Gulf of Mexico Paleogene "Whopper Sand" Sedimentology: Hypersaline Drawdown Versus Low-Salinity Hyperpycnite Models*

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Search and Discovery Article #40418 (2009)
Posted May 14, 2009

*Adapted from oral presentation at AAPG International Conference and Exhibition, Cape Town, South Africa, October 26-29, 2008

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Abstract

Billions of barrels of oil have been found since 2001 in the Paleocene-Eocene, Wilcox-equivalent "Whopper Sand" turbidites, deposited on the Gulf of Mexico abyssal plain, anomalously far (100s km) from the coeval shelf margin. Major evaporative drawdown (1-2 km), after tectonic damming of the Gulf (Cuban orogeny), has been proposed to explain (1) turbidite deposition so far basinward (shore advance), and (2) deep paleocanyons incising the shelf margin and slope. This model suffers from a lack of associated evaporites and from the unlikelihood of southern Gulf aridity (evaporation) outweighing inflow from humid (peaty) northern deltas.

An alternative, "opposite", low-salinity model is as follows. During three Paleocene-Eocene eustatic superlows, each involving a fall of about 100 m (Haq chart), world sea level fell toward or below the level of the Gulf's lowest inlet/outlet (sill), such that inflow from the ocean was reduced or cut (cf. Quaternary Black Sea). River inflow exceeded evaporation, desalinating the Gulf, turning it brackish or even, at times, fresh ("Lake Mexico" proposed here). Reduced salinity meant that river-fed (hyperpycnal) turbidity currents of long duration (weeks), already known to transport silt far out (100s km) onto modern marine abyssal plains, would have become more frequent and more sustained, carving the canyons and supplying the Whopper. Coriolis turning of unchanneled basin-floor flows impedes prediction of proximality trends, vital for exploration and development. Proper outcrop analogs of the Whopper low-salinity abyssal hyperpycnites may exist only in collisional accretionary complexes, because abyssal plains are ultimately subducted. Partial analogs are Carboniferous and Permian formations interpreted by the author as lacustrine hyperpycnites, but deposited above storm wave base (Brushy Canyon, Bude, Ross, Laingsburg, Skoorsteenberg)

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Gulf of Mexico Paleogene “Whopper Sand” sedimentology: hypersaline drawdown versus low-salinity hyperpycnite models

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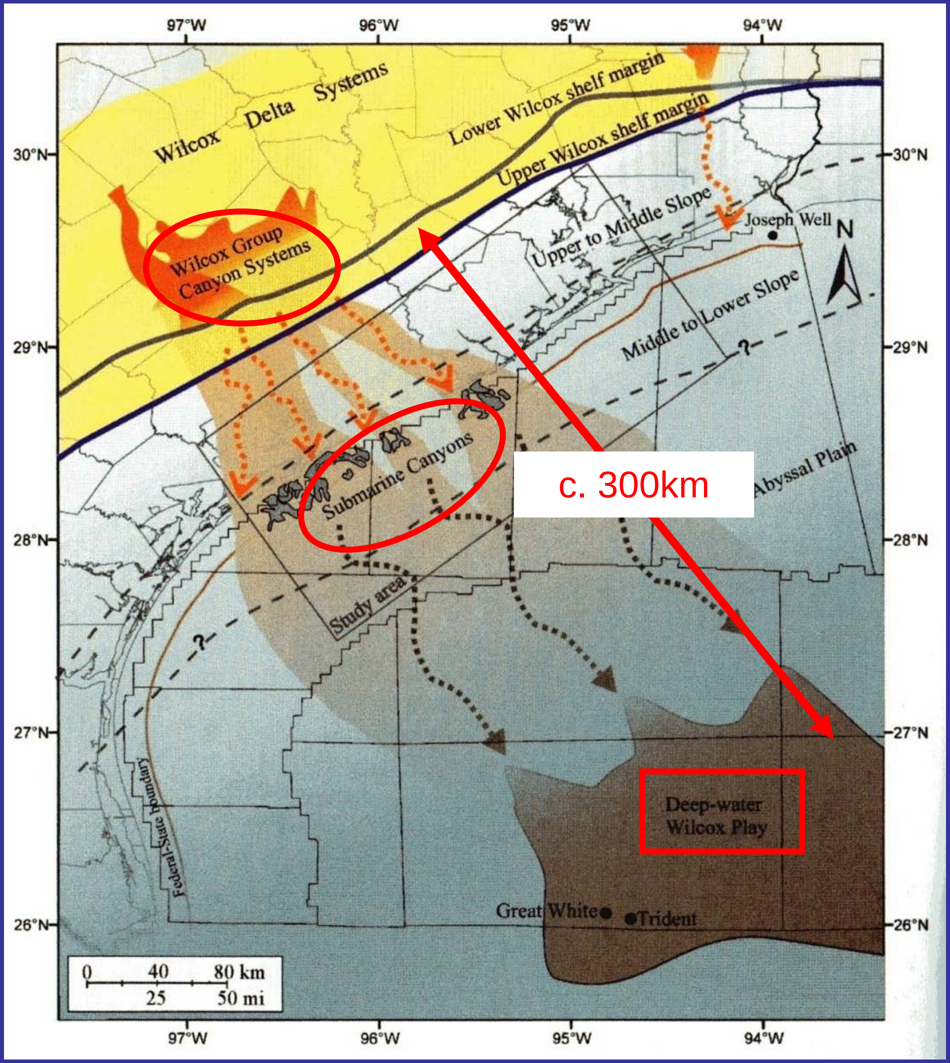
INTRODUCTION

Billions of barrels discovered since 2001 in Paleogene (Wilcox-equivalent) "Whopper Sand"

GoM major evaporative drawdown (1-2 km) has been proposed to explain (A) turbidite deposition anomalously far (100s km) from coeval shelf edge & (B) deep canyons in paleo-shelf/slope

Drawdown models suffers from (A) lack of Paleogene evaporites in GoM & (B) unlikelihood that Gulf evaporation outweighed river inflow at northern GoM deltas

McDonnell et al. 2008



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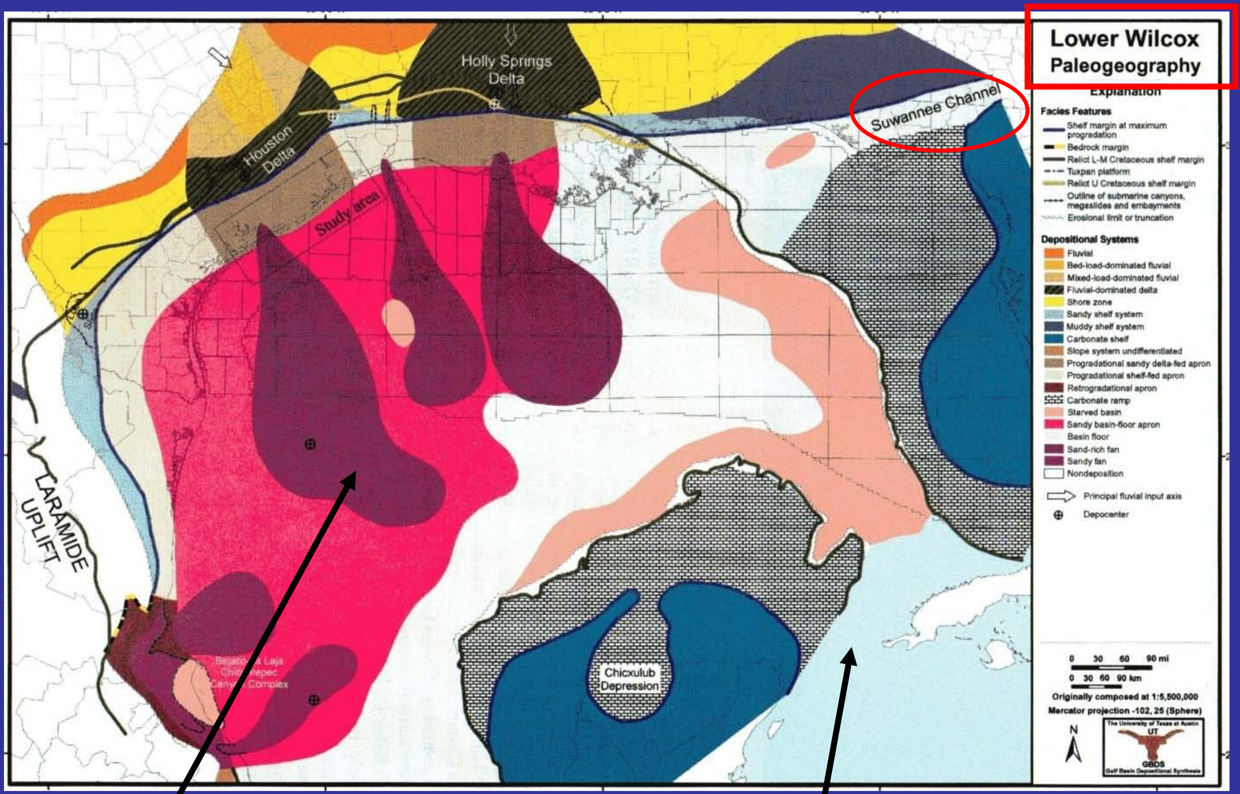
McDonnell et al. 2008



"sand-rich fan" present-day Yucatan Strait

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Rosenfeld & Pindell 2003

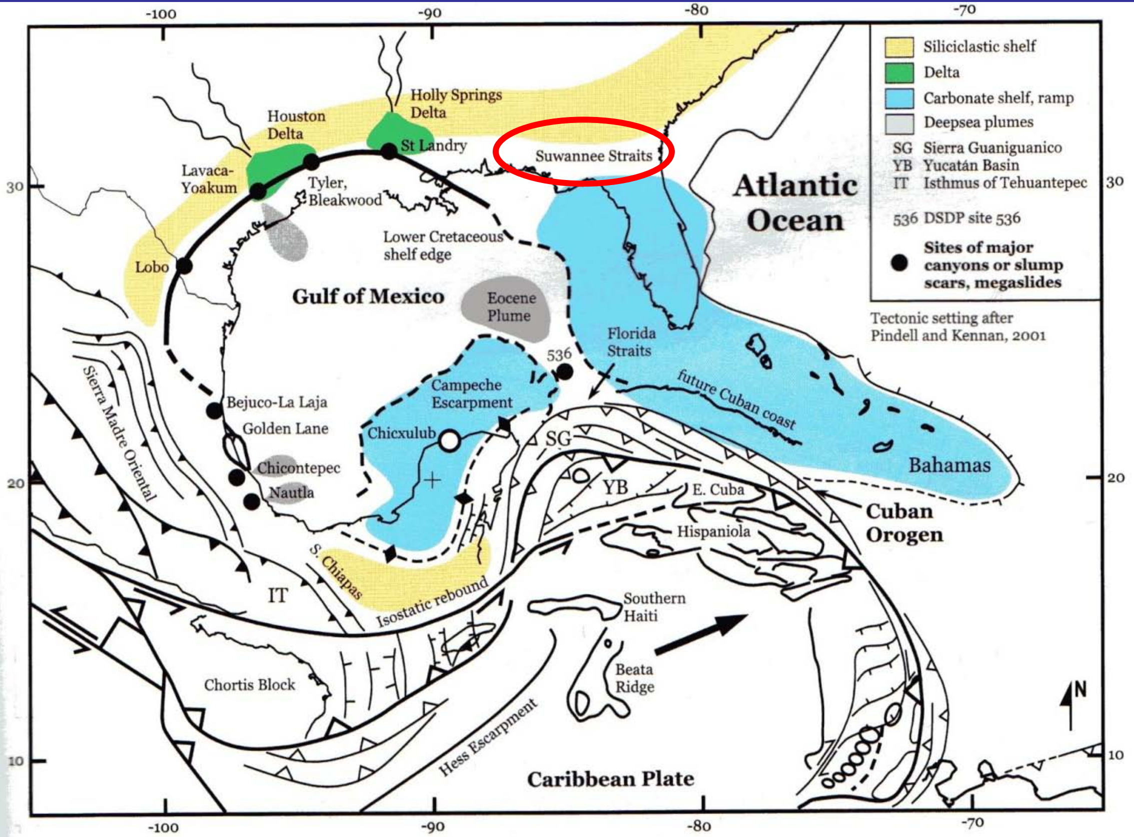

Figure 1. General map of the tectonic setting of the Gulf of Mexico region at the time of the Paleocene-Eocene boundary (~56 Ma, after Pindell and Kennan, 2001), showing localities noted in the text. Note the way in which the Cuban Orogen blocked the entrance to the Gulf of Mexico.

Canyon incision & Whopper deposition related to tectonic damming at Yucatan Strait? (also Berman & Rosenfeld 2007)

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McDonnell et al. 2008

Haq et al. 1988

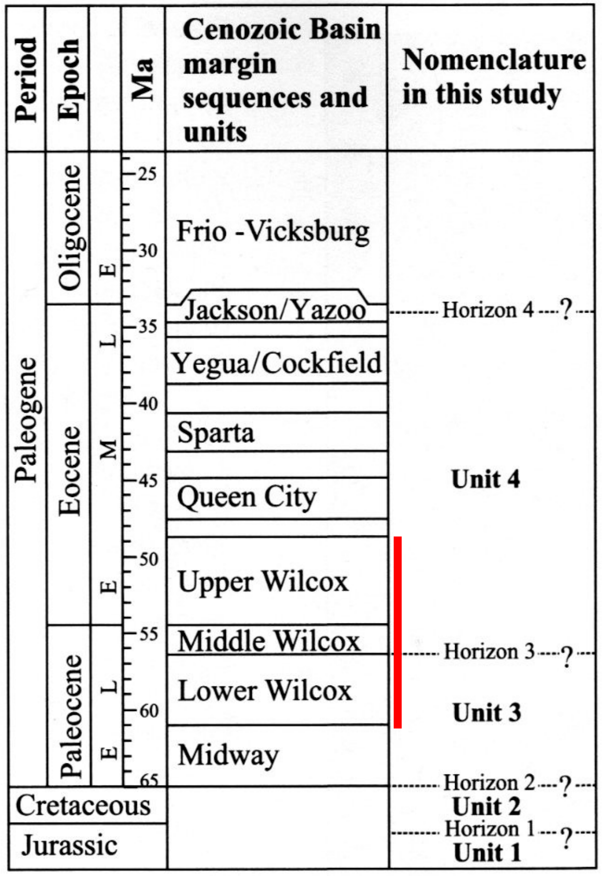

Figure 2. Generalized stratigraphic column for the Paleogene of the Texas coastal zone; modified from Galloway et al. (2000). The time scale is that of Berggren et al. (1995). E = early; M = middle; L = late.

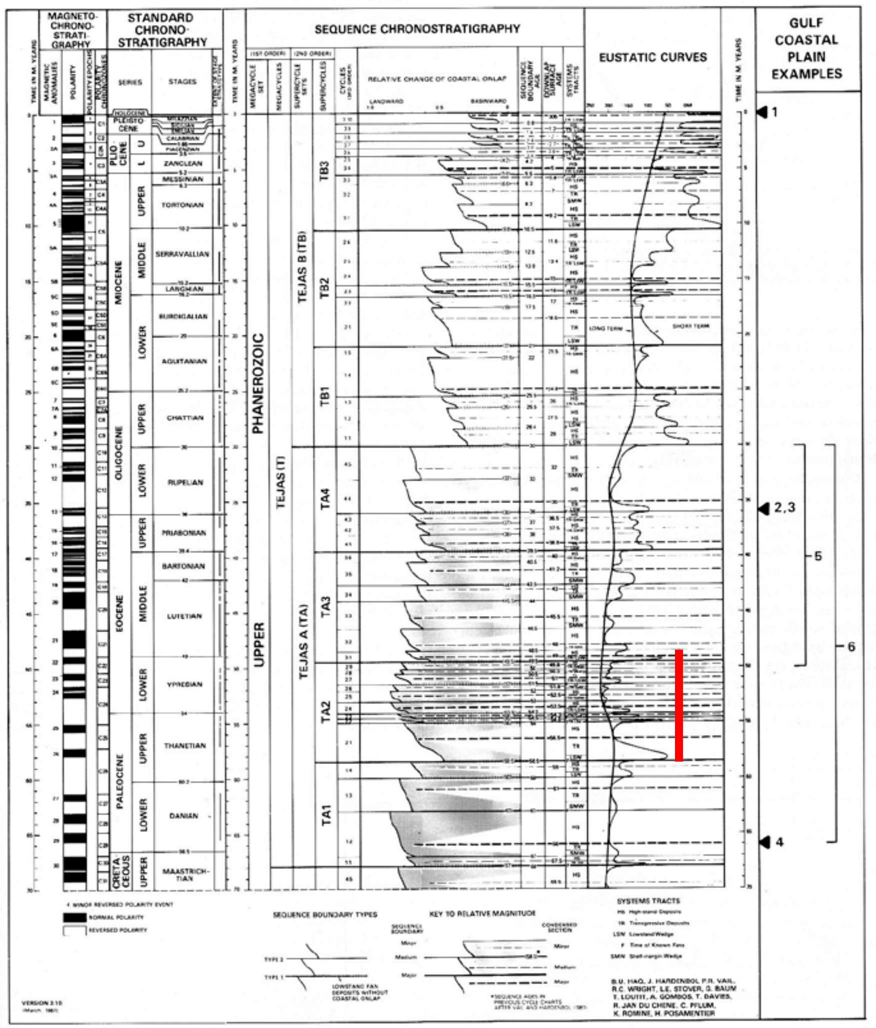

FIG. 13.—Cenozoic cycle chart modified after Haq *and others* (1987) showing age of Gulf coastal plain examples discussed herein.

Canyon incision & Whopper deposition related to eustasy?

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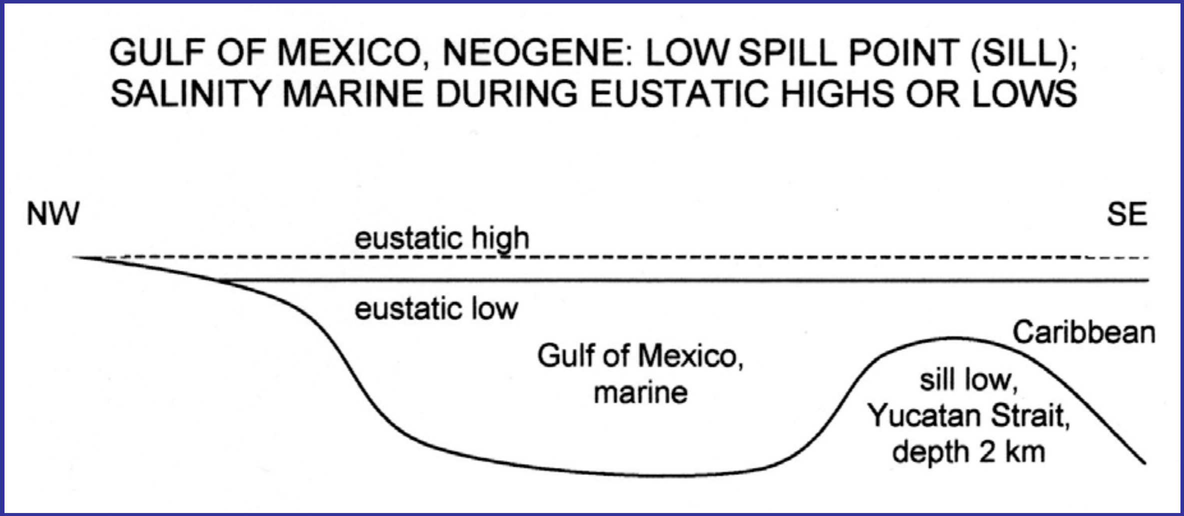
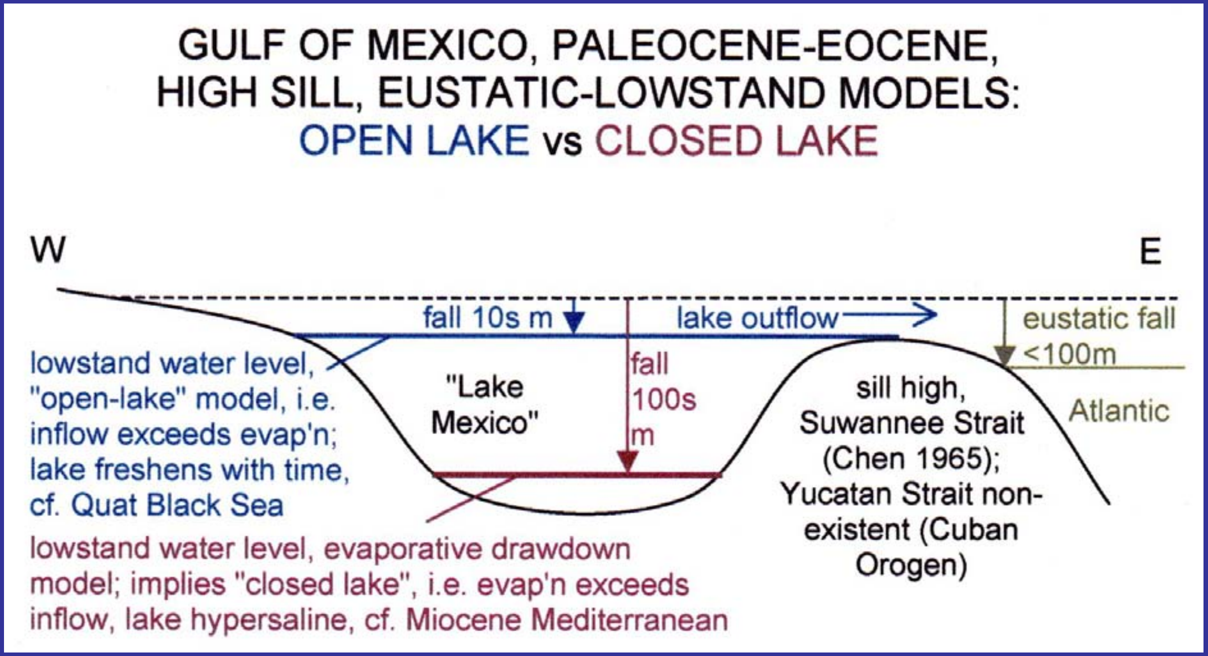
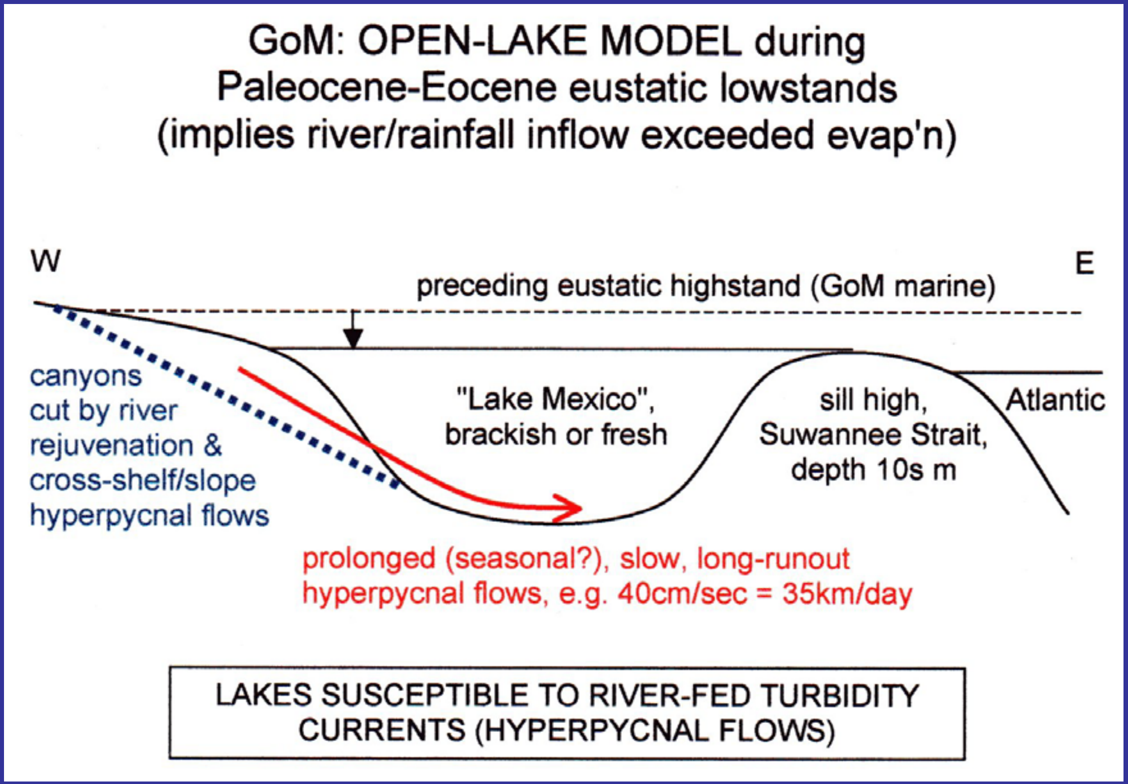

GULF OF MEXICO, NEOGENE: LOW SPILL POINT (SILL);
SALINITY MARINE DURING EUSTATIC HIGHS OR LOWS
NW
SE
eustatic high
eustatic low
Gulf of Mexico,
marine
Caribbean
sill low,
Yucatan Strait,
depth 2 km


GULF OF MEXICO, PALEOCENE-EOCENE,
HIGH SILL, EUSTATIC-LOWSTAND MODELS:
OPEN LAKE vs CLOSED LAKE
W
E
fall 10s m
lake outflow
eustatic fall
<100m
Atlantic
lowstand water level,
"open-lake" model, i.e.
inflow exceeds evap'n;
lake freshens with time,
cf. Quat Black Sea
"Lake
Mexico"
fall
100s
m
sill high,
Suwannee Strait
(Chen 1965);
Yucatan Strait non-
existent (Cuban
Orogen)
lowstand water level, evaporative drawdown
model; implies "closed lake", i.e. evap'n exceeds
inflow, lake hypersaline, cf. Miocene Mediterranean



MOST LIKELY MODEL, as (1) GoM Paleogene evaporites absent, & (2) GoM aridity unlikely to outweigh inflow from humid (peaty) deltas in N

Zavala et al. 2007

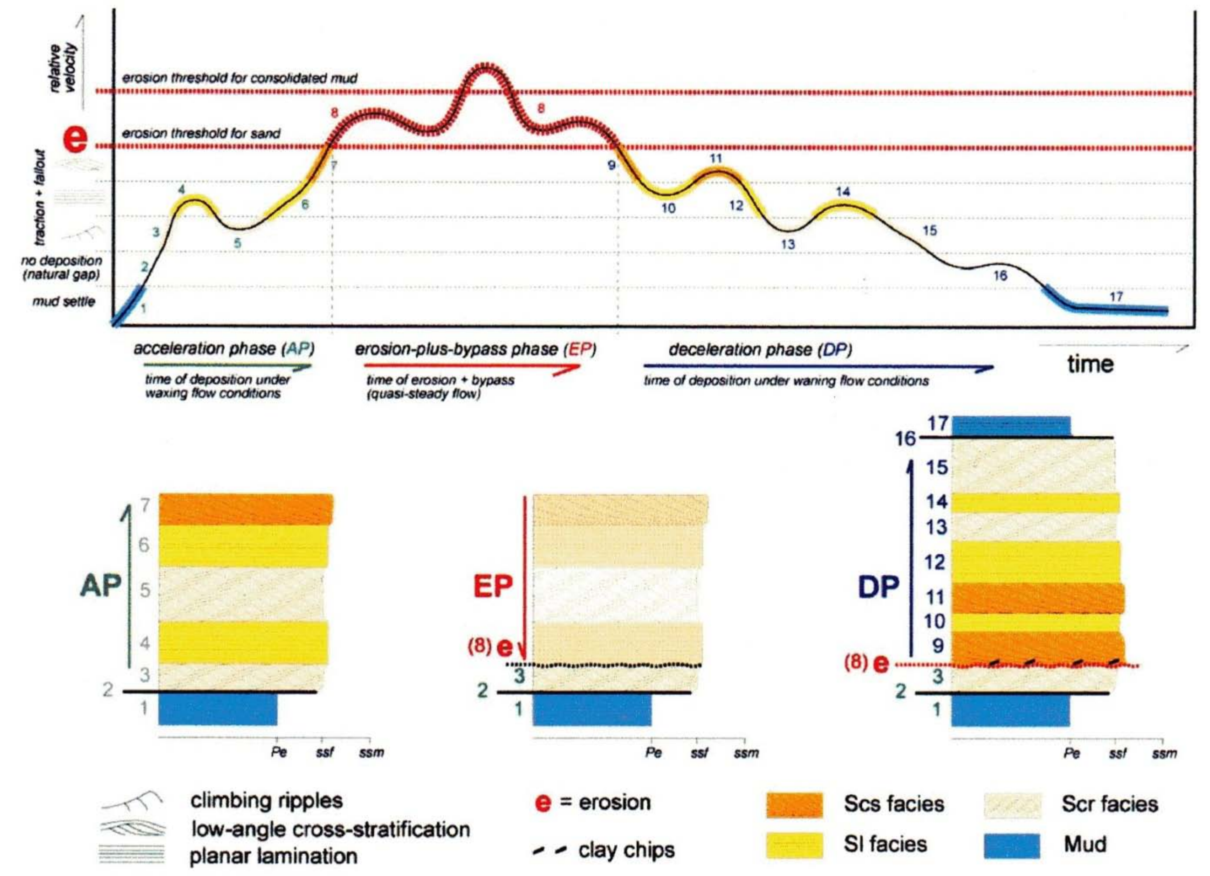


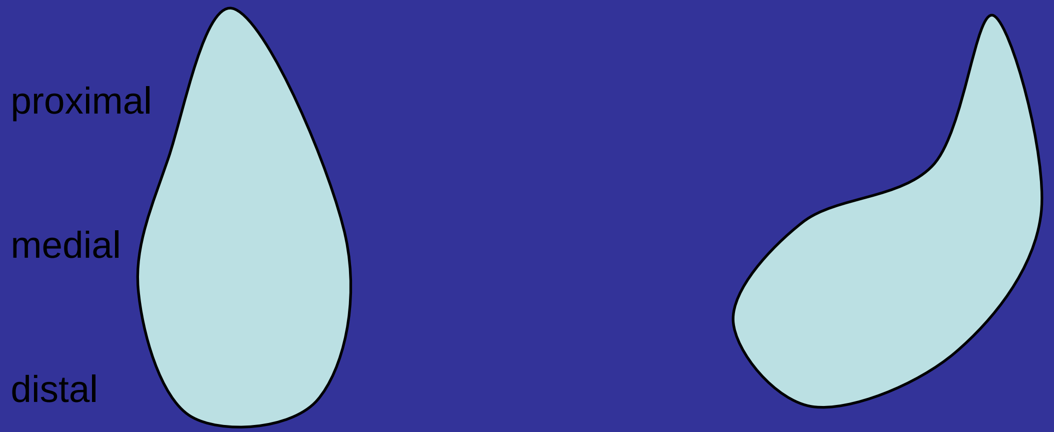
FIG. 11.—Hypothetical diagram showing a curve of fluctuating velocity related to a quasi-steady underflow and its consequences for sedimentation at a fixed point in the basin. Three main phases are recognized: Acceleration phase (AP): accumulation of intervals 1 to 7 by an accelerating and fluctuating flow. Erosion-plus-bypass phase (EP): erosion of some of the preceding deposits. Deceleration phase (DP): accumulation of intervals 9 to 15 from a decelerating and fluctuating flow.

potential Whopper hyperpycnite facies

Sustained hyperpycnal flows:

More susceptible to Coriolis turning effect (compared to brief slump-generated flows) due to longer duration

Affects prediction of fan proximality trends, vital for exploration & development.



http://public.cambridge.scr.slb.com/NOMAD/index.html

Skoorsteenberg Fm, South Africa, widely used as analog for passive margin, marine, deep water reservoirs

probable lacustrine hyperpycnites,
i.e. PARTIAL WHOPPER ANALOG?

CONCLUSIONS

-radical "sea-level fall of as much as 6,000 ft" (Berman 2008) in Paleogene GoM not necessary

-facies predictions can be made, using Zavala hyperpycnal model, and making allowance for Coriolis deflection

-biostrat problems likely, due to (A) canyon incision (reworking), and (B) lowered salinity (brackish/fresh microfauna & microflora

THANK YOU