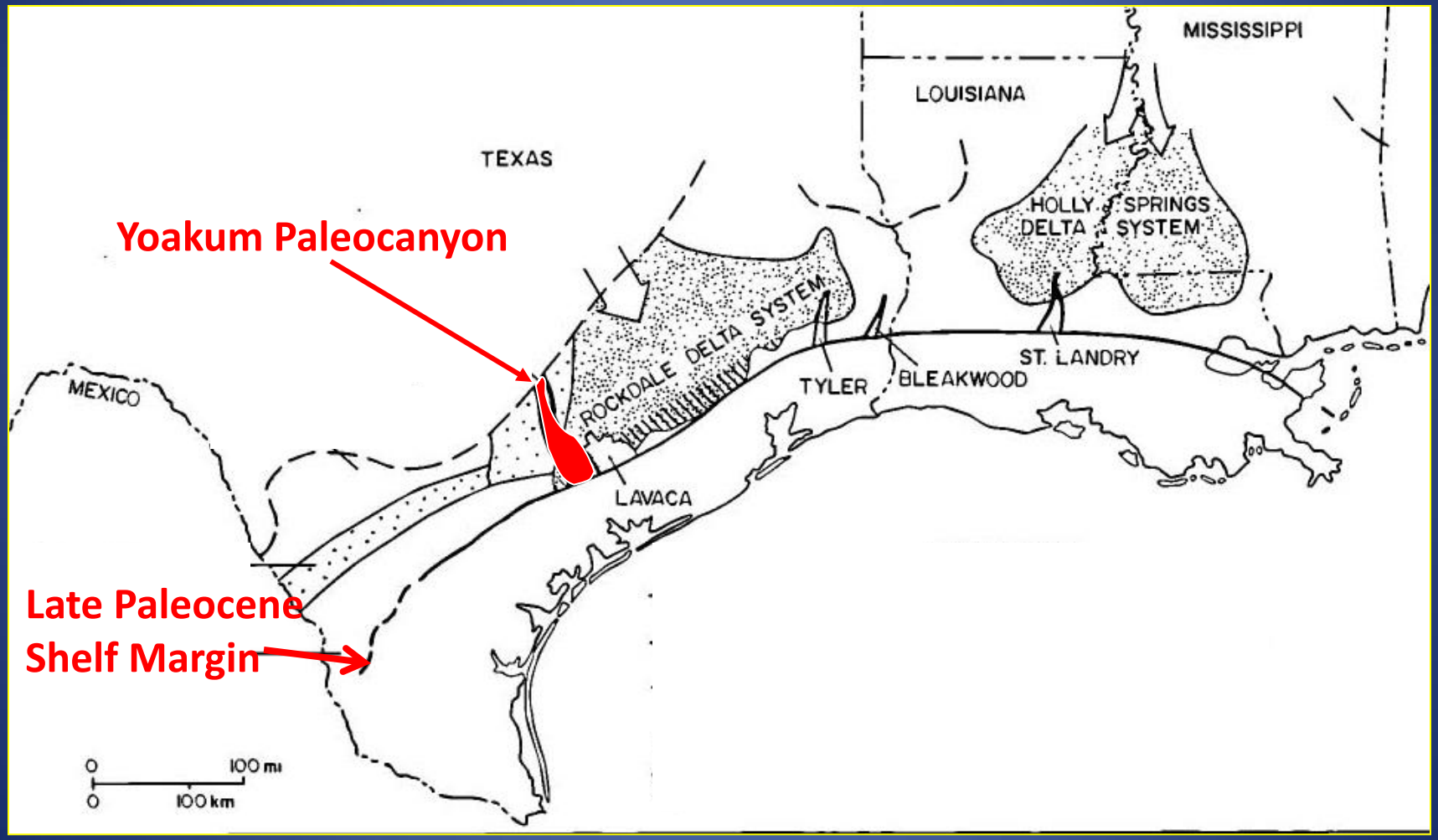
= Proven sandstone area

"Forced Regression" Sequence



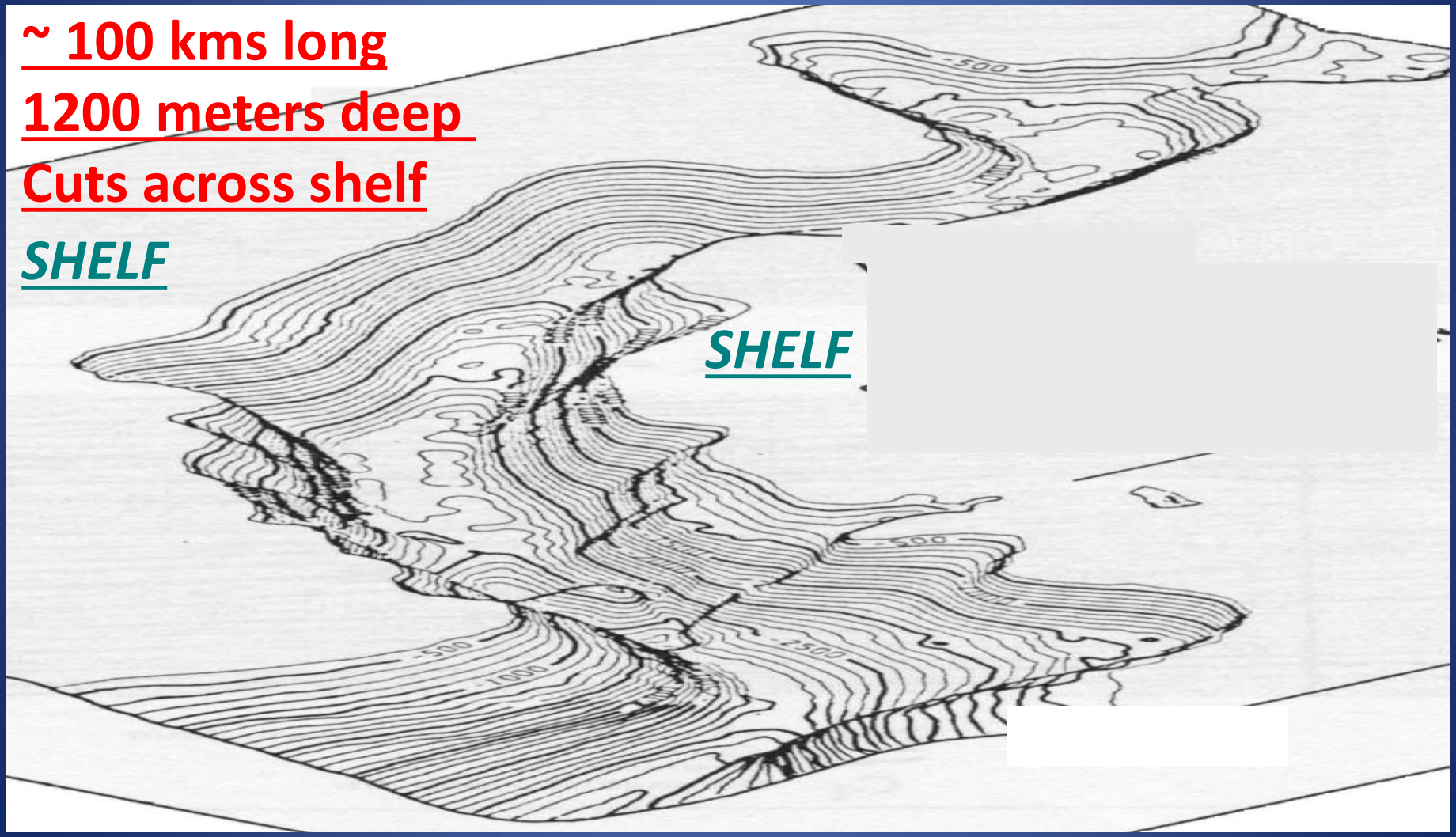
Posamentier et al, 1992

Paleocanyons



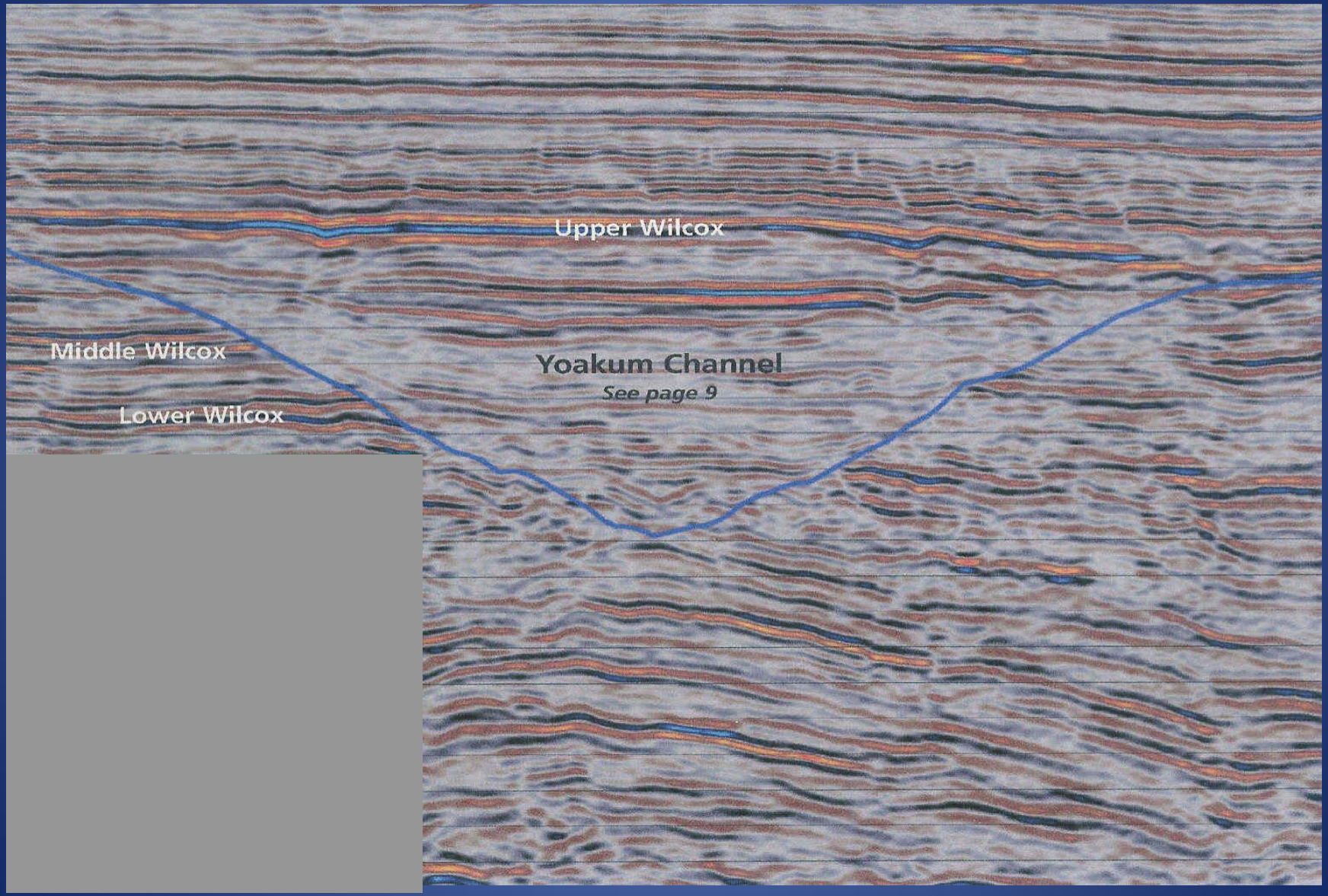
From Galloway, Dingus and Paige, 1991

Yoakum Paleocanyon



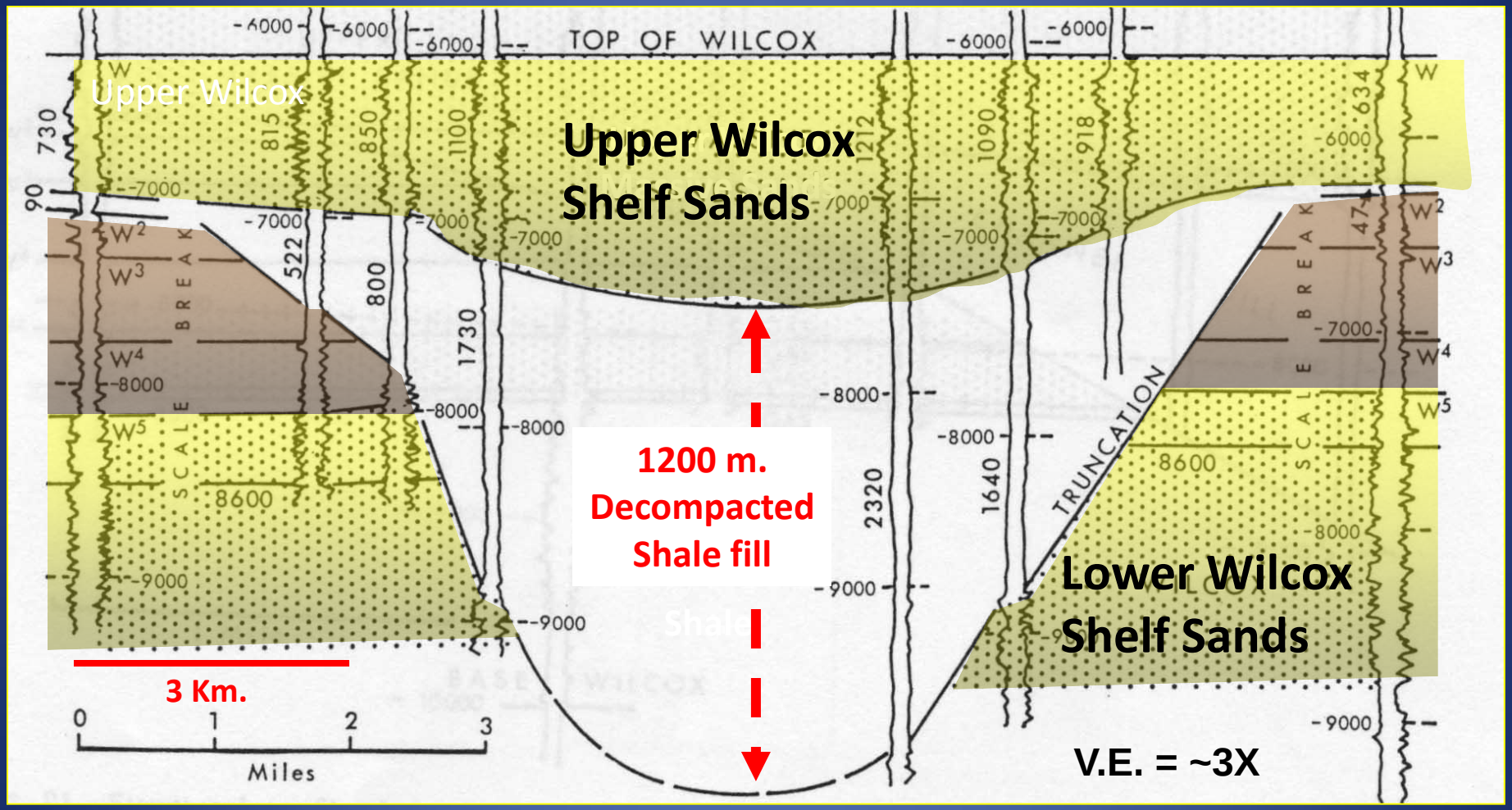
From Galloway, Dingus and Paige, 1991

Seismic Section – Yoakum Paleocanyon



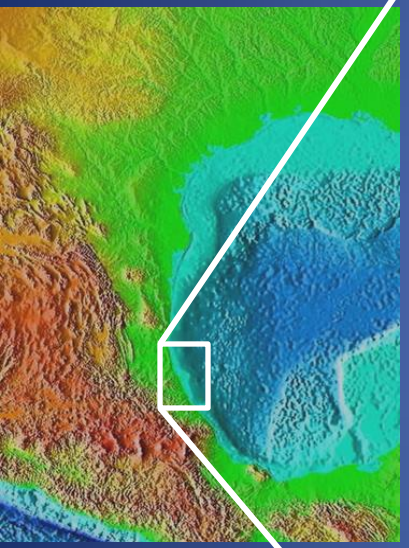
P. Britt, HGS Bulletin April, 2006

Yoakum Paleocanyon

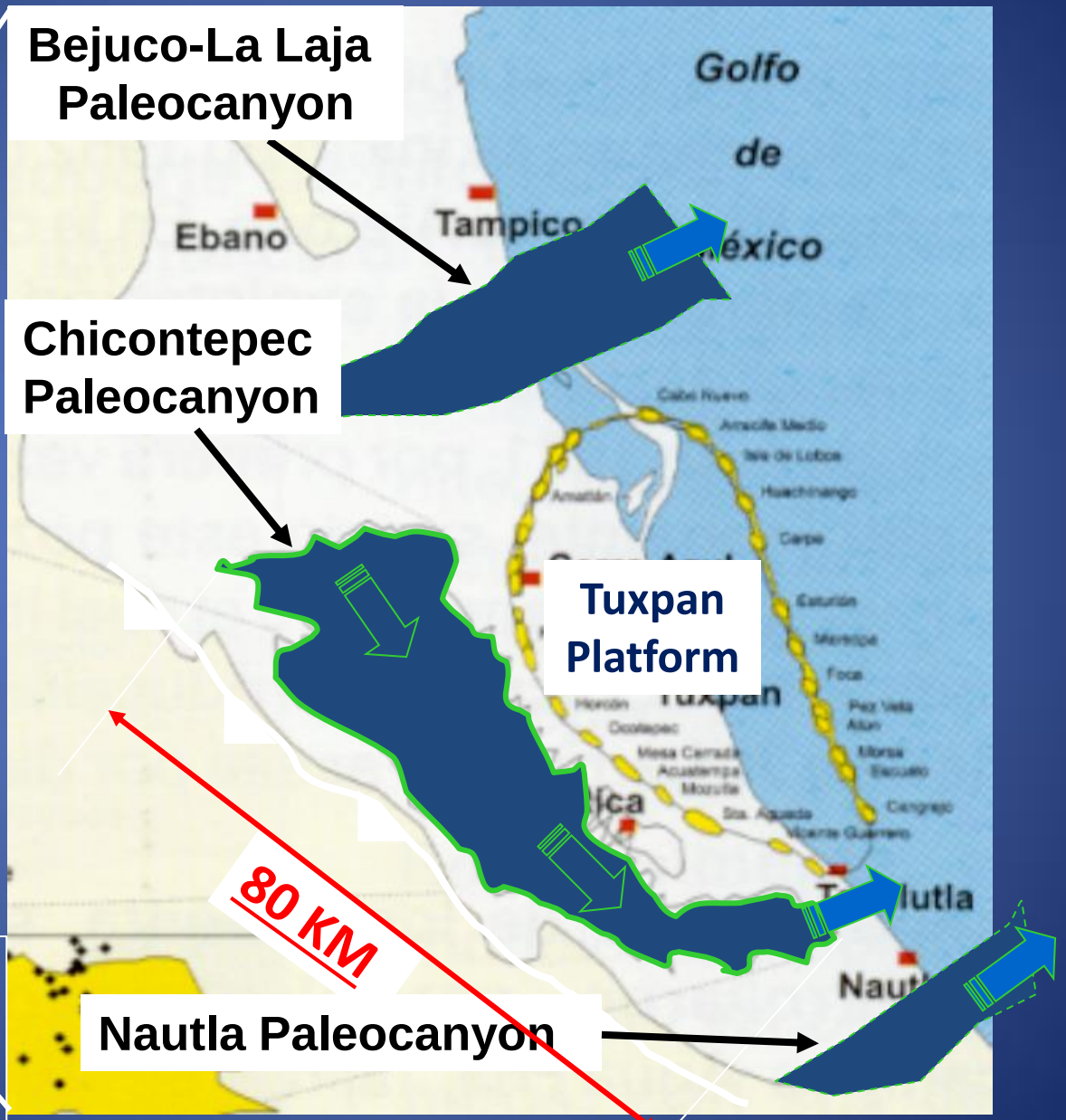


From Hoyt, 1959

Central Mexico Paleocanyons

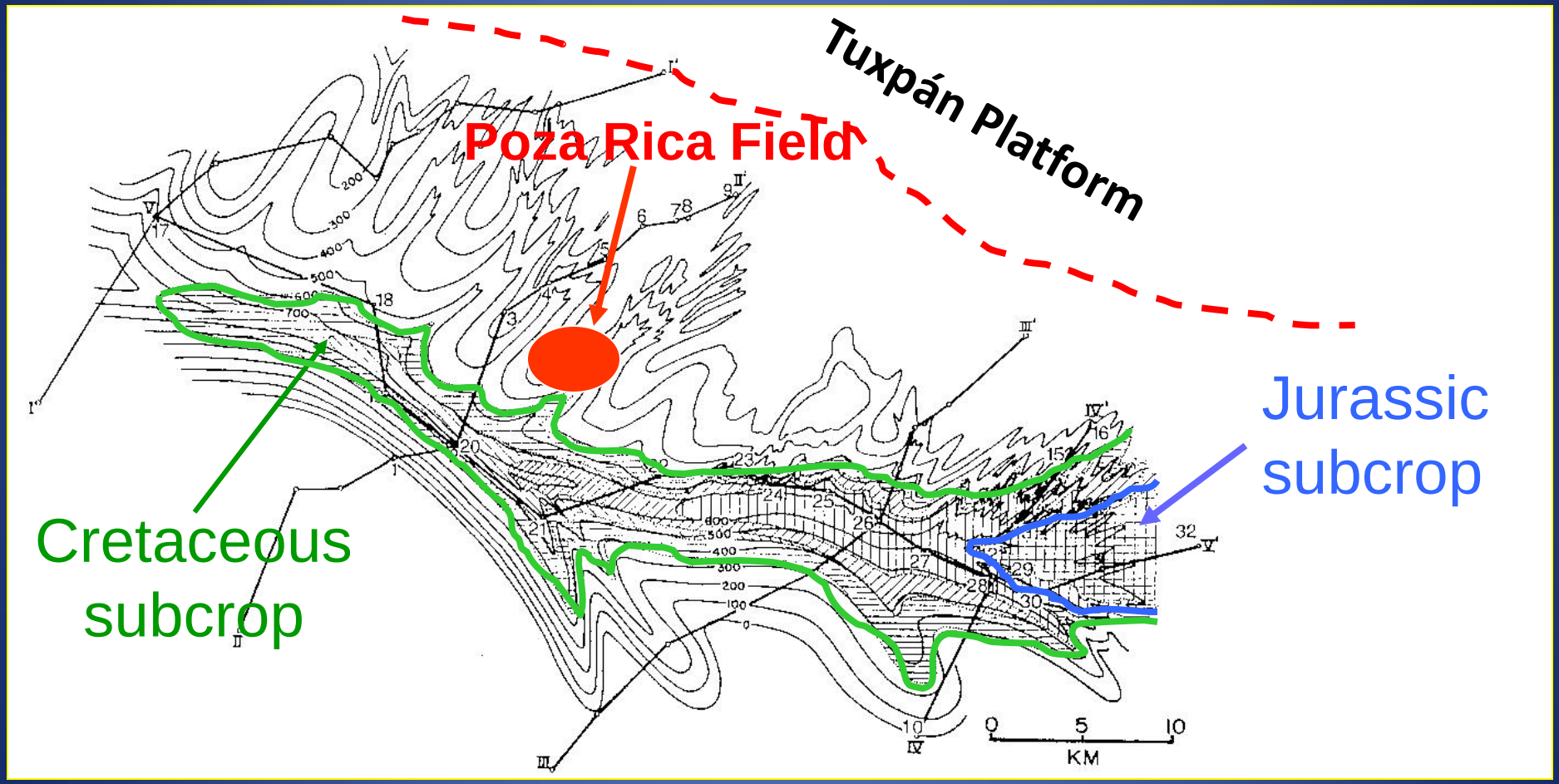


- *Youngest subcrop is Paleocene*
- *Oldest fill is Eocene*



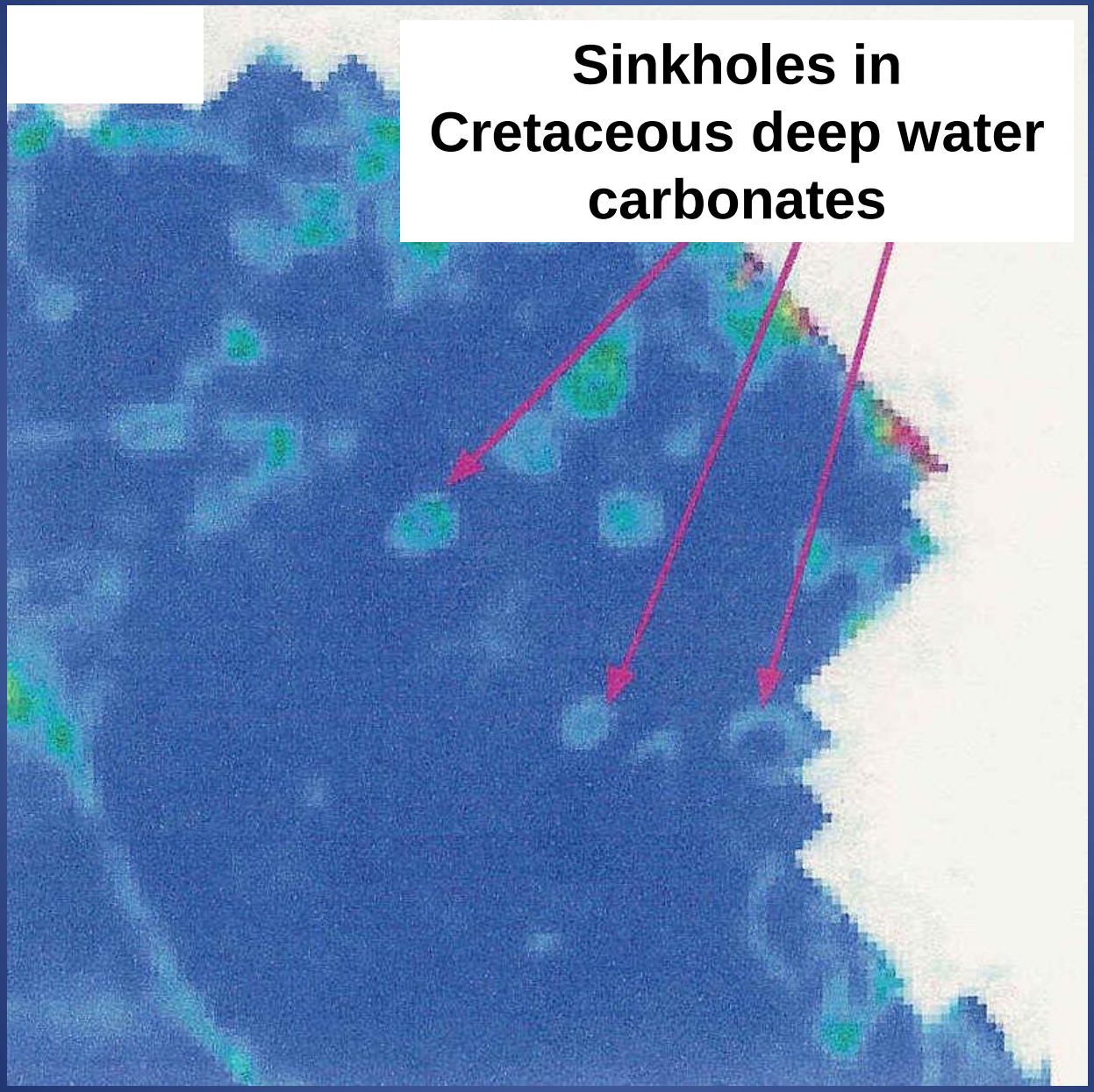
Adapted from Pemex, 1999

Chicontepec Paleocanyon eroded into lithified carbonates



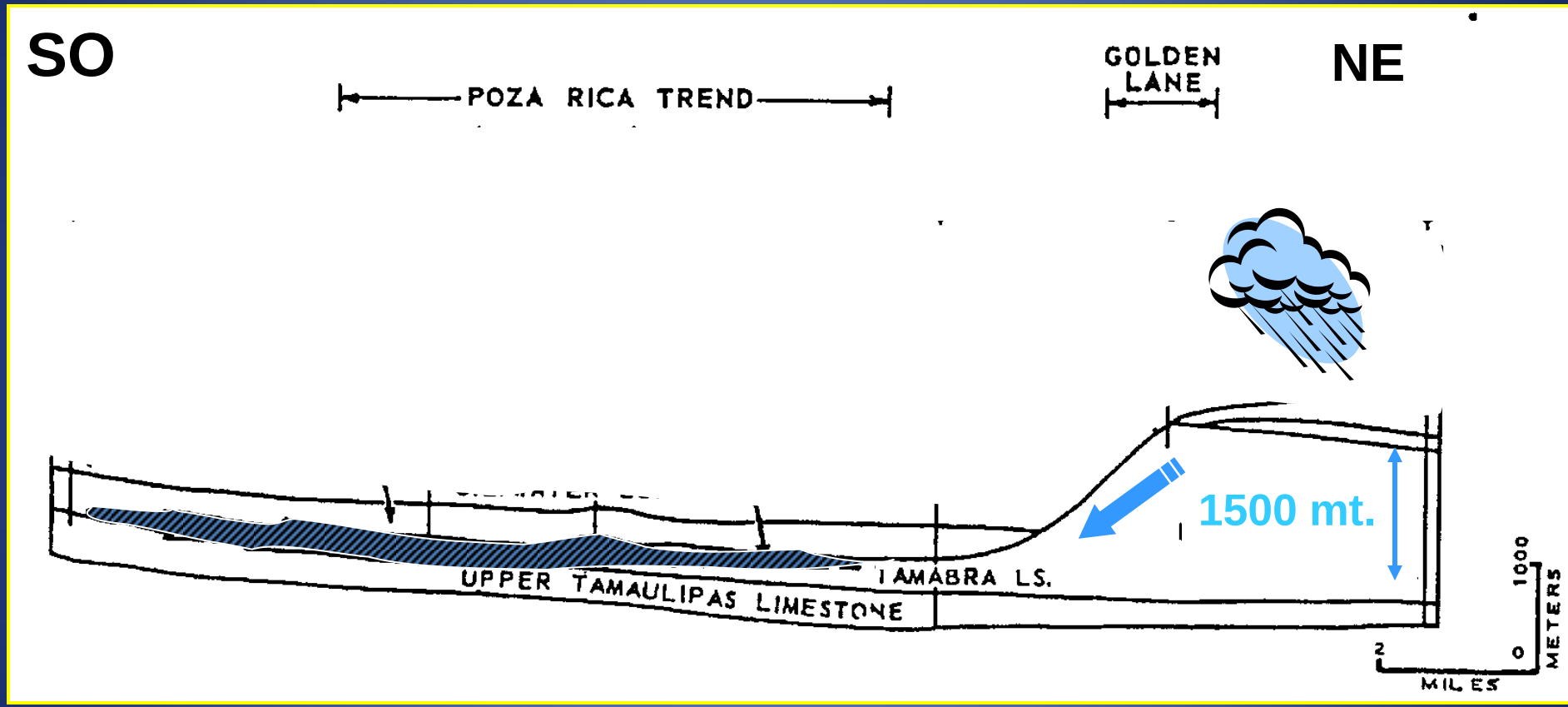
Adapted from Busch and Govela, 1978

Poza Rica 3D Seismic (Time slice)



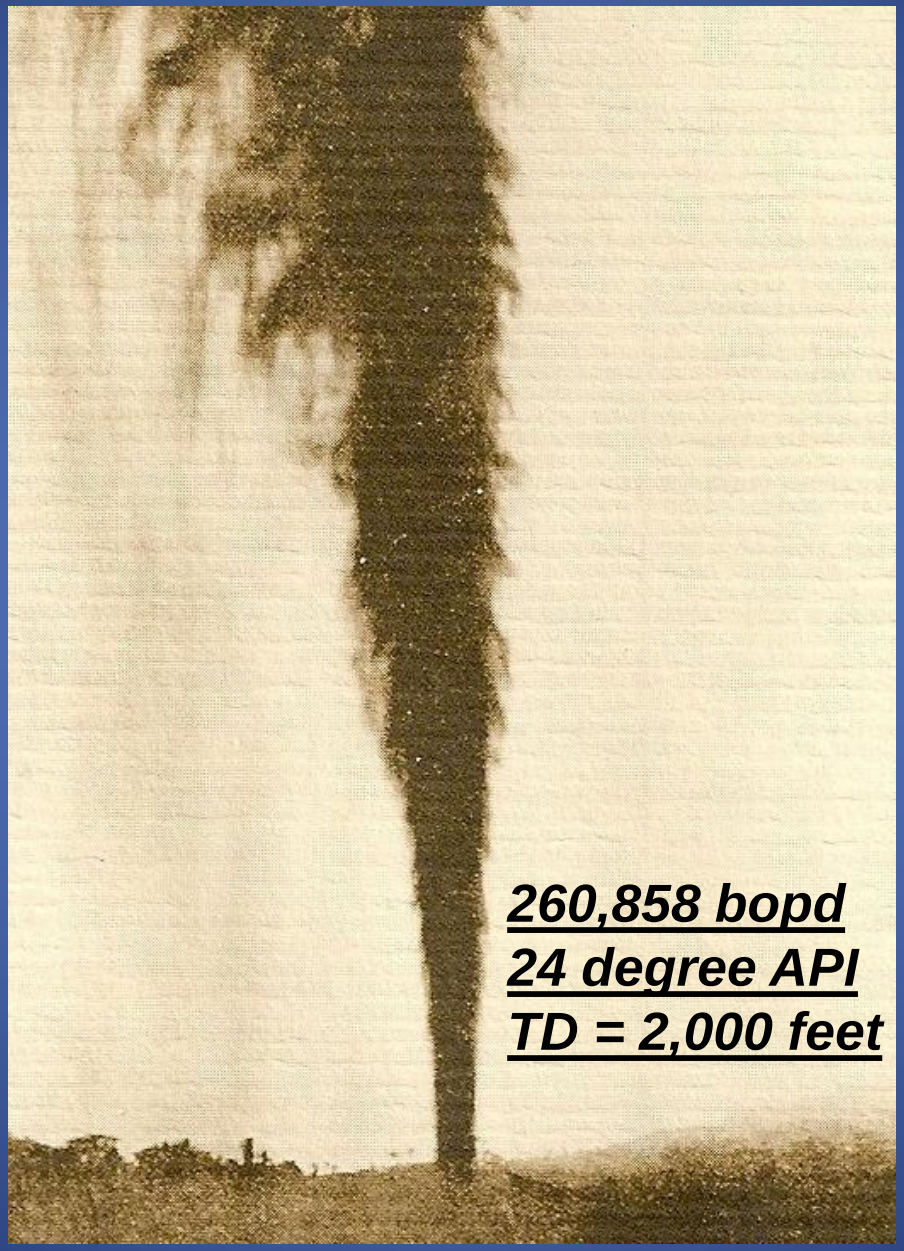
Horbury, 2004

Campo Poza Rica – Faja de Oro

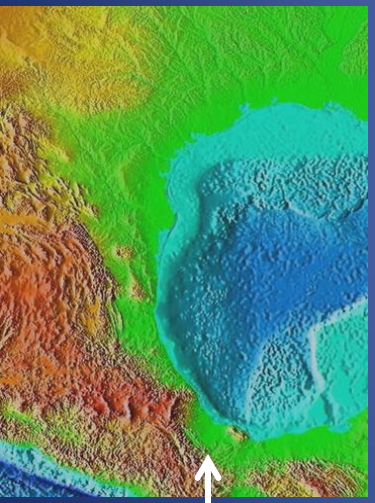


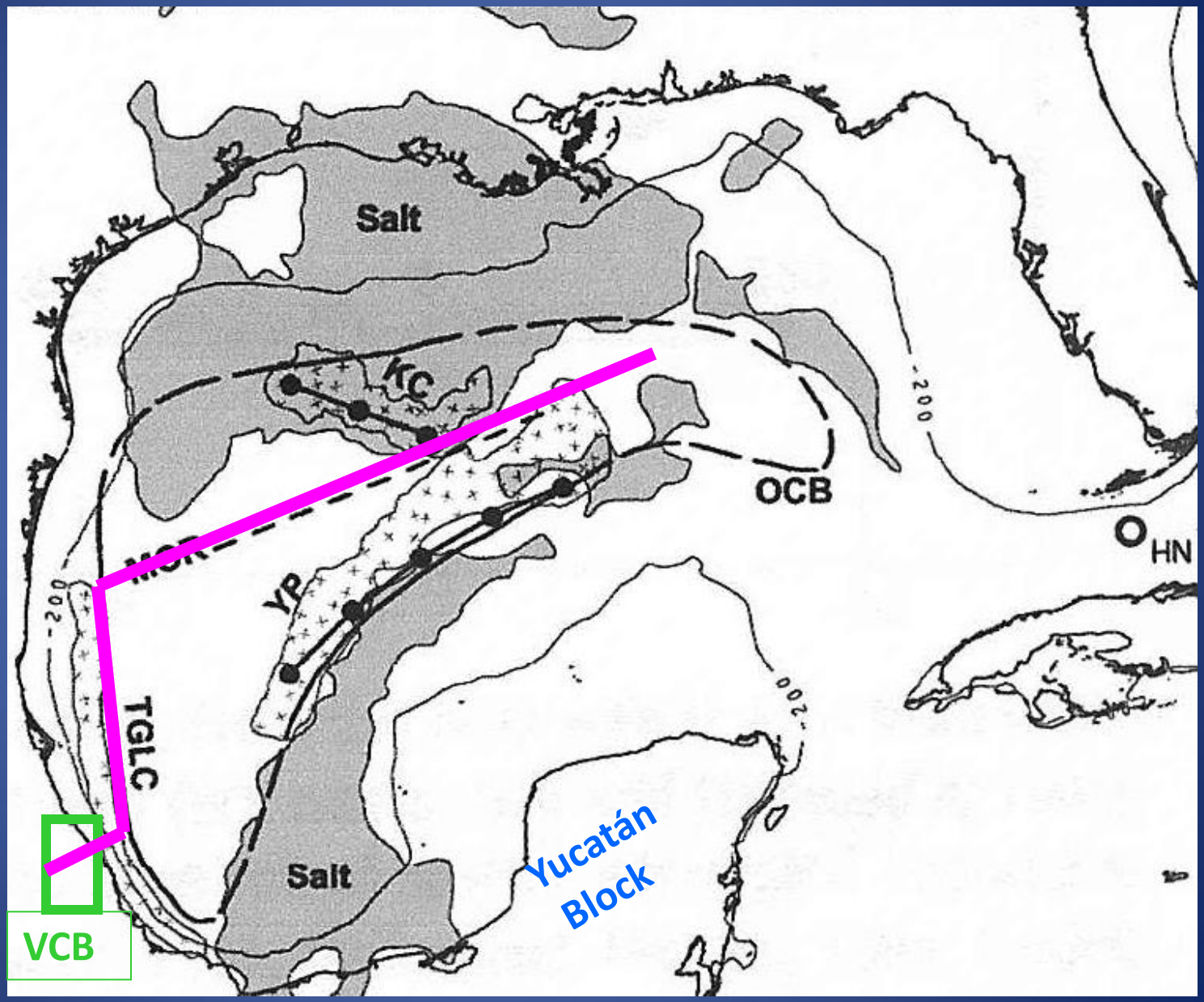
Adapted from Coogan, Bebout and Maggio, 1972

Cerro Azul # 4: February, 1921

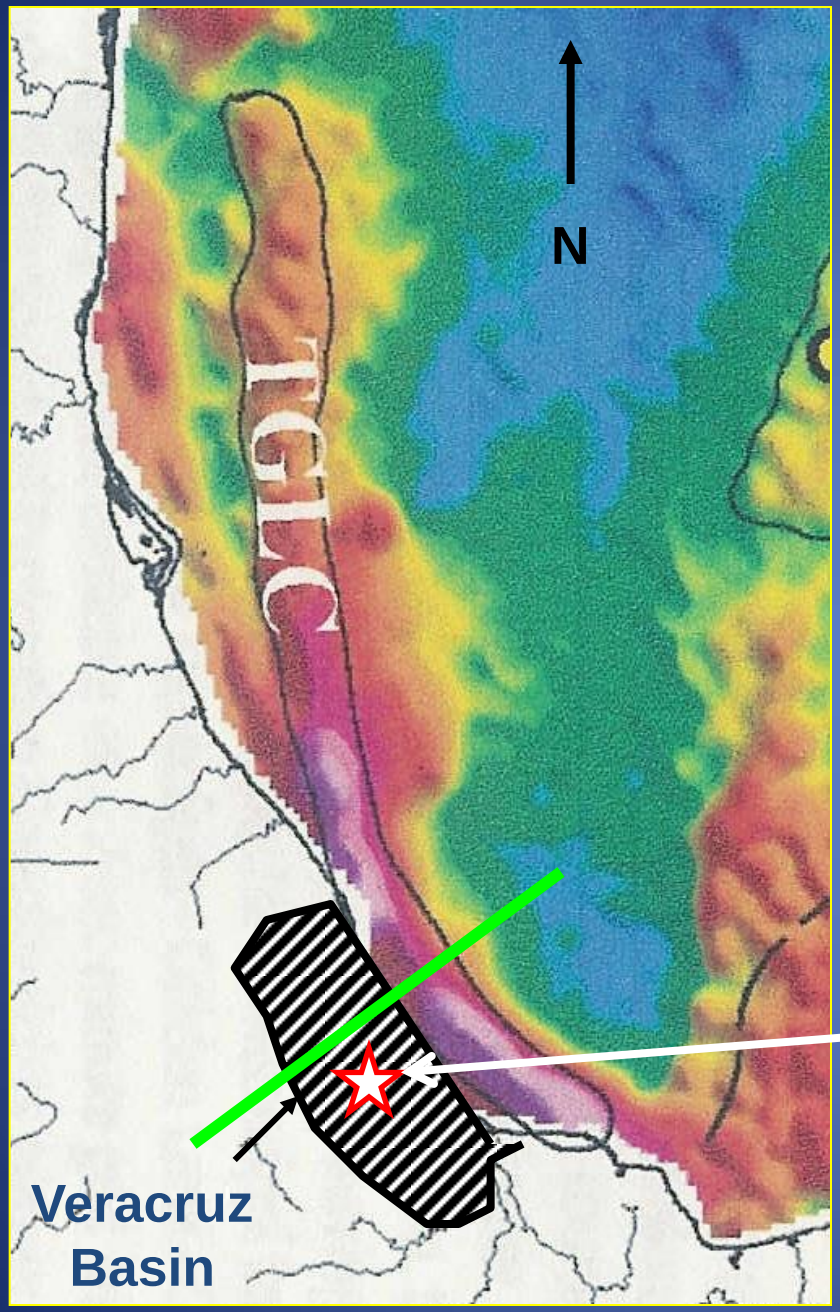


Veracruz Basin is built on Oceanic Crust





From Bird et. al, 2005

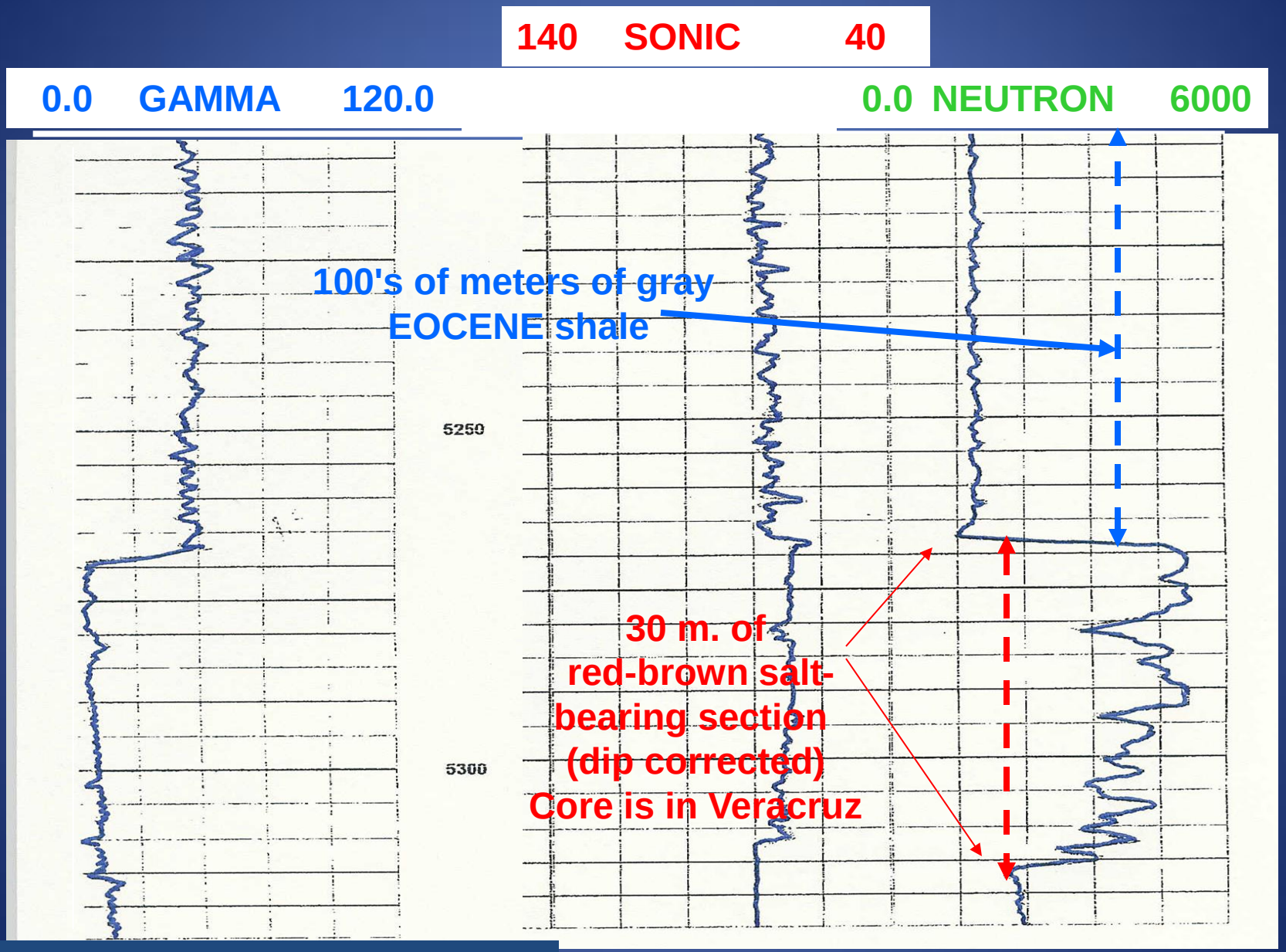


Veracruz Basin separated from main GOM by a basaltic transform ridge (Anegada High)

Mataespino 101-B well

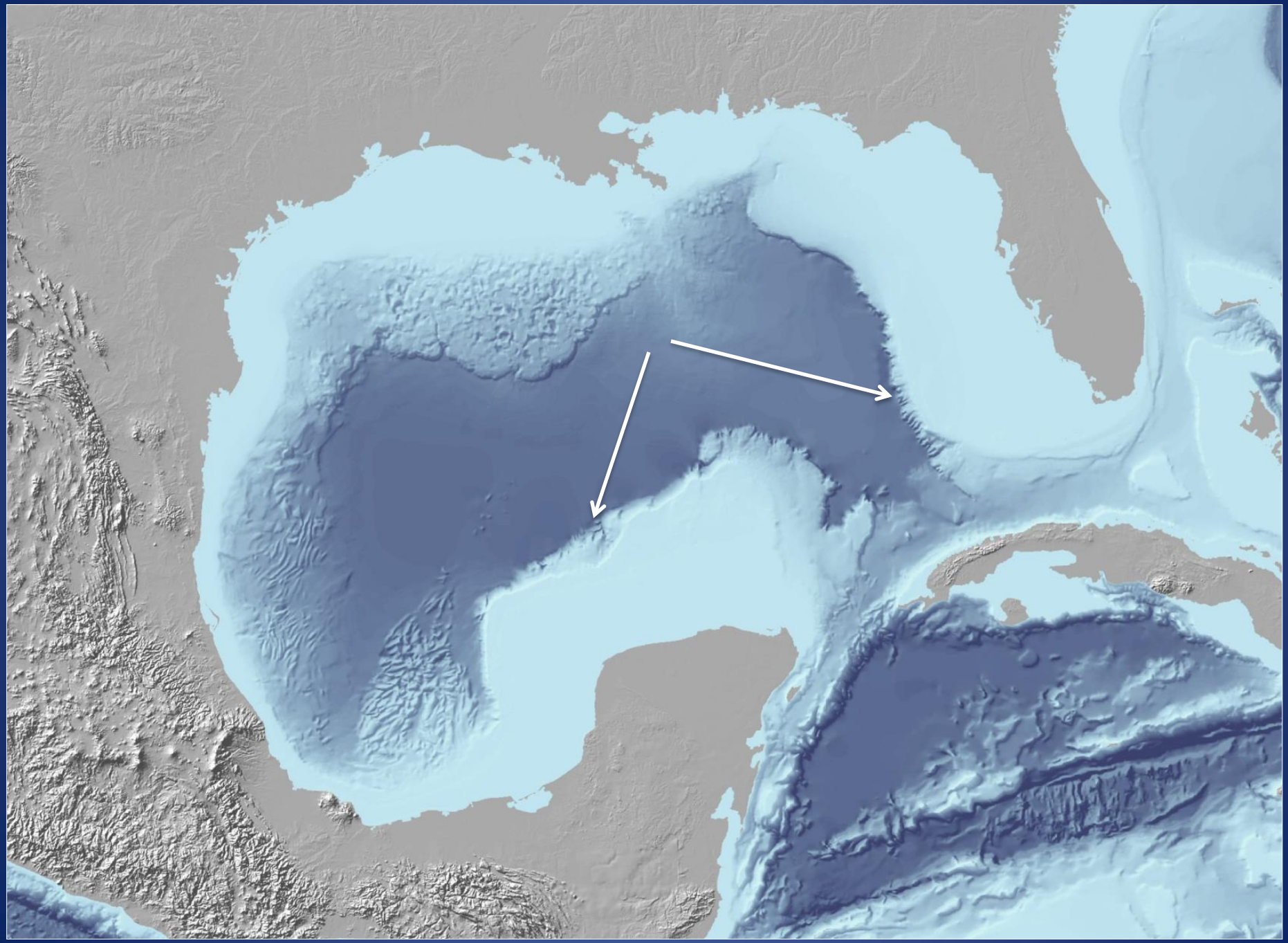
Bird et. al, 2005

Pemex Mataespino-101B

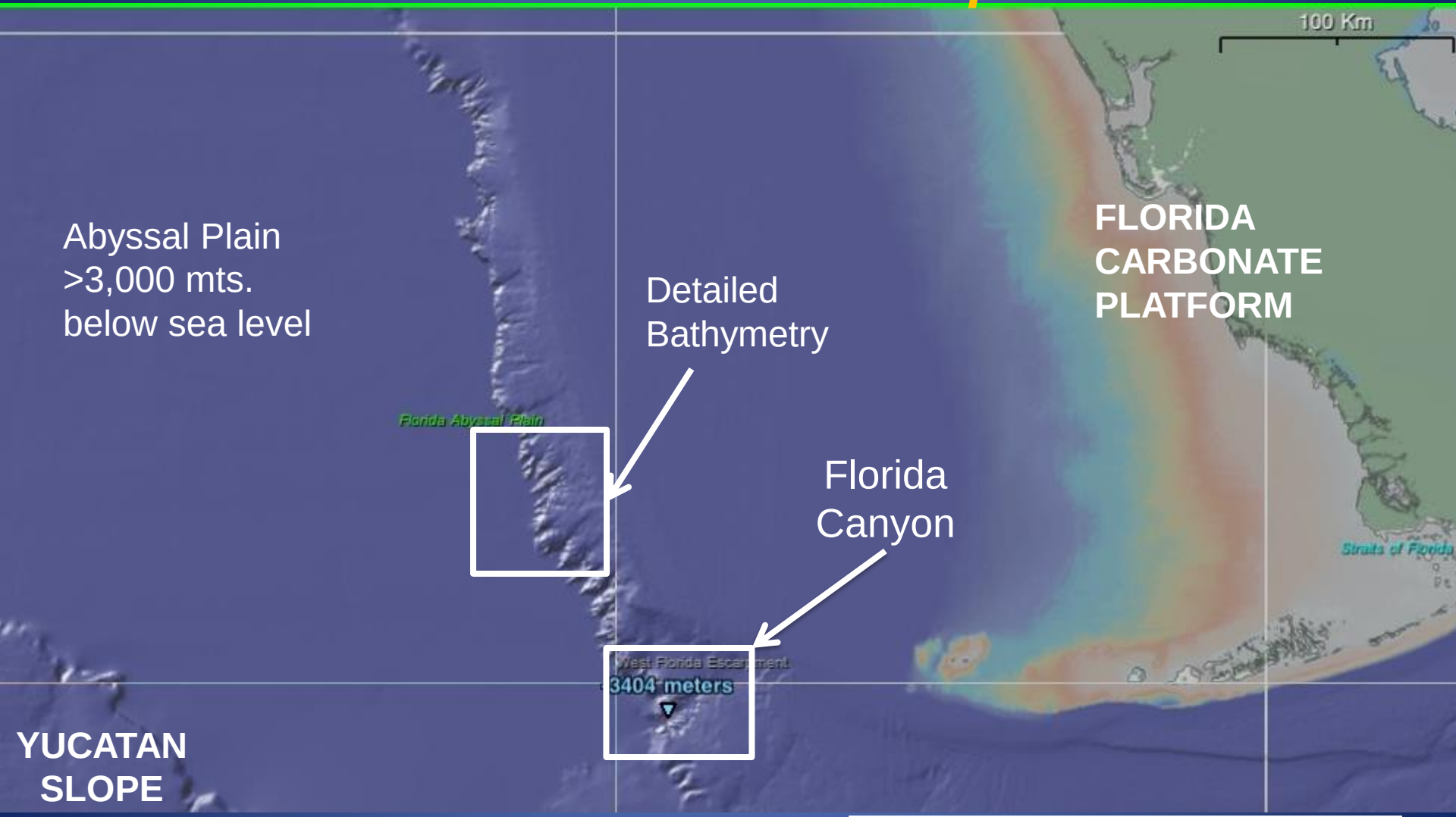


The Southeastern Gulf

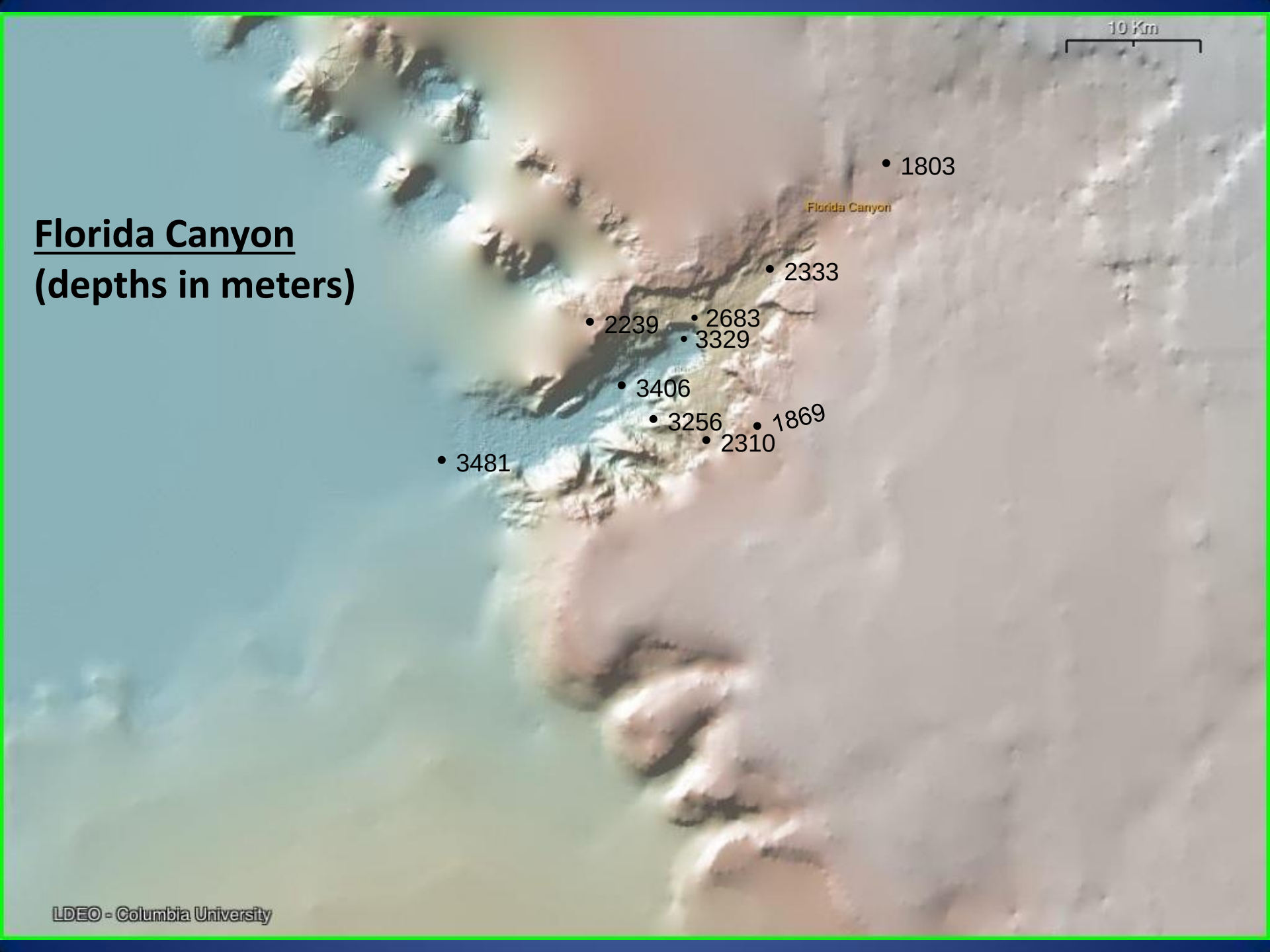
(Florida and Yucatan margins)



Erosional Aspect of the Florida and Yucatán Carbonate Escarpments

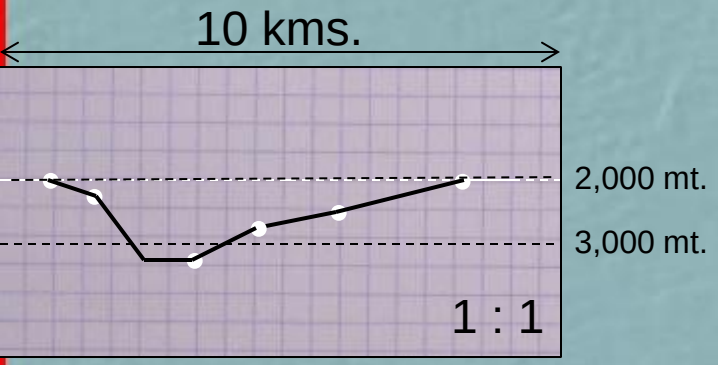


NOTE: No Paleocene/Eocene tectonic activity, topographic relief, nor major rivers.

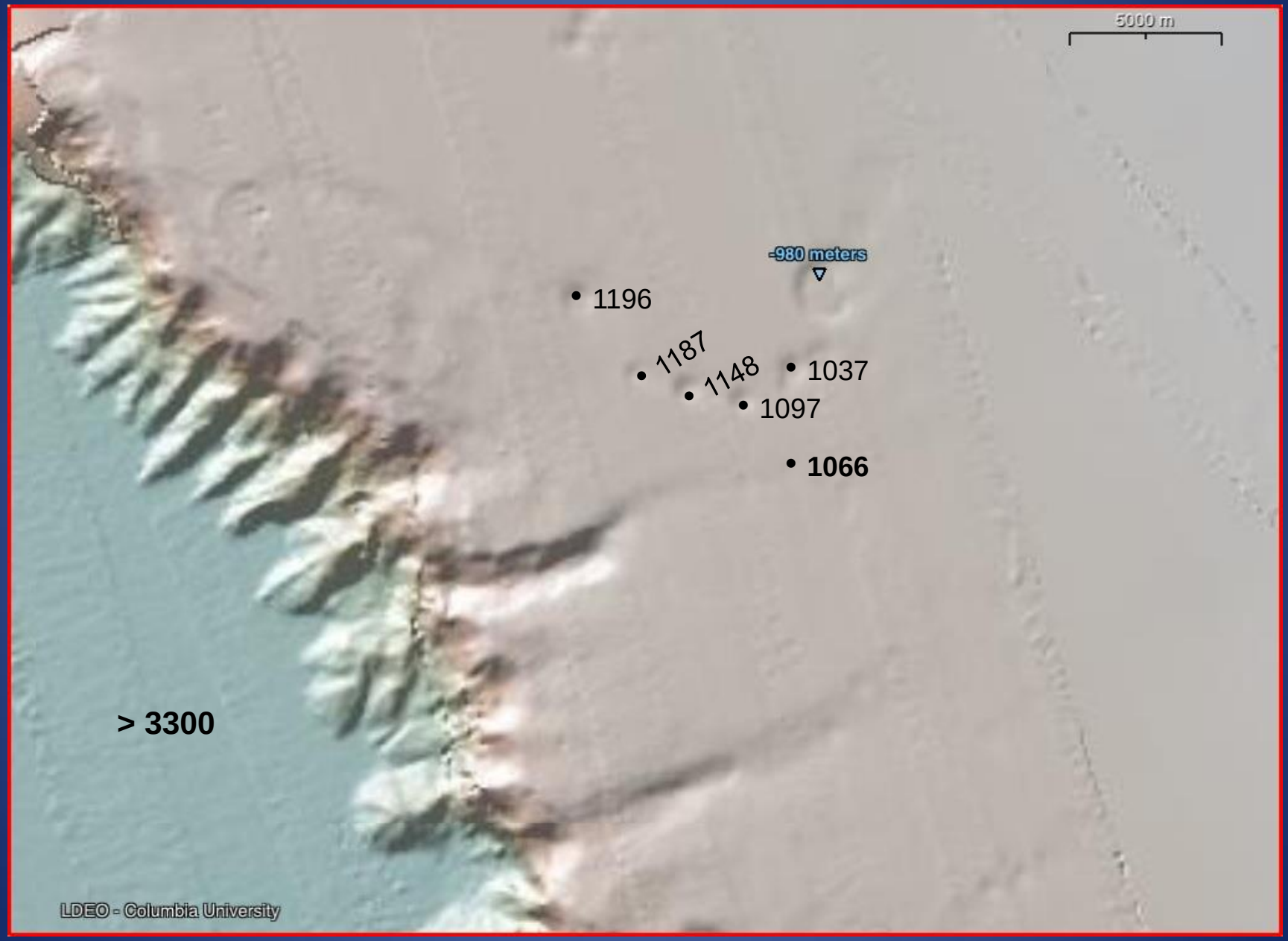


Florida Canyon
(depths in meters)

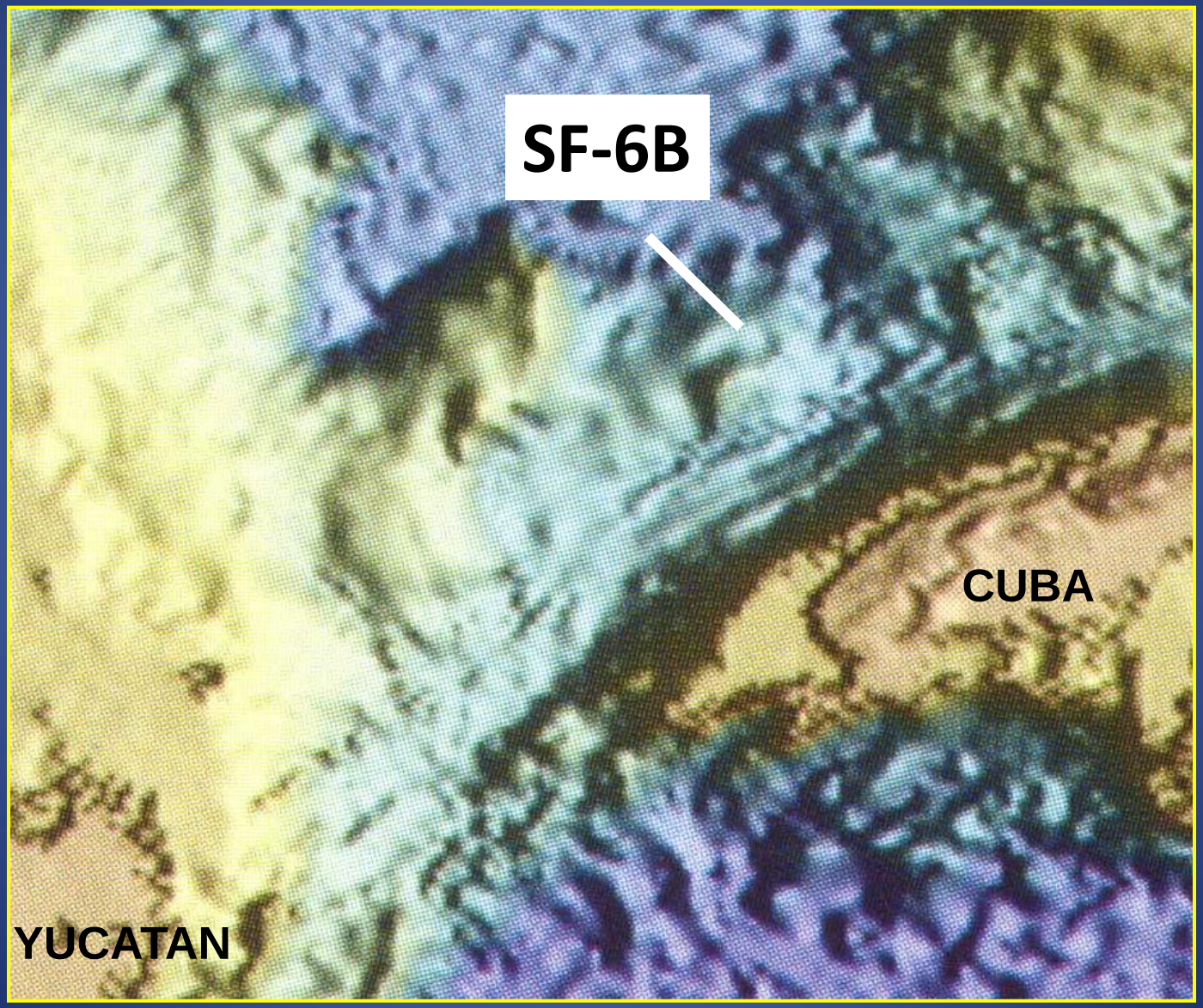
Typical “minor canyon”



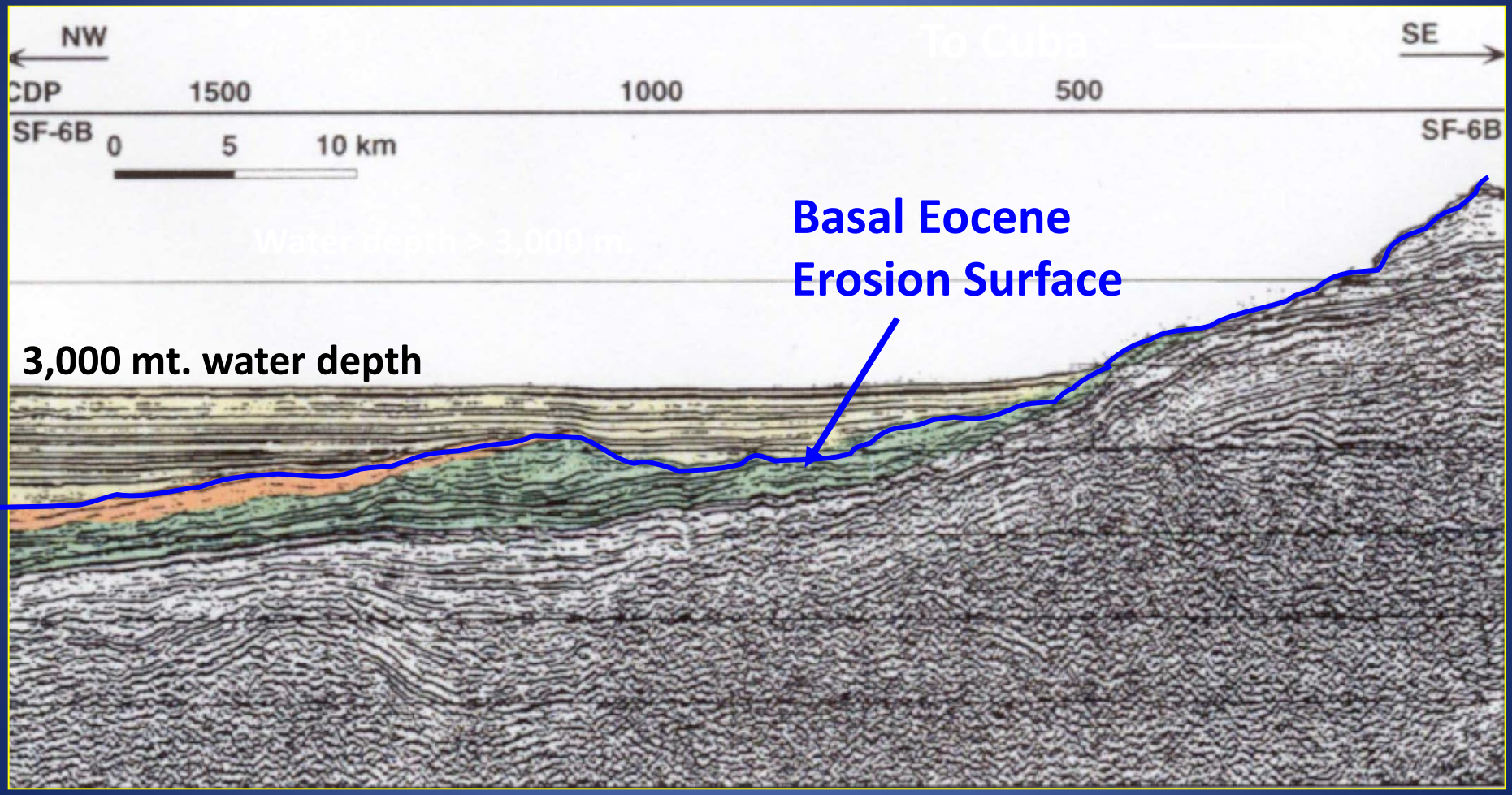
A: Sinkholes on Florida Slope



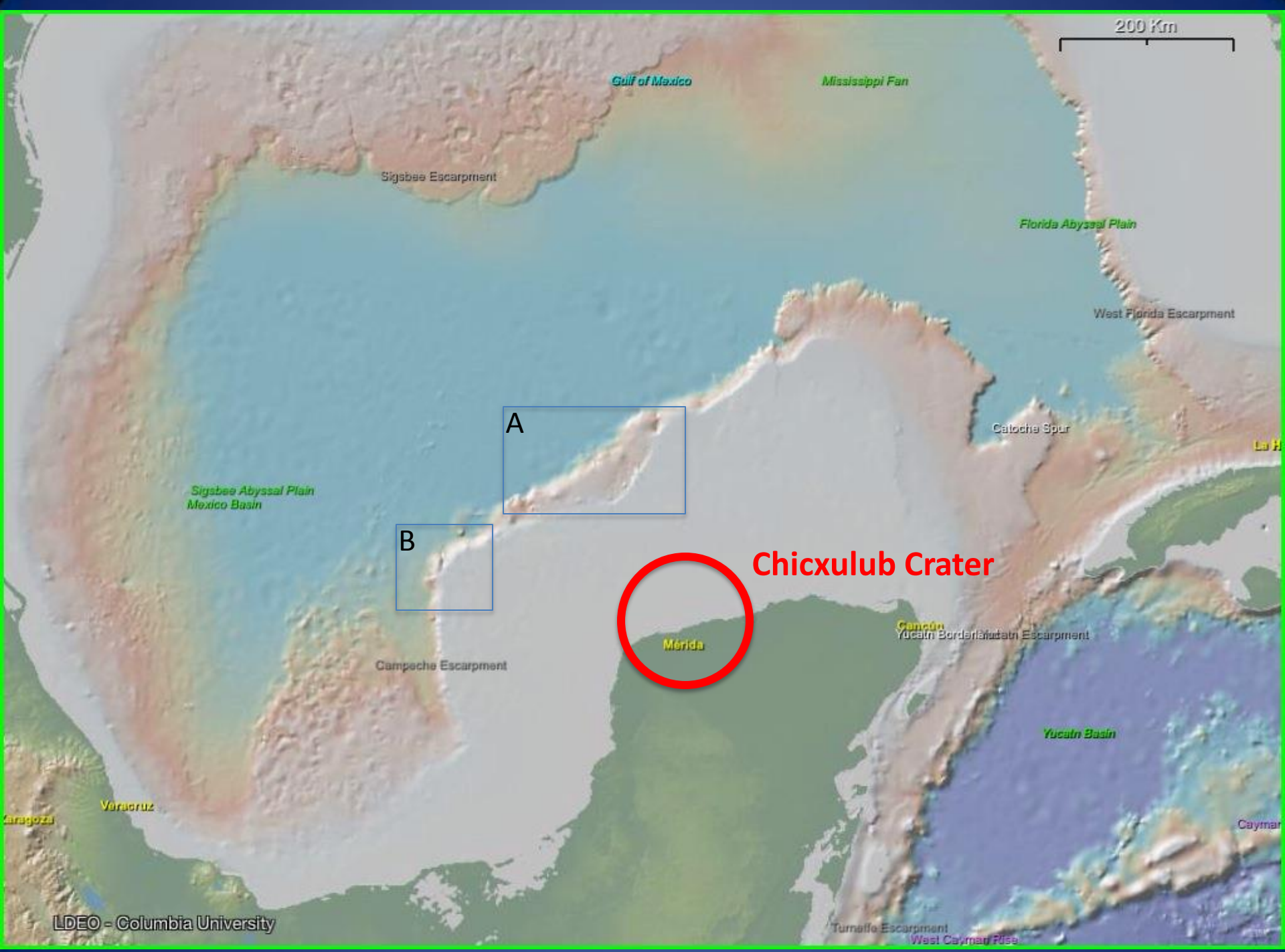
Seismic Line Location



Seismic Line SF-6B

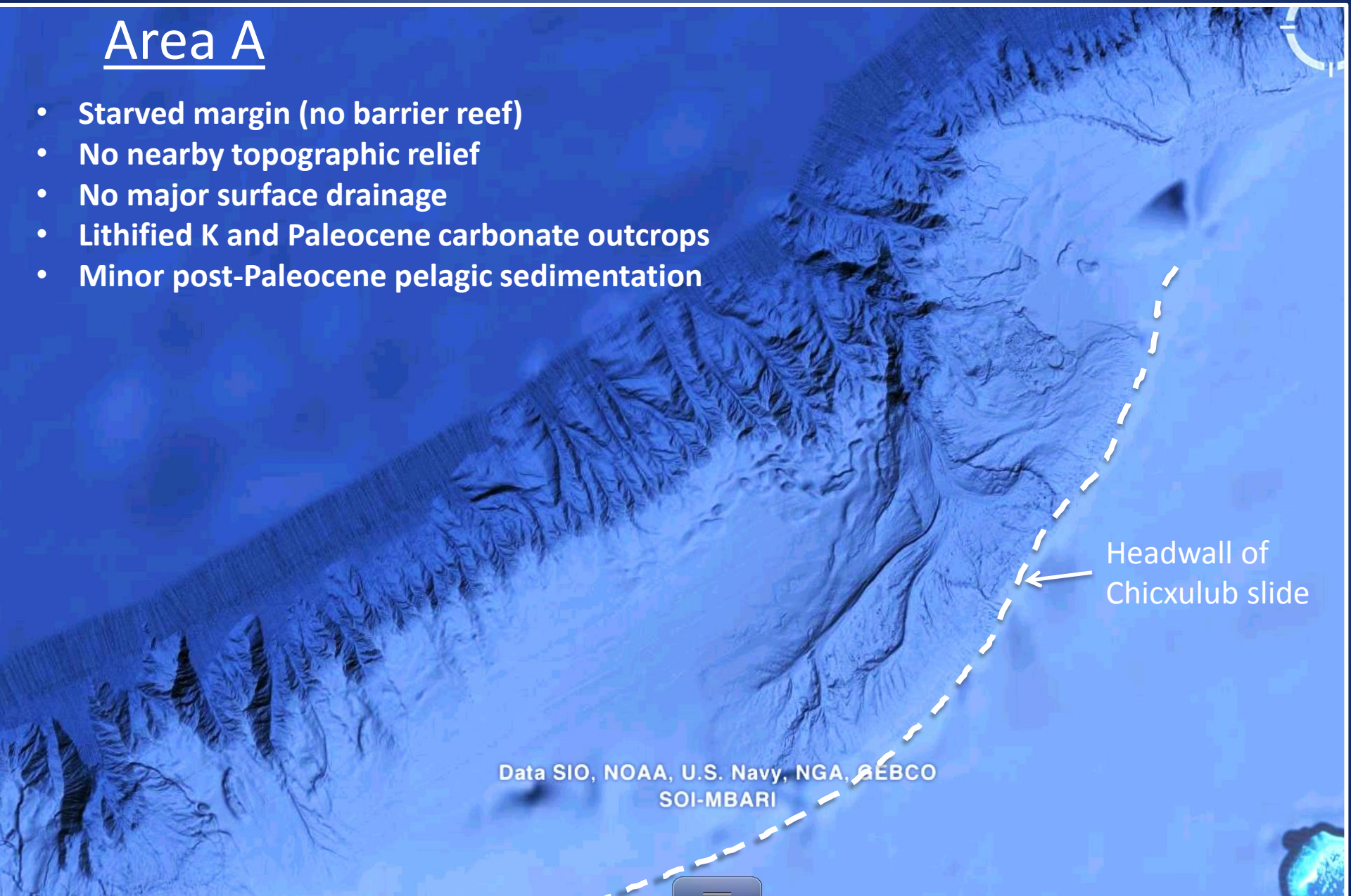


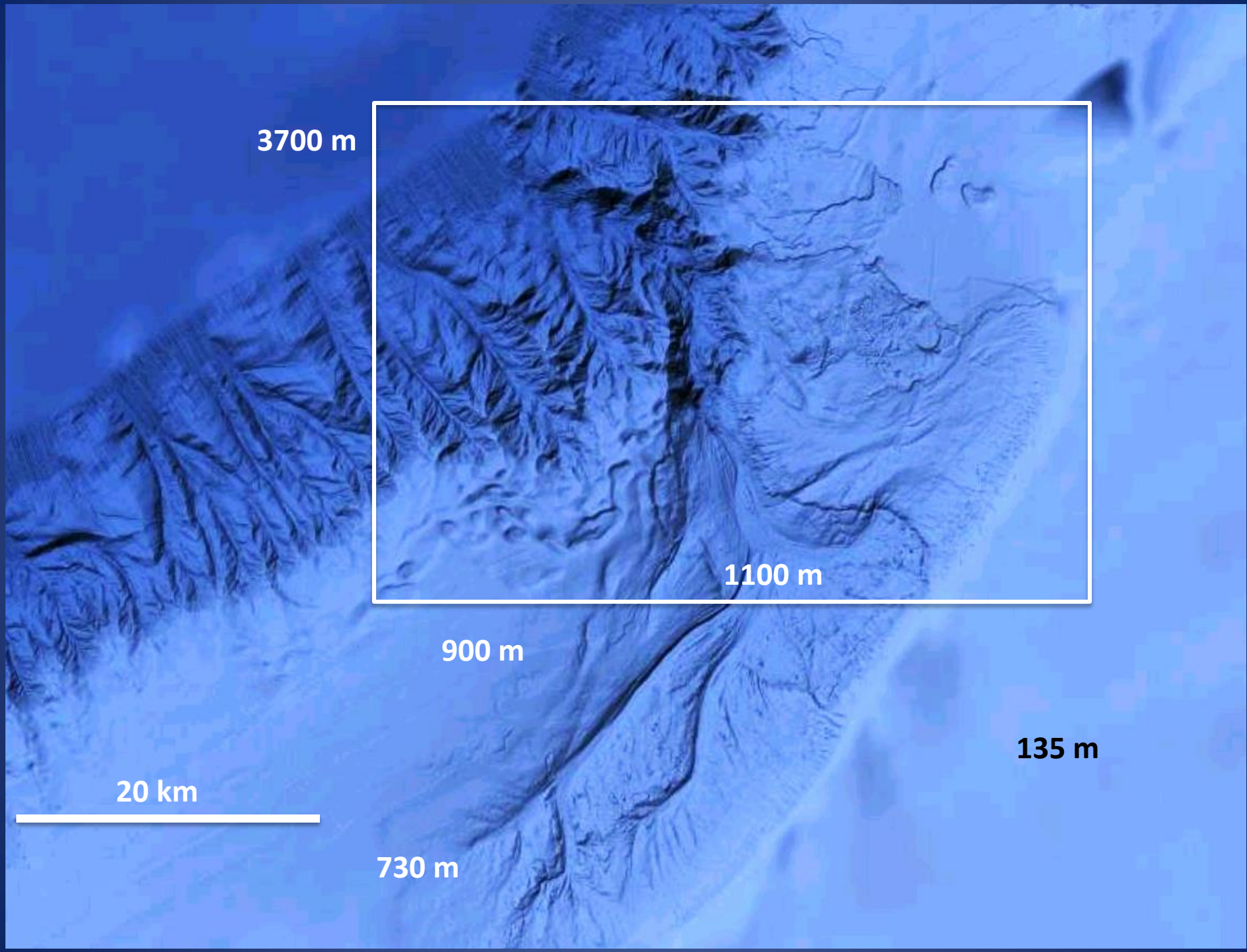
From Marton and Buffler, 1999

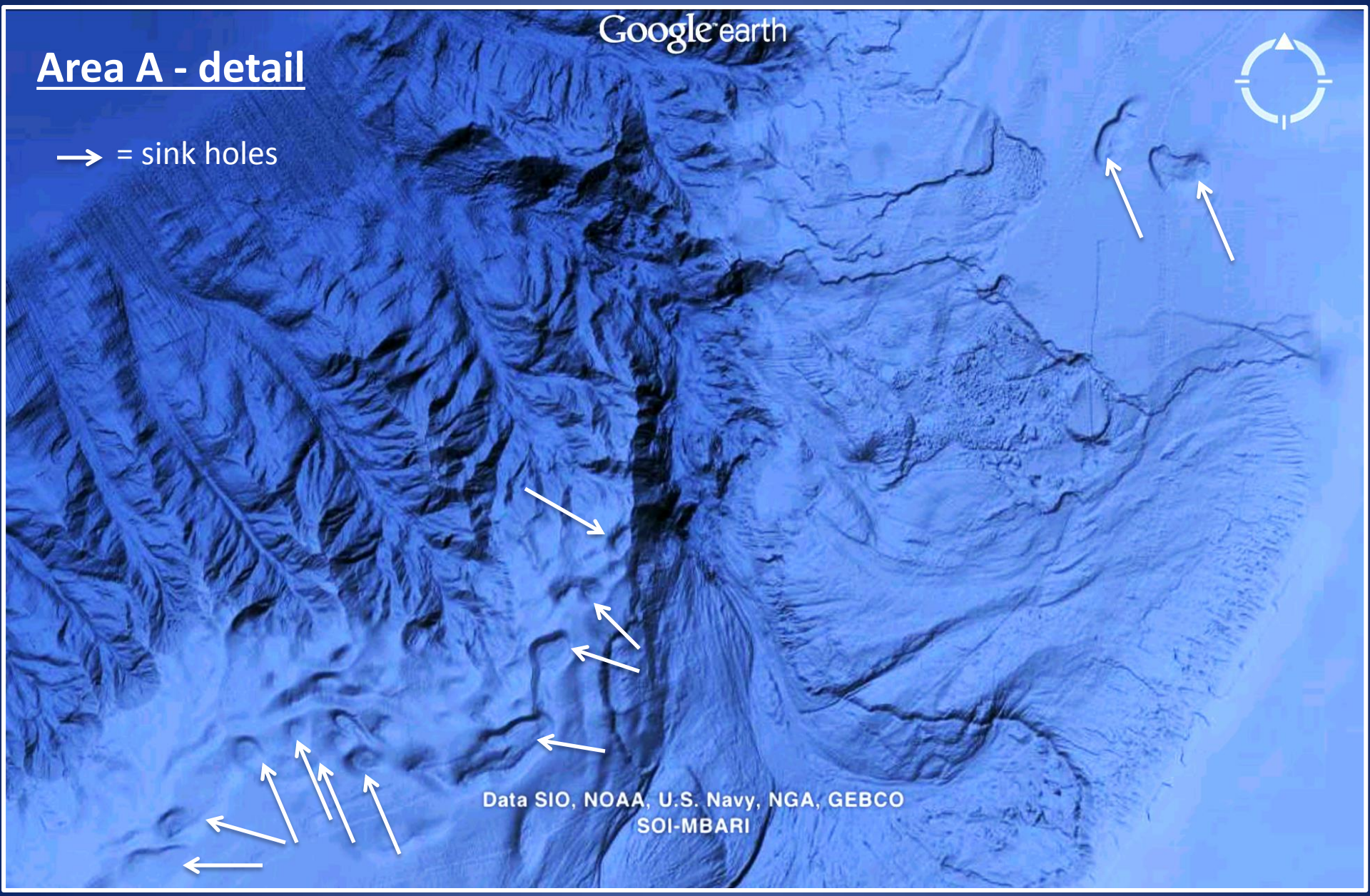

200 Km
Gulf of Mexico
Mississippi Fan
Sigsbee Escarpment
Florida Abyssal Plain
West Florida Escarpment
A
Catoche Spur
Sigsbee Abyssal Plain
Mexico Basin
B
Chicxulub Crater
Mérida
Cancún
Yucatn Escarpment
Campeche Escarpment
Yucatn Basin
Veracruz
Turneffe Escarpment
West Cayman Rise
LDEO - Columbia University

Area A

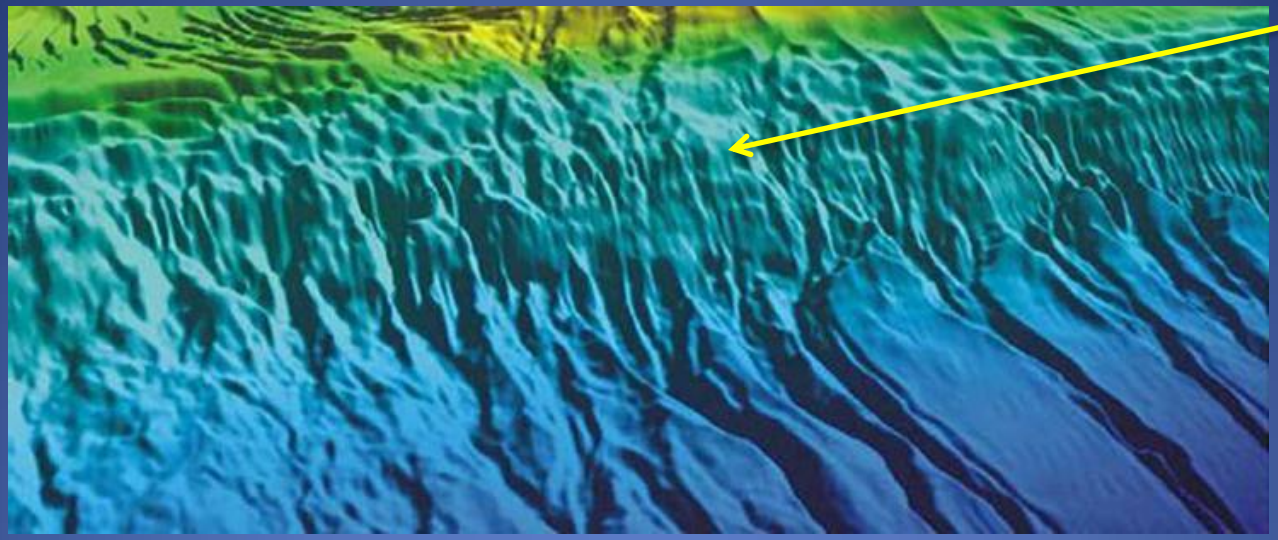
- Starved margin (no barrier reef)
- No nearby topographic relief
- No major surface drainage
- Lithified K and Paleocene carbonate outcrops
- Minor post-Paleocene pelagic sedimentation




3700 m
1100 m
900 m
135 m
20 km
730 m


Area A - detail
= sink holes
Google earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
SOI-MBARI

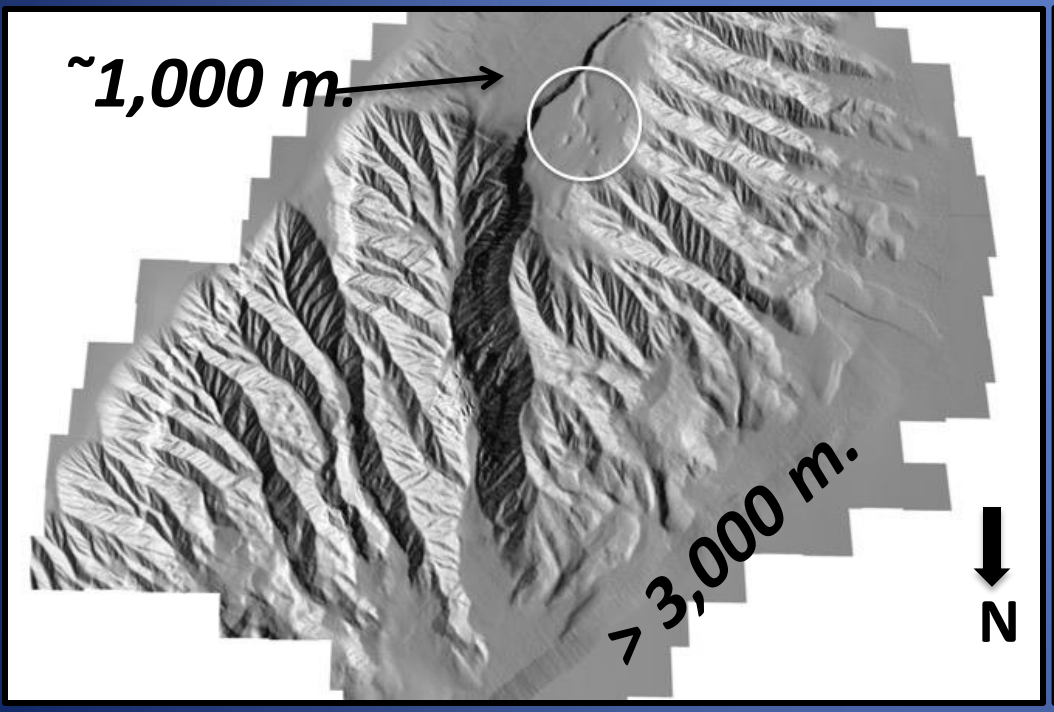
Normal slope canyons: ***Abundant tributaries at shelf-slope break.***



Anomalous slope canyons: ***Abundant tributaries on lower slope***

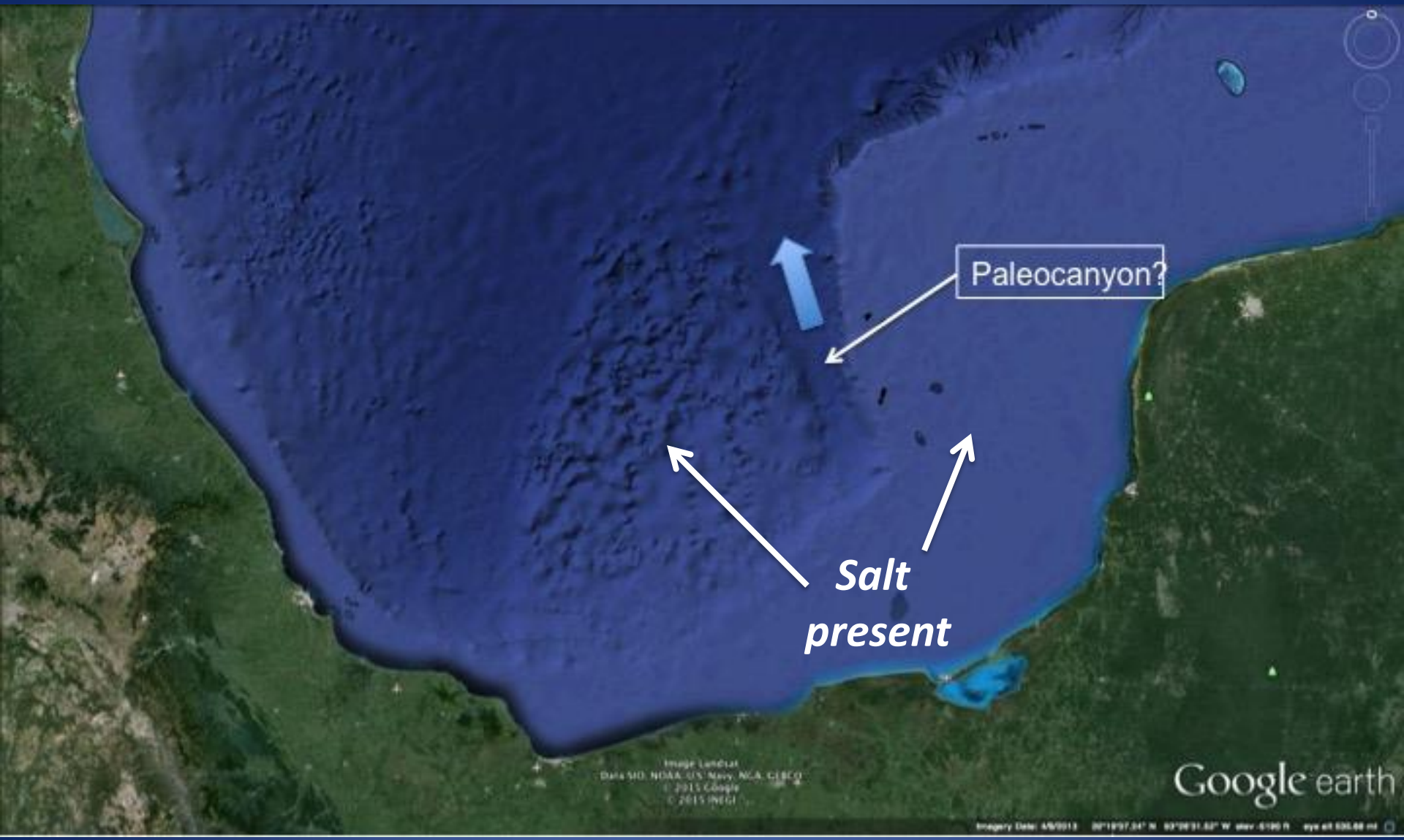
Subaerial Relief Analog

Area B - NW corner Yucatan slope



Death Valley

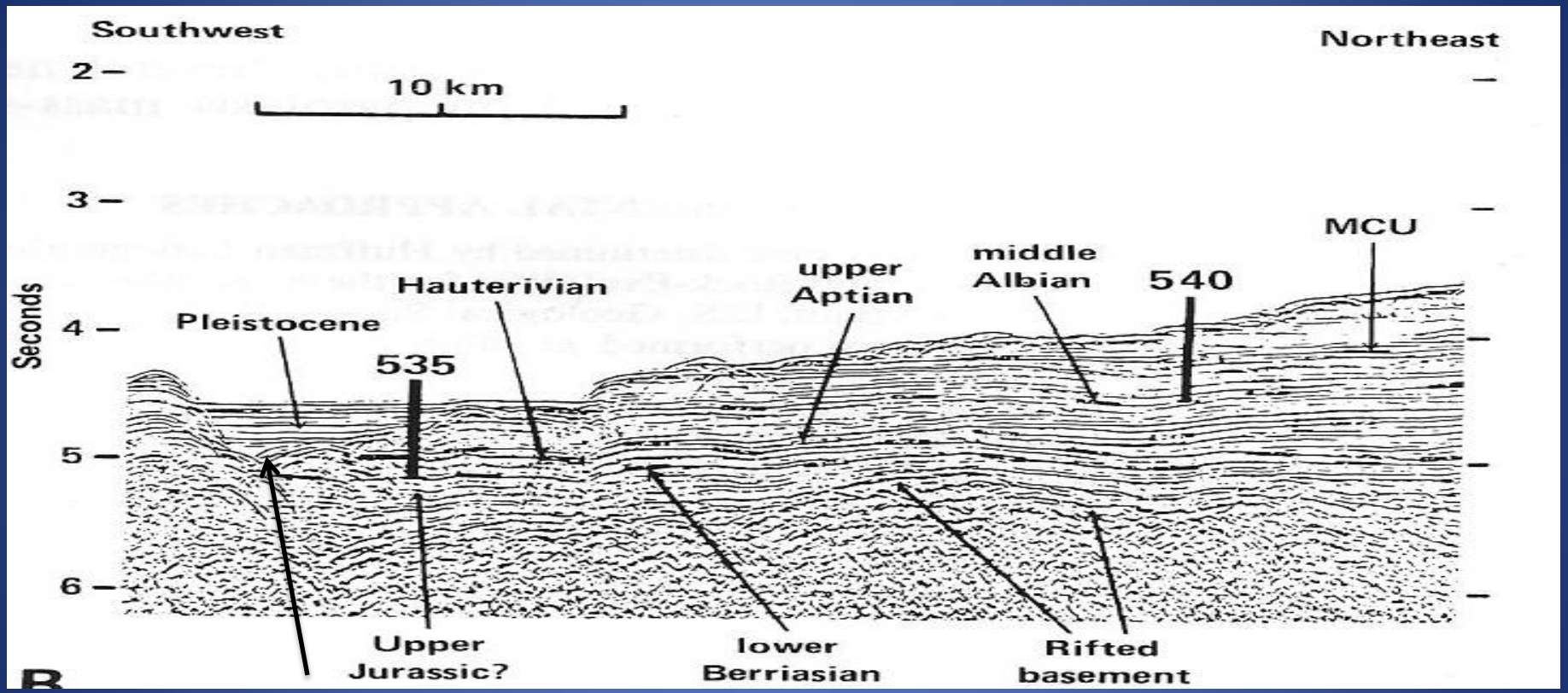
Comalcalco Basin - a drawdown paleocanyon?



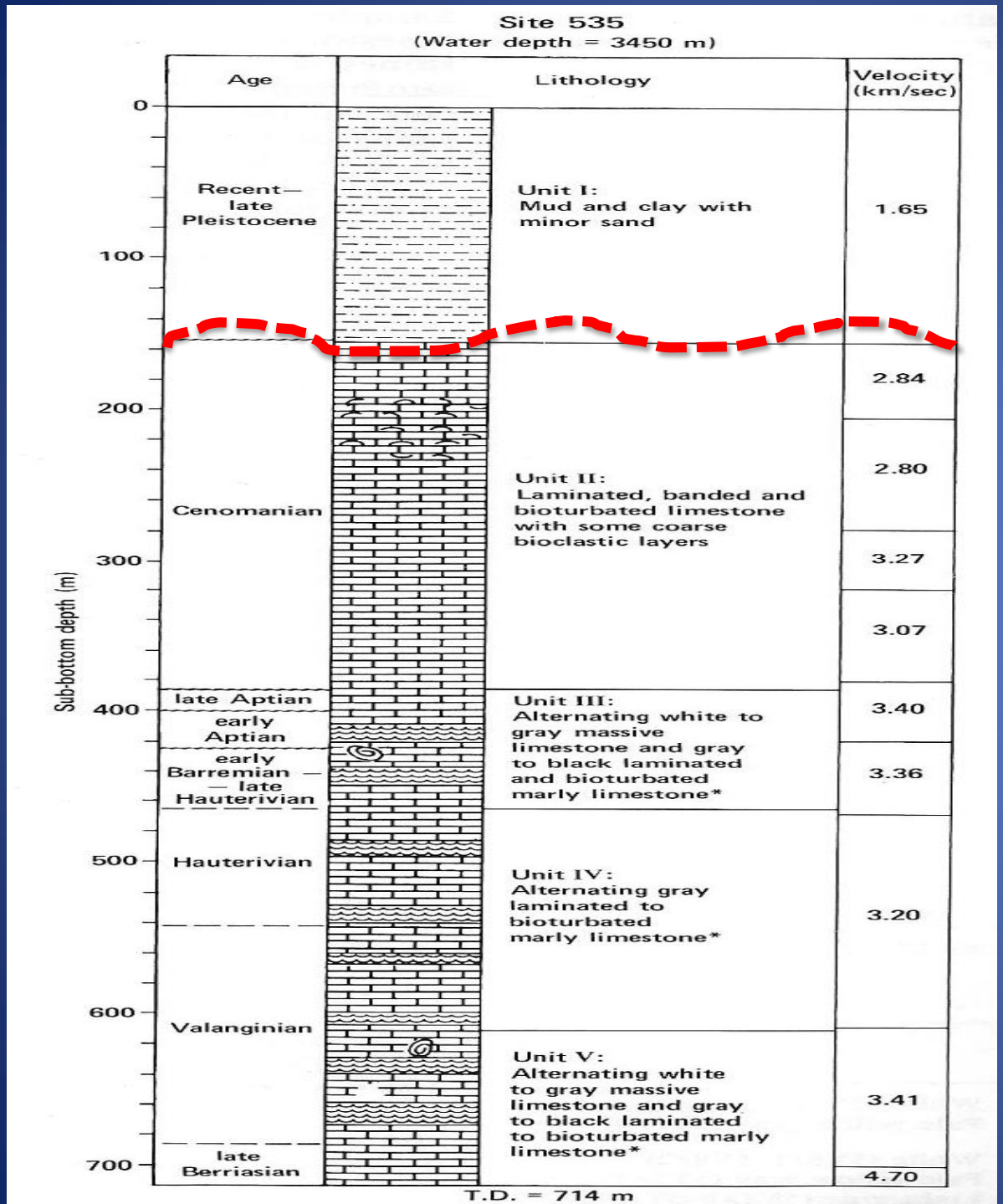
Reconnection with the World Ocean and Refill

Breakthrough and Refill

DSDP Leg 77, 1981
Straits of Florida
Site 535

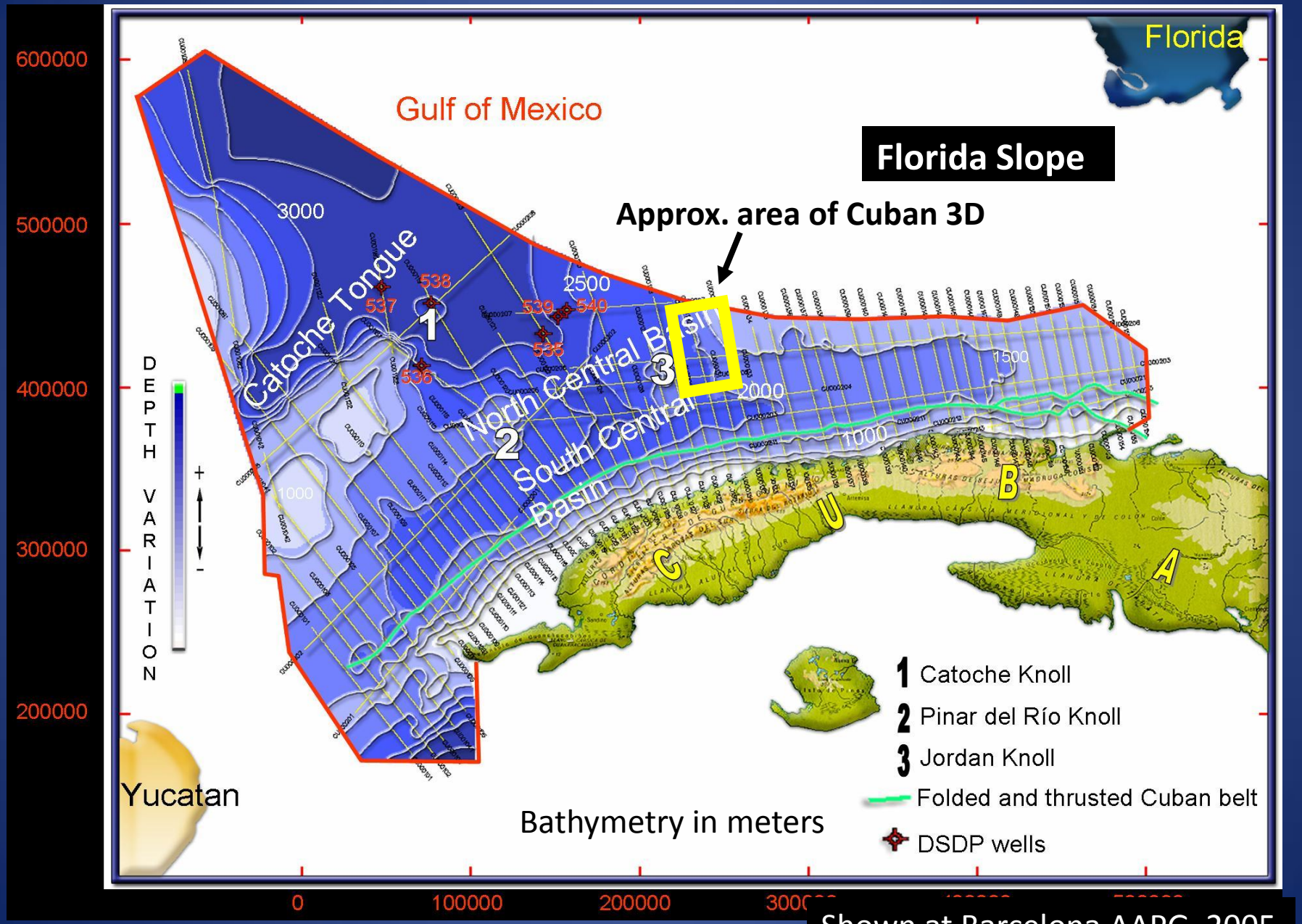


Thalweg cut >800 meters into lithified mid-Cretaceous carbonates



DSDP Leg 77, Site 535 (site is on the flank of the thalweg)

Sinkholes and Erosion in Deep Florida Strait

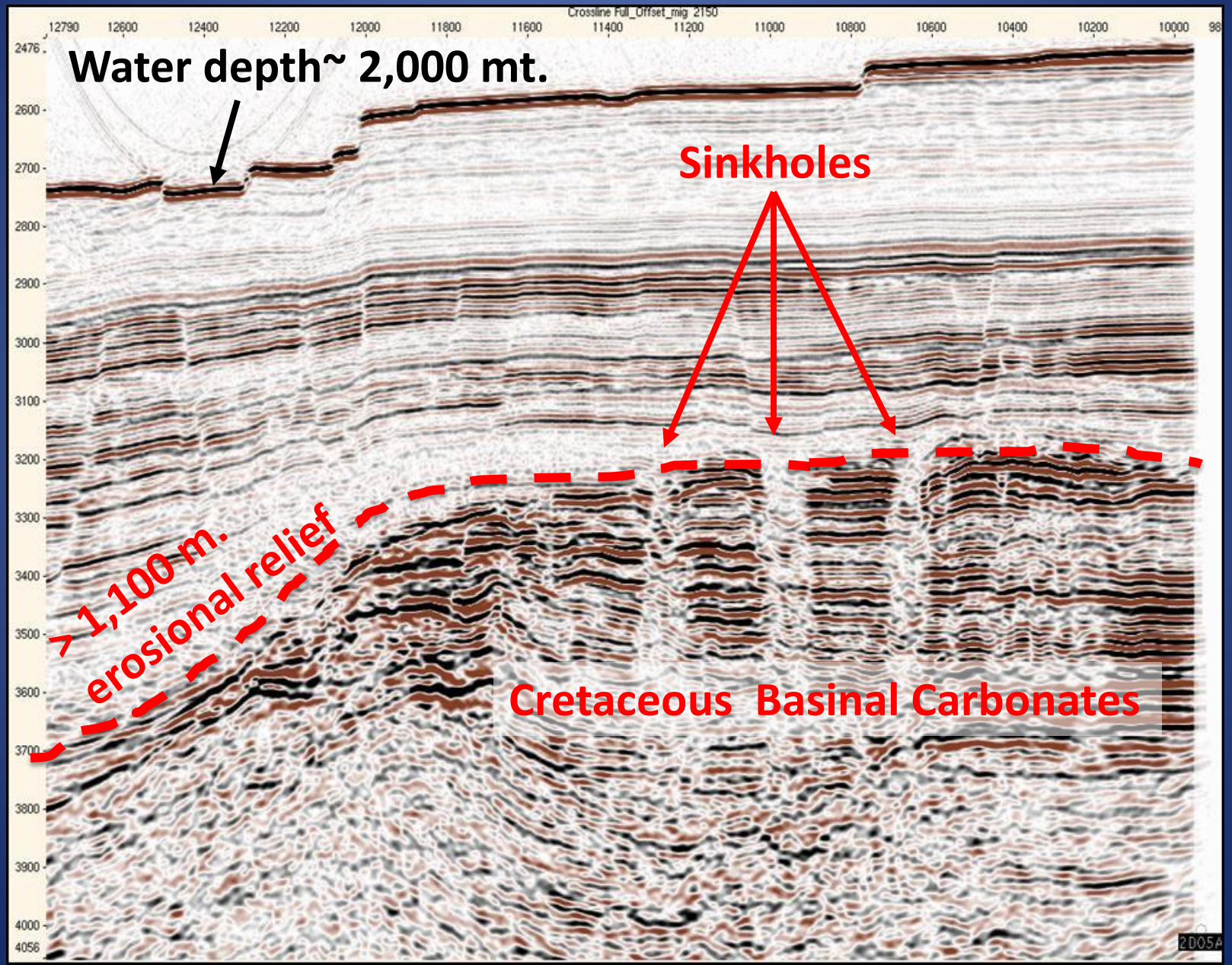


Shown at Barcelona AAPG, 2005

Sinkholes and Erosion in Florida Strait - Cuban 3D

S

N



Anomalies that the drawdown explains (Occams's Razor)

- *Sudden start and sudden end of regional sheet sand deposition at least 450 kms outboard of the shelf break.*
- *Rapid excavation and backfill of deep canyons across tens of kms of shelf with no tectonic uplift nor global drop in sea level.*
- *Erosion (karst and canyons) and fresh water diagenesis of lithified carbonates in the deep basin.*
- *Deep thalweg squarely in the Cuba - Florida/Bahamas suture zone.*
- *The Suwanee Channel crossing northern Florida (additional refill).*