Paleocene-Eocene Drawdown and Refill of the Gulf of Mexico—Concept History and Status

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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 from the world ocean (Fig. 1). Within several thousand years, net evaporation in the Gulf lowered its level by about 2,000 meters and formed a land bridge across the eastern Gulf that encompassed Yucatan, Florida, Cuba, and the Bahamas (Fig. 2). Formation of the land bridge was enhanced by isostatic uplift of the basin's margins as sea level dropped. After about 1 Ma of isolation, reconnection with the world ocean resulted in energetic refill of the basin that cut a deep thalweg between Florida and Cuba (Fig. 3). 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 (Figs. 4, 5, and 6), St. Landry, Chicontepec/Bejuco-La Laja (Figs. 7 and 8) paleocanyons, and the many canyons found along the lower continental slopes of Florida and Yucatan (discussed below)
- the sudden deposition, and equally sudden cessation of a widespread, thick, high net sand blanket in the deep Gulf Basin (Figs. 9 and 10)
- salt deposition in the barred Tertiary Veracruz Basin (Fig. 11)
- an unconformity in the eastern, carbonate-dominated Gulf Basin (Fig. 12).

The drawdown is coeval with the worldwide Paleocene-Eocene thermal maximum (PETM) possibly triggered by the release of voluminous methane from

destabilized hydrates and breached conventional reservoirs of the Gulf at low stand.

The drawdown also profoundly affected the petroleum geology of the Gulf of Mexico, most obviously by deposition of basal Wilcox "Whopper Sand" reservoirs in U.S. and Mexican waters. Further petroleum ramifications include porosity enhancement by fresh water infiltration and leaching of reefal carbonates of the Golden Lane Atoll and deep-water carbonate detritus reservoirs in the Poza Rica Trend and Campeche Sound K/T breccias.

Although a "smoking gun" has not yet been recognized that induces general acceptance of the Paleocene-Eocene Gulf drawdown, convincing evidence may be on the deep-water slopes of western Florida and northeastern Yucatan where sinkholes (Figs. 13 and 14) are present, and steep-walled canyons are observed (Figs. 15, 16, and 17) resembling those along eroded escarpments in present-day sub-aerial environments (Fig. 18).

With increased investigation of the eastern Gulf, the author is confident that definitive evidence will be found that either supports or eliminates the proposed drawdown. Meanwhile, explorers are encouraged to include the idea among their working hypotheses.

References

Rosenfeld, Joshua, and James Pindell, 2002, U.S. Gulf's early isolation from ocean hypothesis for steep base level fall: Offshore Magazine, v. 62, no. 1, p. 26, 28, 76.

Rosenfeld, Joshua, and James Pindell, 2003, Early Paleogene isolation of the Gulf of Mexico from the world's oceans: Implications for hydrocarbon exploration and eustasy, *in* C. Bartolini, R.T. Buffler, and J. Blickwede, eds., The circum-Gulf of Mexico and the Caribbean: Hydrocarbon habitats, basin formation, and plate tectonics: AAPG Memoir 79, p. 89-103.

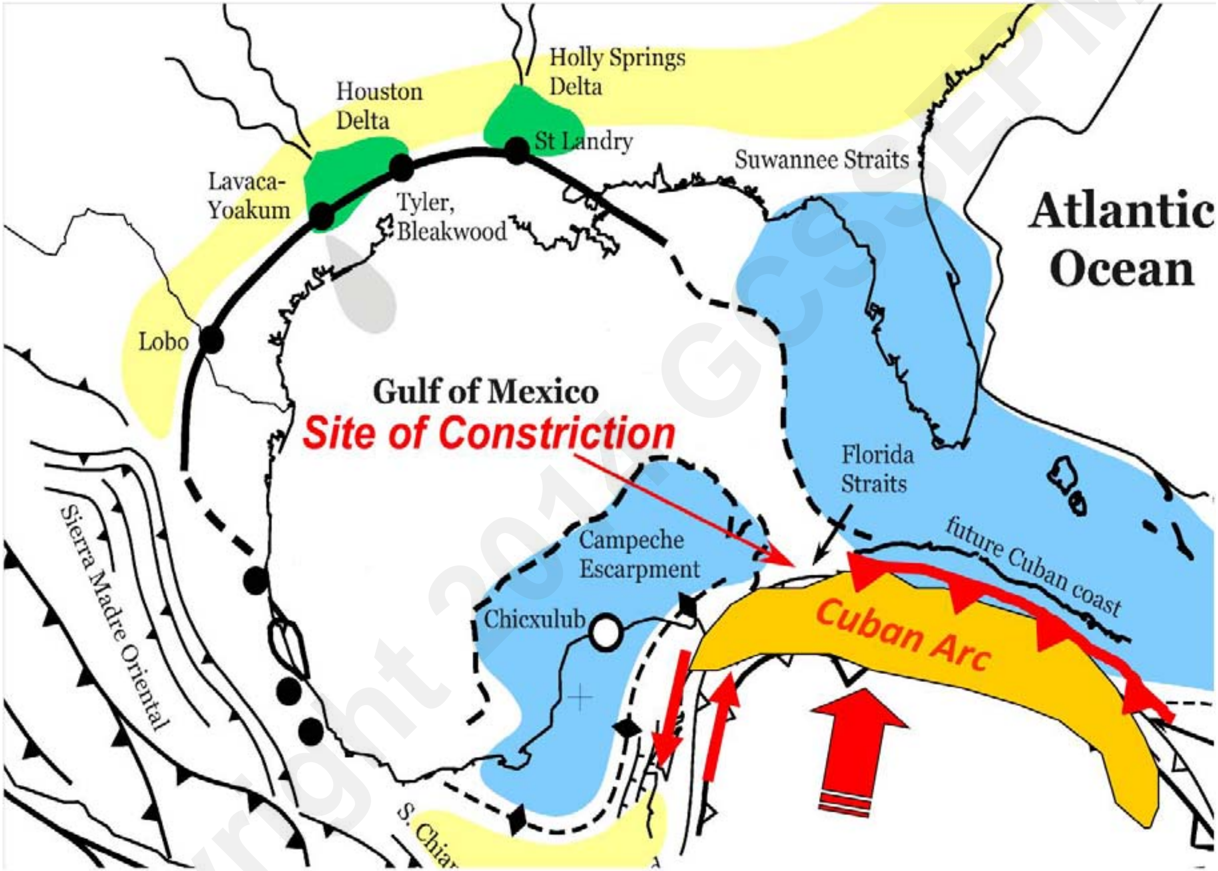


Figure 1. The Cuban Arc at the leading edge of the northward moving Caribbean Plate sealed the entrance to the Gulf of Mexico at the end of the Paleocene.

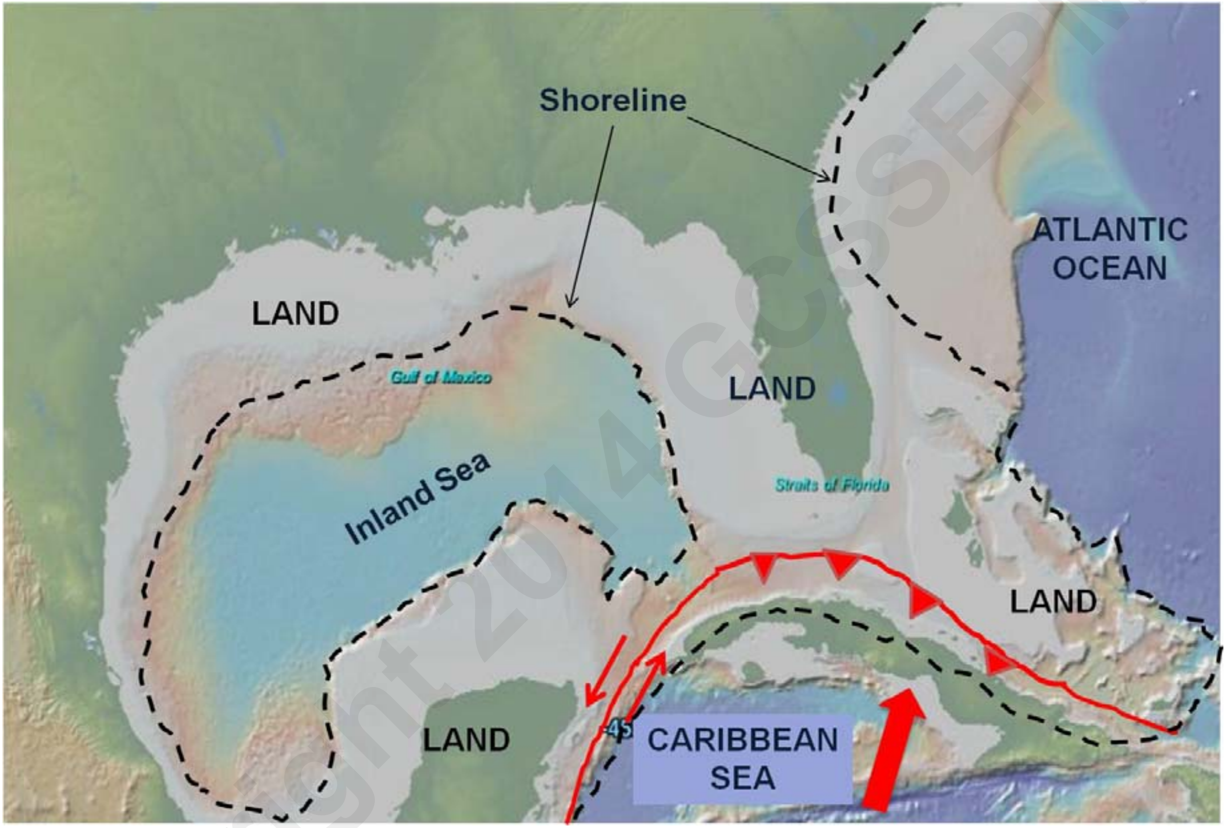


Figure 2. Isolation of the Gulf led to a ~2,000 meter drawdown of its level forming a hypersaline inland sea separated from the Atlantic and Caribbean by an extensive land bridge.

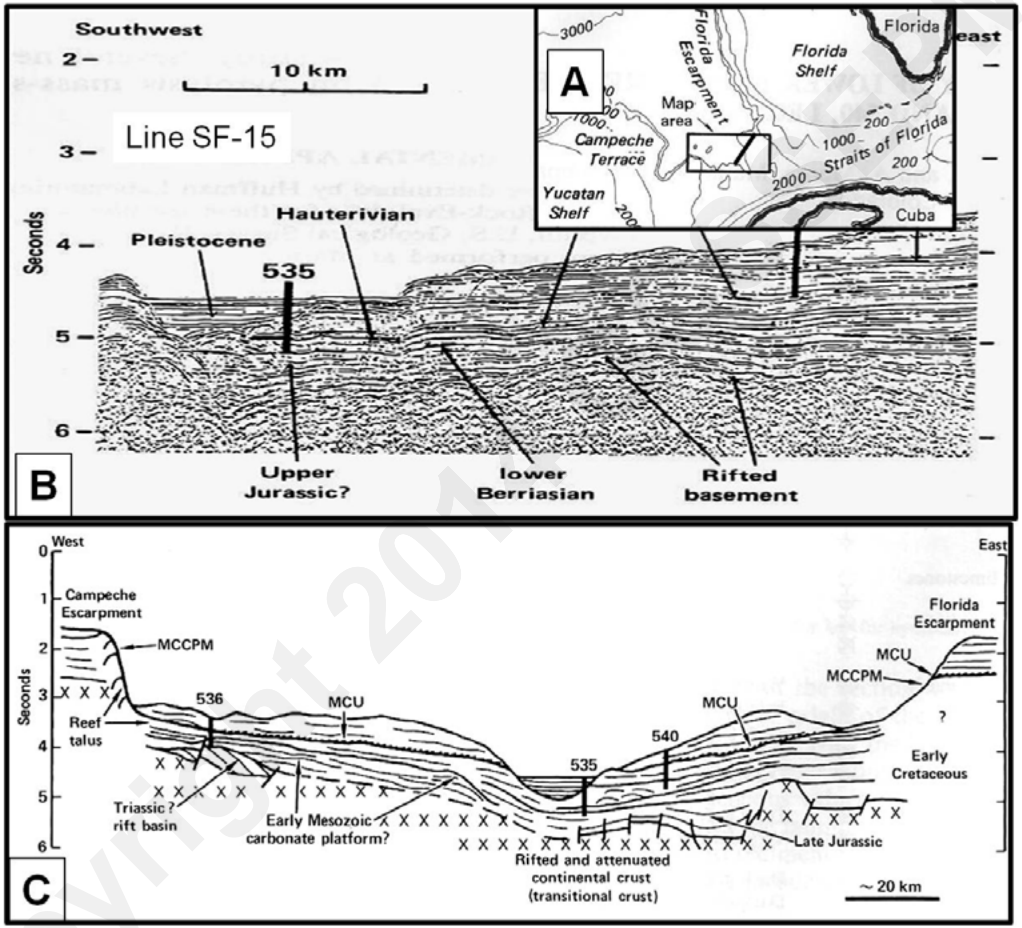
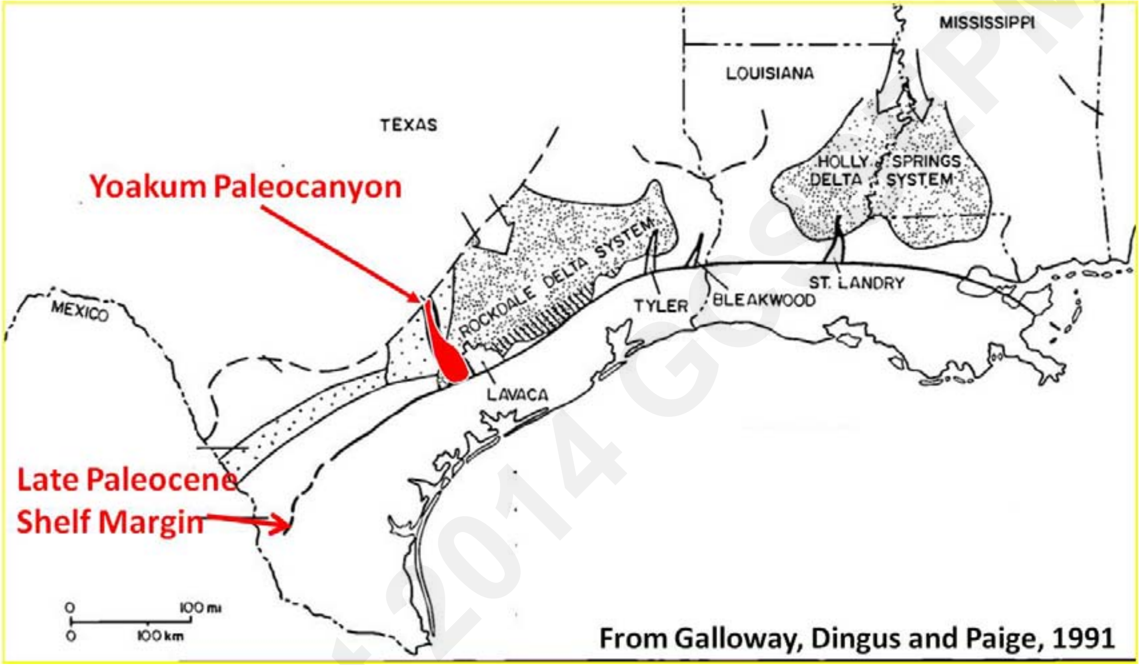
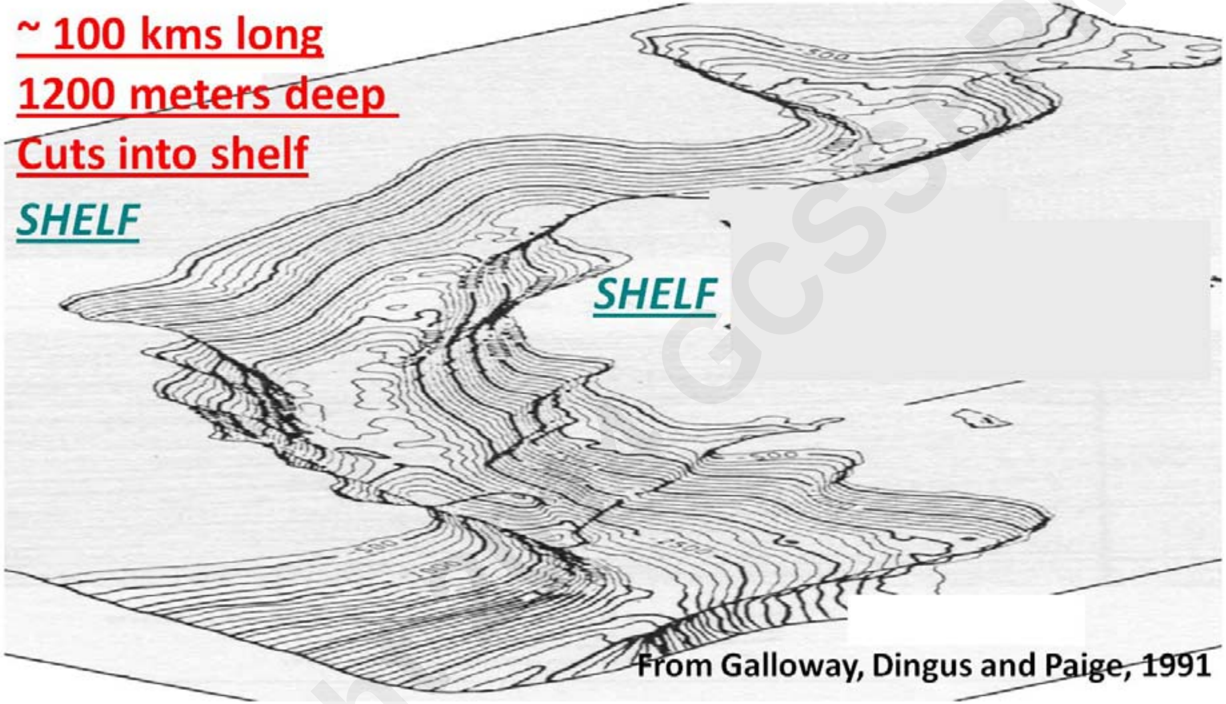


Figure 3. Breaching of the barrier cut a deep channel through the Florida Strait cut into lithified Cretaceous carbonates. Data from DSDP 77 (1980-81).



From Galloway, Dingus and Paige, 1991

Figure 4. Map of the Yoakum and other paleocanyons of the northern Gulf of Mexico eroded into contemporaneous shelves during lowered sea level.



~ 100 kms long

1200 meters deep

Cuts into shelf

From Galloway, Dingus and Paige, 1991

Figure 5. Map of the Yoakum paleocanyon that is cut across at least 100 km of the paleoshelf.

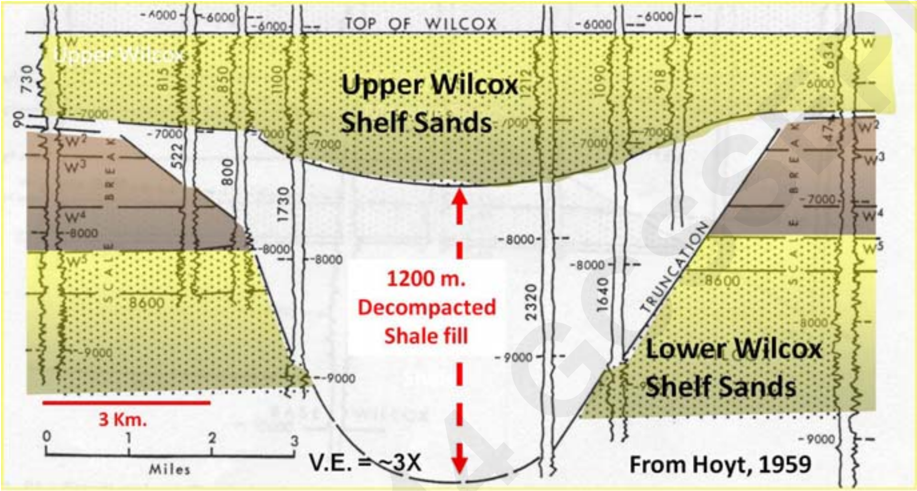


Figure 6. Cross section of the Yoakum paleocanyon cut 1200 m into the Lower Wilcox paleoshelf. Excavation and backfill of the canyon occurred within 1 Ma. Remobilization of Lower Wilcox shelf sand is probably the main contributor to the Wilcox "Whopper Sand" of the deep Gulf basin.

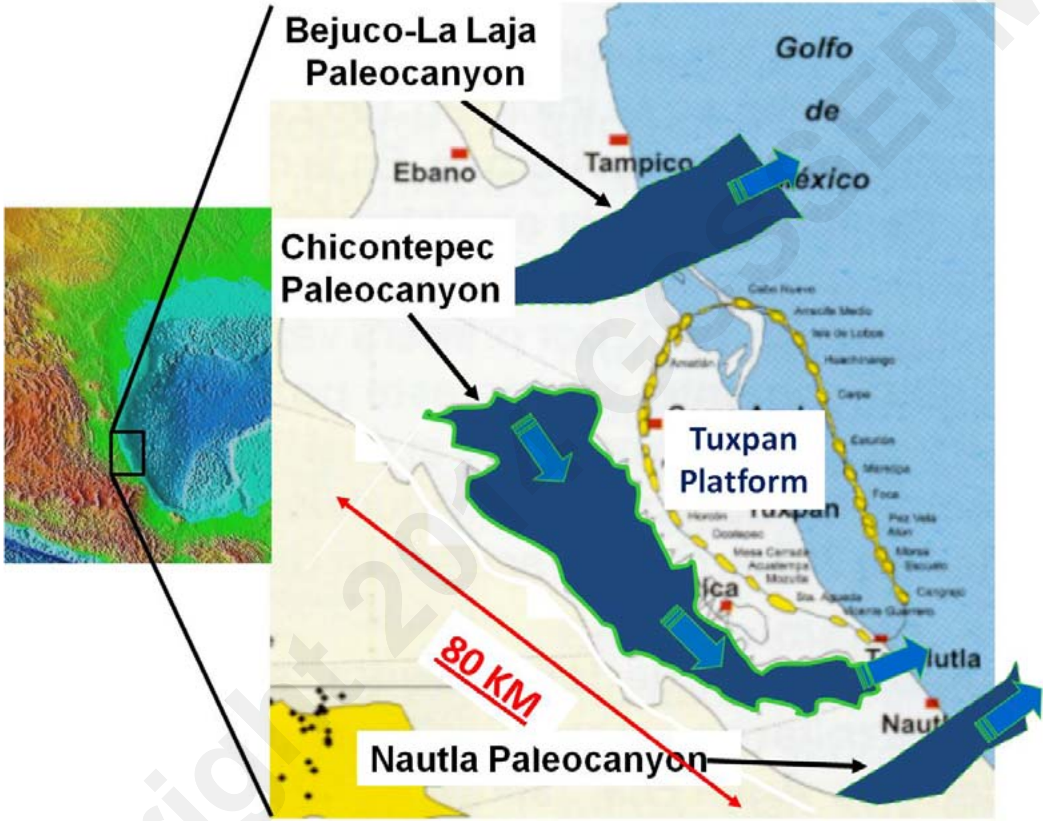
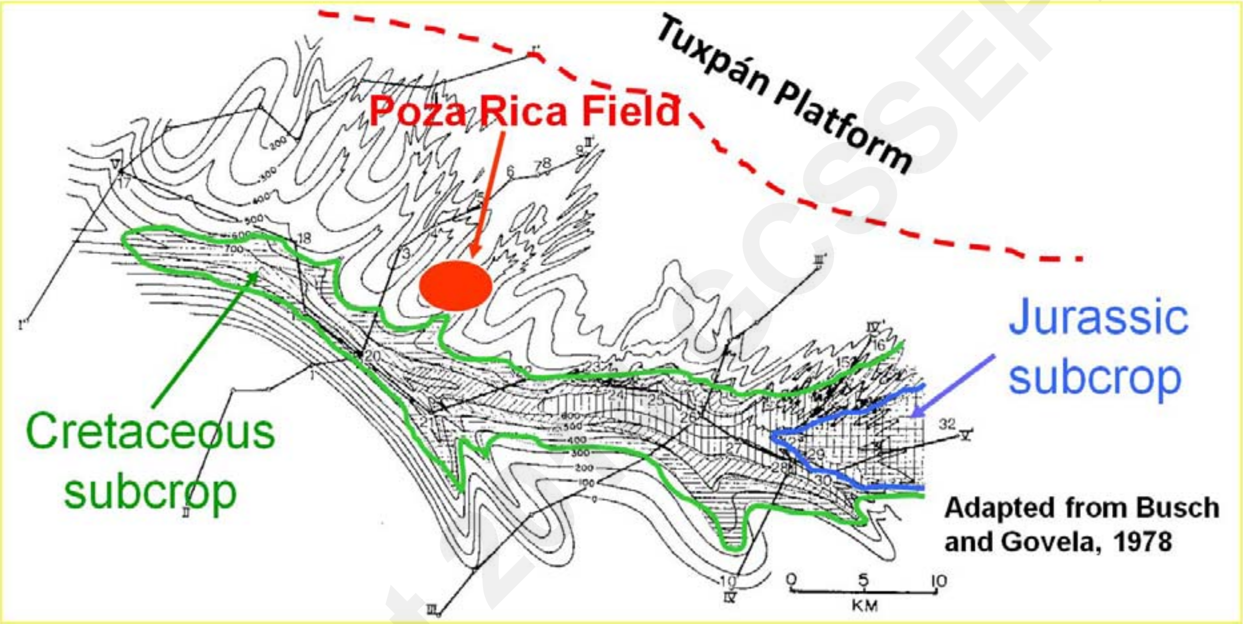


Figure 7. Location of Chicontepec and other paleocanyons around the Tuxpan Platform, eastern Mexico.



Adapted from Busch and Govela, 1978

Figure 8. The Lower part of the Chicontepec paleocanyon that was cut from west to east (left to right in the figure) into lithified Cretaceous and Jurassic carbonates. Deep-water carbonates of Poza Rica Field experienced porosity enhancement from freshwater diagenesis during lowered sea level.

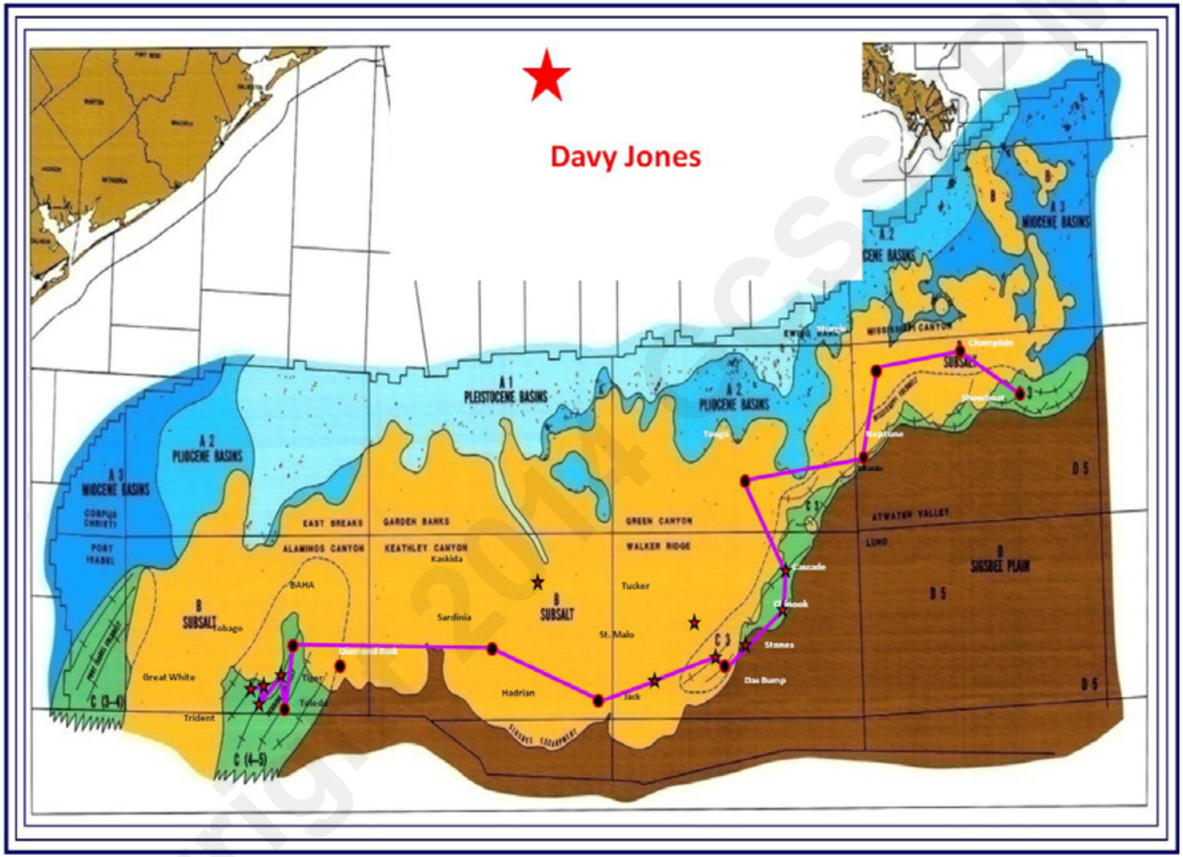


Figure 9. Distribution of Wilcox sandstone across several hundred kilometers in the deep Gulf Basin shown in yellow (from Rains, Zarra, and Meyer, 2008). Wilcox sandstone under the present day shelf (Davy Jones and other wells) suggests that the sand blanket is also extensive in the north-south, as well as the east-west direction. The Wilcox has been found to continue south into the deep basin offshore Mexico.

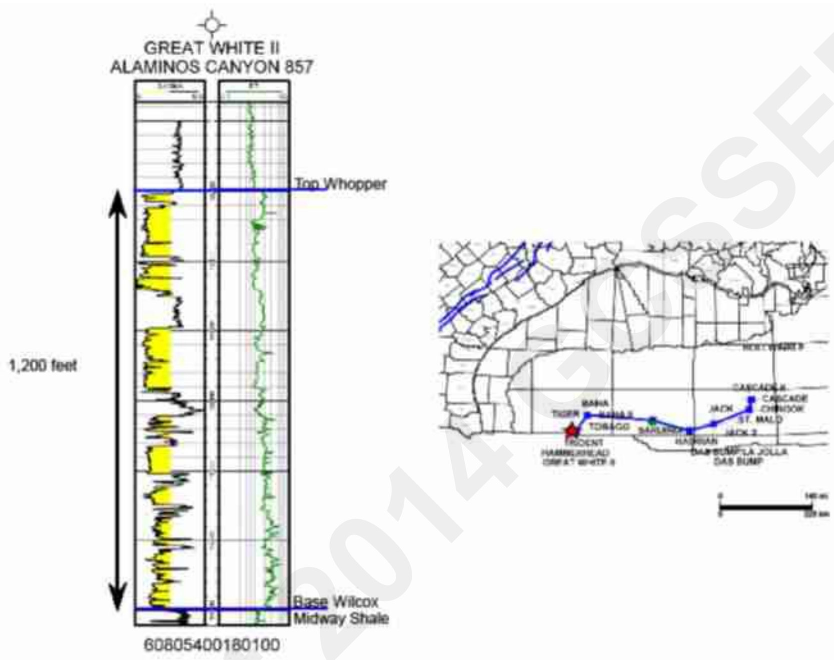
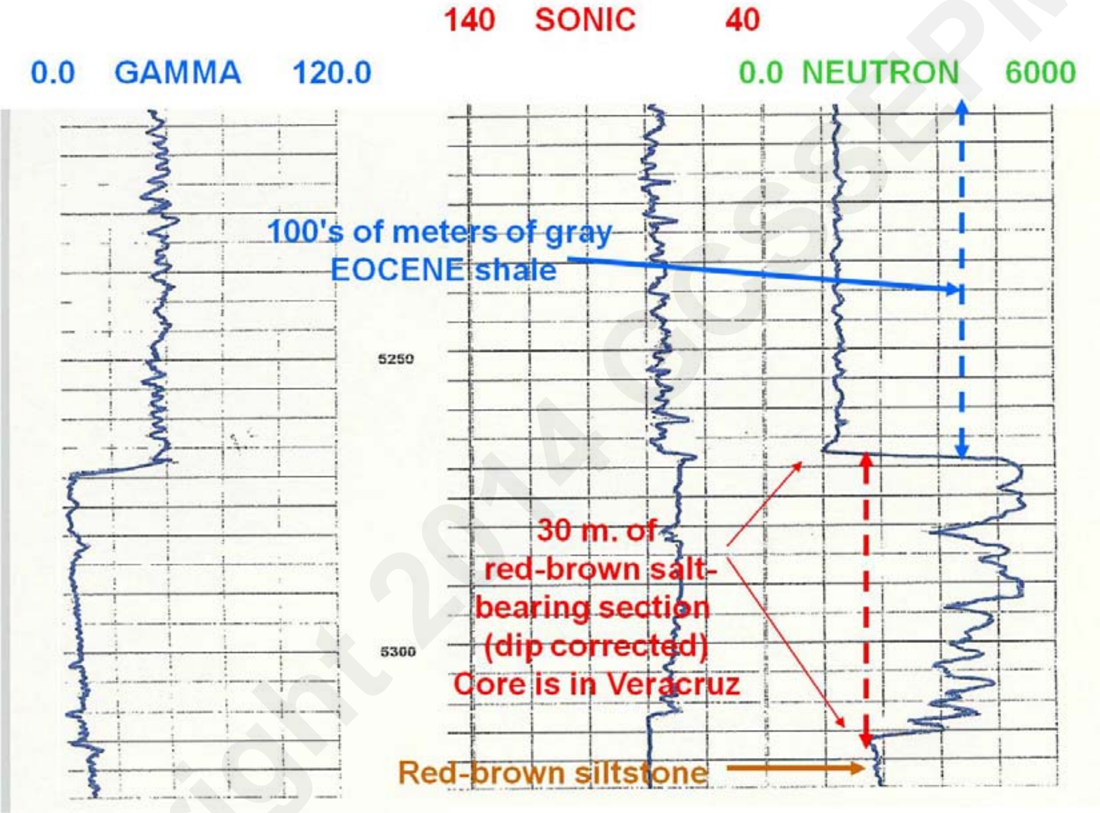


Figure 10. The sharply defined base and top of the "Whoppper Sand" in the Shell Great White well indicates the sudden start and cessation of sand deposition consistent with rapid eustatic changes.



100's of meters of gray EOCENE shale

30 m. of red-brown salt-bearing section (dip corrected) Core is in Veracruz

Red-brown siltstone

Figure 11. Log of the Mataespino 101B well of the Tertiary Veracruz basin, Mexico showing salt of probable playa lake origin buried by marine shale. The Veracruz basin is separated from the Gulf of Mexico by the Anegada high, which led to lowstand isolation and desiccation.

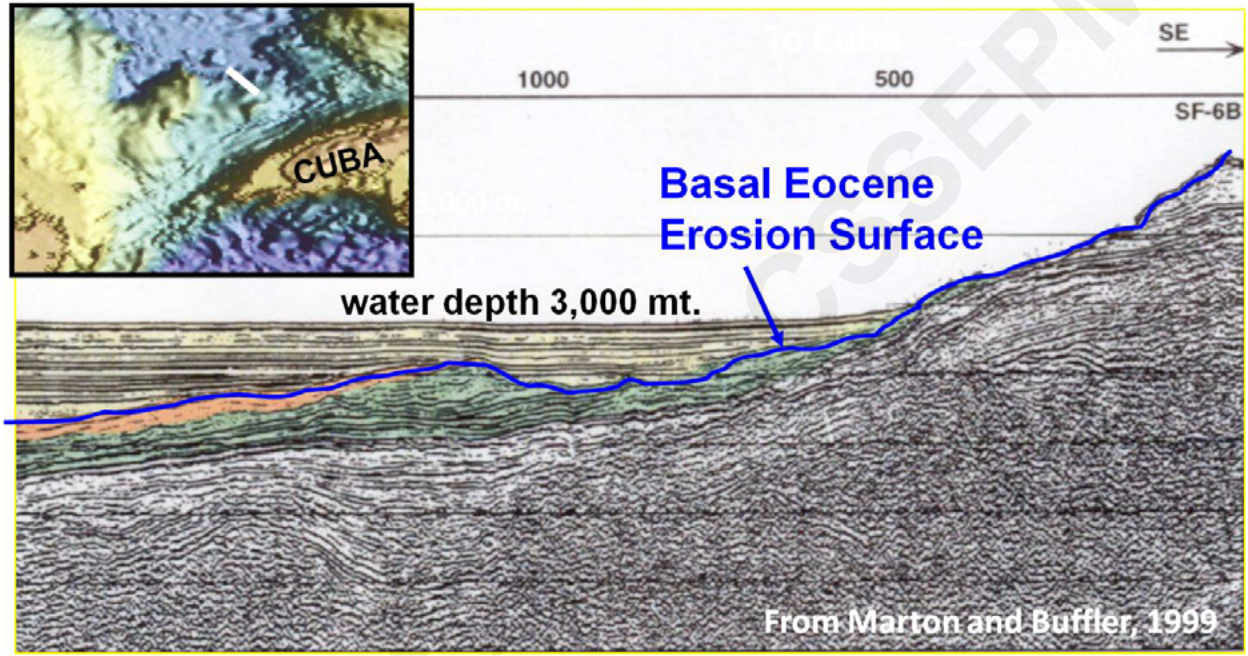


Figure 12. Erosional unconformity in the western deep Gulf of Mexico Basin formed during lowstand. The seismic line location is indicated by the white line in the inset map.

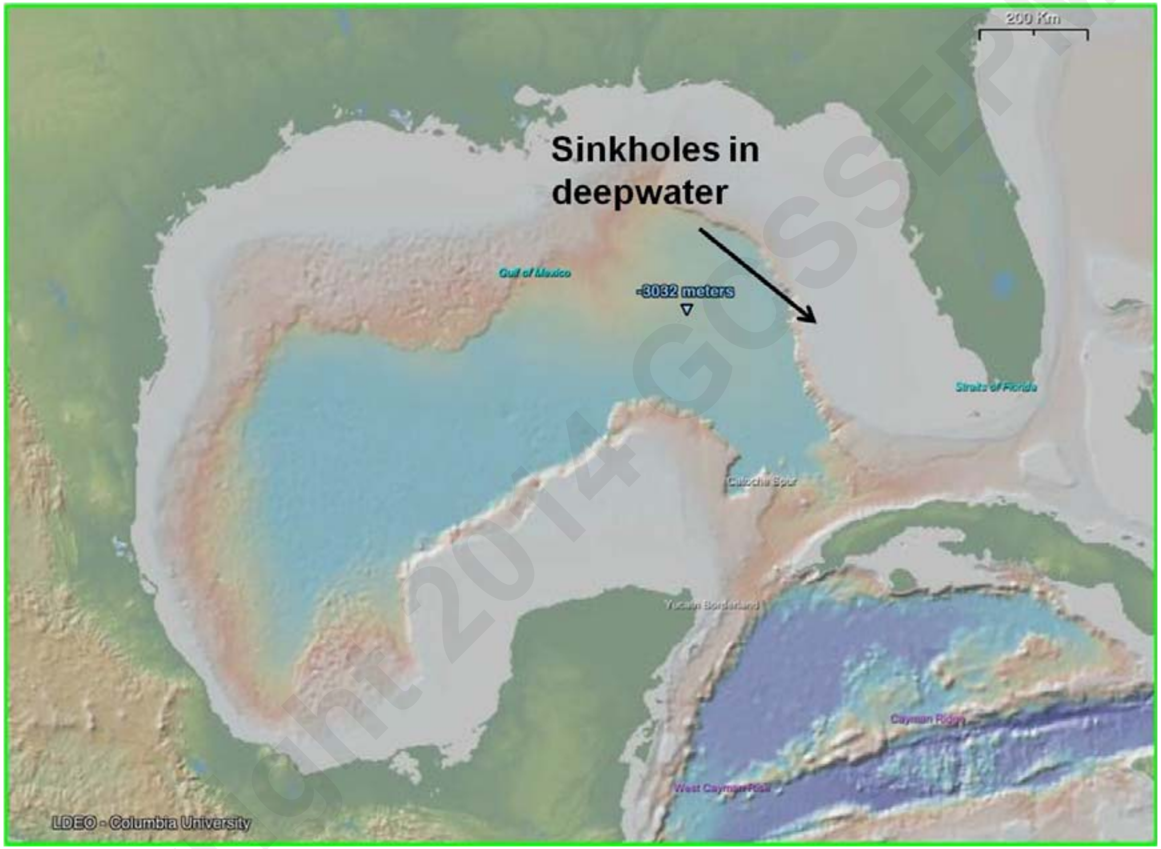


Figure 13. Location map for sinkholes of Figure 14.

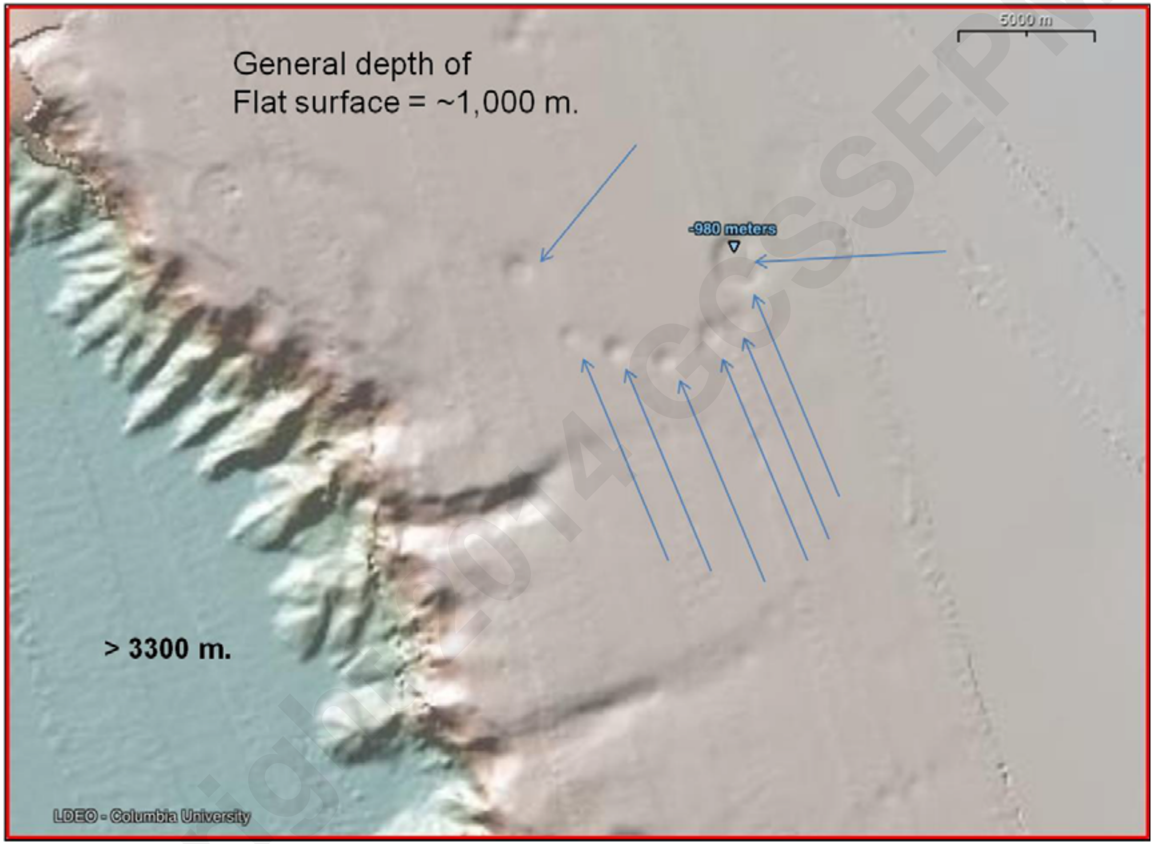


Figure 14. Sinkholes on the Florida slope at approximately 1,000 meters of depth.

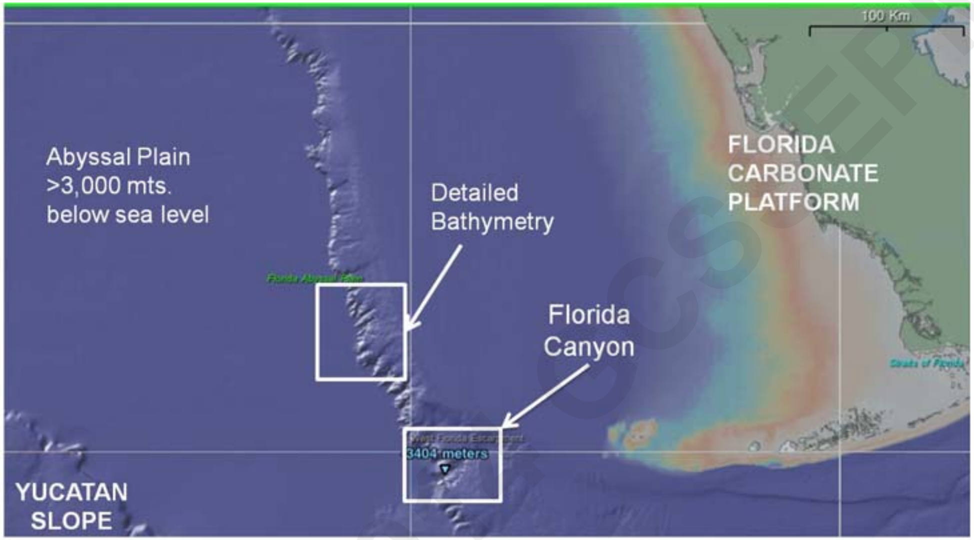


Figure 15. Location map for canyons of Figures 16, 17 and 18.

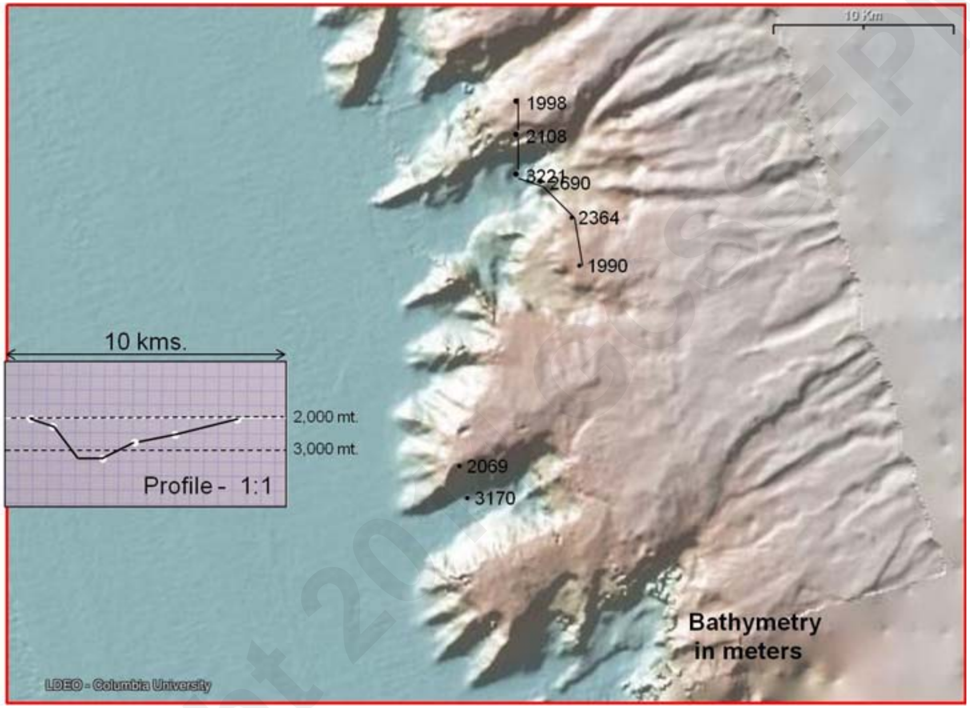


Figure 16. Typical bathymetry of steep walled canyons along the lower Florida slope. Profile shown in the inset indicates that the canyons are cut into hard rocks.

Figure 17. The Florida Canyon is the largest canyon cut into the Florida slope.

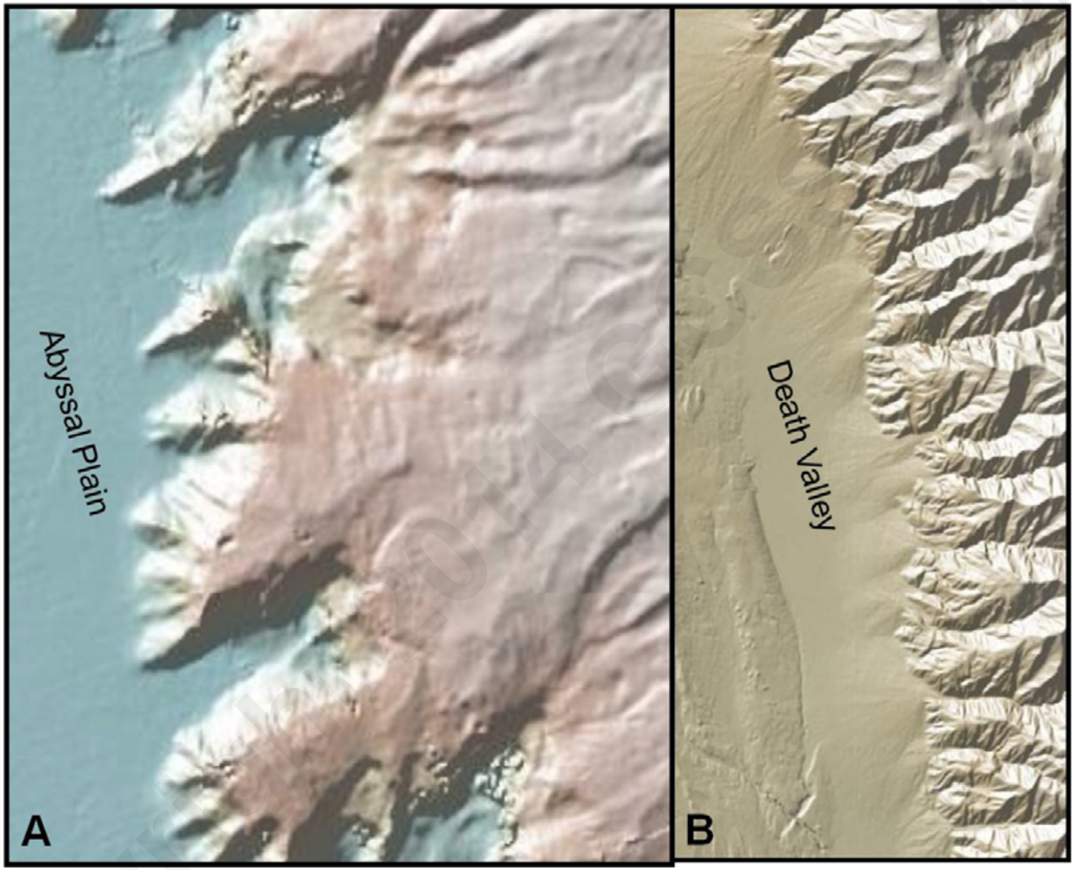


Figure 18. Typical lower Florida slope canyon bathymetry compared to the eroded scarp of the Panamint Range, Death Valley, U.S.A. at about the same scale.