



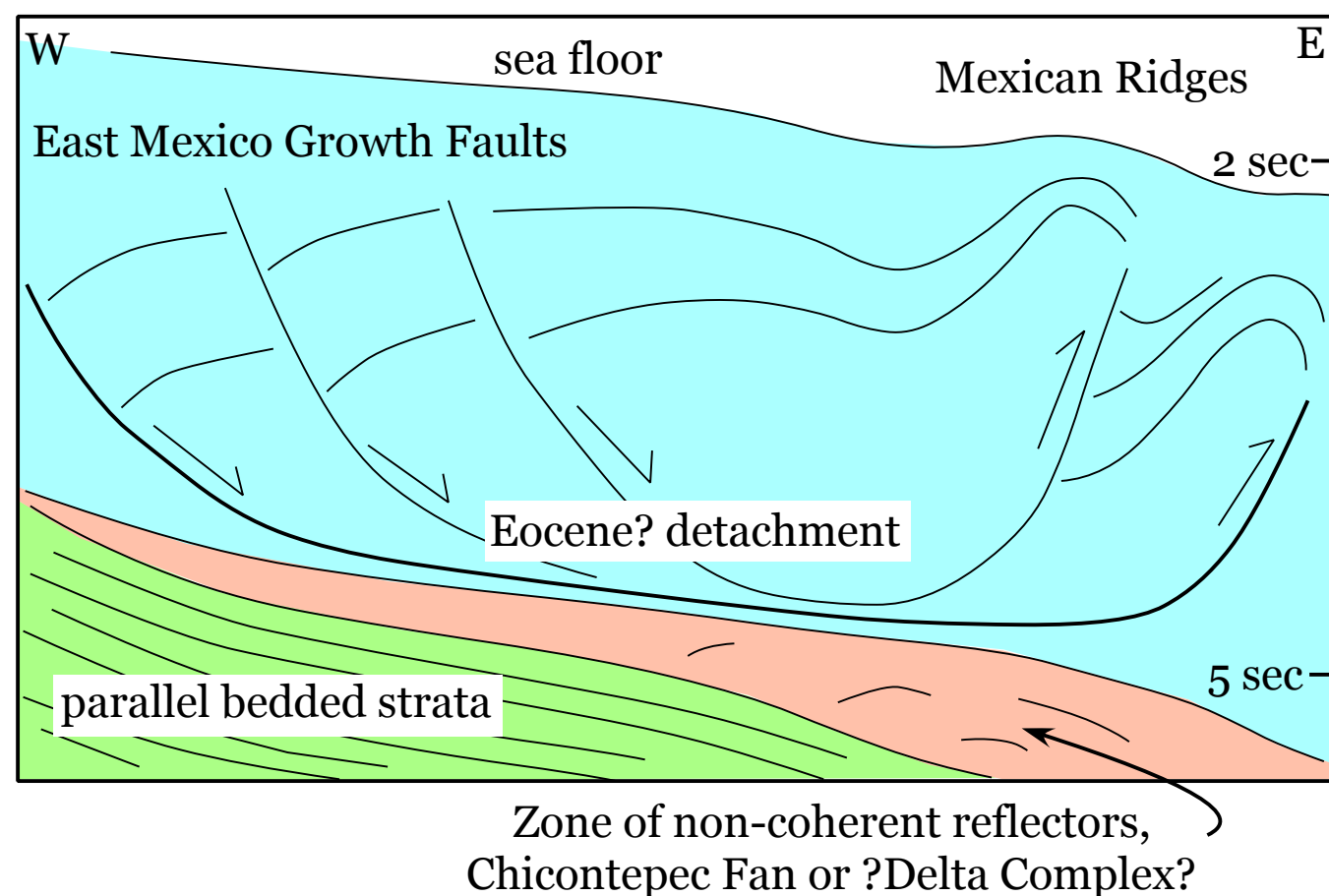
### Rosenfeld and Pindell, 2002, Gulf drawdown hypothesis, cont...

(4) Overlying this member are the prograding littoral and neritic Guayabal and Tantoyuca Formations of Middle and Upper Eocene age. The Upper Chicontepec (canyon fill) isopach thickens westward, and Busch and Govela (1978) considered that current direction was westward during canyon formation. However, if the original depositional surface dipped eastwards as the canyon was cut, the same isopach could be formed with a flat or east-dipping floor with eastward flow. We find this to be more in line with regional geology, as did Cantú (1985) and Carillo (1980).

#### Chicontepec geology

At the Nautla canyon to the south, some 6,000 feet of Chicontepec sediments overlie Jurassic red beds (Viniegra, 1966; Bitter, 1993), suggesting the canyon cut the entire marine section here. The Cretaceous sections cut by these canyons comprised carbonates and marls that were probably well lithified by Paleocene, and thus fairly strong currents operating over a significant time interval were probably needed to cut them. Offshore seismic lines suggest the existence of a thick wedge of Paleocene-Eocene material beneath the Mexican Ridges Foldbelt that may represent the eroded canyon fill plus material brought down the canyon from the shelf (see **Figure 3**).

Concerning Tamabra talus breccias west of Golden Lane, Enos (1988) details the need to flush meteoric water down to 2 km to explain cavernous and other secondary porosities, which becomes far easier to understand if the Chicontepec Canyon were subaerial for a time. Halley et al. (1984) describes similar features at DSDP Site 536, the location of which may also have been subaerial or nearly so for part(s) of the early Paleogene (note: Eocene is missing; OSDN range charts). Like the canyon itself, such secondary porosity in the Golden Lane and Tamabra carbonates may have required significant time to form.



**Figure 3.** Schematic seismic section of the eastern Mexican deepwater margin east of the Chicontepec Canyon, drawn from memory of sections presented in presentations at the 2001 AMGP/AAPG meeting, Veracruz, Mexico.

#### Yoakum, West Texas margin

To the north, the Lobo and Lavaca mega-slumps comprise Lower Wilcox and equivalent material of the shelf-slope break. At Lavaca, the Yoakum canyon cuts the Lavaca slumps as well as low-gradient Lower Wilcox shelf deposits to the northwest for at least 80 km. Like Chicontepec, the incision is about 3,000 ft with canyon sides sloping locally at 30°, and the canyon is filled with silts that spill beyond the canyon limits.

The shelf rather than slope setting for this canyon is important because we cannot find other analogues where shelf sections are incised in this way without severe relative drops in base level, and we can more confidently propose a subaerial rather than submarine setting for canyon incision here. We speculate that the “sandy channel fills and turbidite mounds” in the canyon cited by Galloway et al. (1991) may suggest a subaerially eroding canyon with slumping walls and a river in the thalweg. We further speculate that a similar major paleo-canyon may exist under the lower Río Grande Valley.

Few other examples of shelf canyons with this magnitude exist in the world, and those that do carry an explanation:

- Nile and Rhone - Messinian dessication in the Mediterranean (Ryan and Cita, 1978; Barber, 1981)
- Congo - possible rapid draining of an interior lake
- Canyons at active margins where rapid tectonic uplift can occur (California).

We expect that dampening of current strength in the marine environment would inhibit such magnitudes of incision on the shelf, and we find it difficult to envisage how canyon flanks in only semi-consolidated material could approach 30° slopes in an active marine environment known otherwise to be a site of strong longshore drift (Galloway et al., 2000).

From the above, we speculate that the Chicontepec (lithified rock) and Yoakum (shelf setting) and other paleo-canyons, phenomena not known for any other time in the Gulf, are best explained as having formed during severe (approaching 3,000 feet) water level drawdown. This was followed by rapid flooding of margins as the barrier to world seas was breached, thereby leading to the marine canyon fill.

If the flooding event was erosive, we would expect little if any record of the subaerial period between Lower Wilcox and canyon fill sediments. A reasonable net evaporation rate of only six inches per year in this paleo-setting of 20°-25° paleo-latitude could have lowered base level by the anticipated 3,000 feet in only 6,000 years, a geological snap in time, but it could have taken longer given the degree of required erosion.

#### Cuba, SE Gulf of Mexico

By end of Paleocene, the Western Interior Seaway (Ziegler and Rowley, 1998), Chiapas Basin, and Suwannee Straits no longer connected the Gulf and world ocean. This left the southeast Gulf only, where widespread Paleocene and Eocene unconformities north and west of Cuba (Rosencrantz, 1990; Angstadt et al., 1983; OSDN, 2001) suggest that the Late Paleocene to Middle Eocene collision of the Cuban forearc with the northeast Yucatán and Bahamas carbonate margins (Pardo, 1975; Pzolyckowski, 1999; Pindell and Kennan, 2001; Ball et al., 1985) might have shut that connection off also.

With the Chicontepec, Yoakum, and other canyons providing direct reason to suspect it, we propose that Cuba did, in fact, close off the southeast Gulf. Further, there is no particular reason to assume that the Gulf was not intermittently or continuously sealed off over the entire Late Paleocene to Late Eocene interval, after which more normal deposition is known to have resumed in Florida Straits.

Finally, we point out that the “Eocene Plume” in the eastern deep Gulf (Galloway, 2000), which is the only Cenozoic unit in US waters to thicken southward, was, in our opinion, probably derived from the Cuban orogen and/or missing section at the unconformities in Florida Straits.

## Rosenfeld and Pindell, 2002, Gulf drawdown hypothesis, cont...

### Discussion

Our hypothesis provides a unifying mechanism for periods of:

- Exposure of circum-Gulf continental shelves/upper slopes
- Severe canyon incision into shelves
- Massive slumping of clastic continental shelf/slope sections
- Deep caving of exposed carbonates
- Sediment bypass and progradation into the deep Gulf.

We do not define the number or duration of times the Gulf was isolated from the world ocean. Multiple cycles of rapid drawdown and flooding of varying magnitude may have occurred, depending on Late Paleocene-Late Eocene kinematics and dynamics of the Cuban orogen, and the orogen's level relative to eustasy on its southeast side.

This assumes episodic blockage of the Florida Straits, but alternatively the Gulf may have remained isolated for the entire Late Paleocene- Late Eocene interval, such that cyclical climatic cycles in the Gulf's catchment area controlled relative water level. In either case, the Gulf is unsatisfactory for calibrating eustasy at this time. A one-km drop (and subsequent rise) in the Gulf's water level would have raised (and lowered) global sea level by a modest two meters (W. Pitman, pers. comm.).

Drawdown of base level by ~3,000 ft would have produced moderately hypersaline conditions in the remaining Gulf. However, no Eocene evaporites are known and we assume for now that they either were not deposited or were dissolved upon reflooding. But it may be presumptuous to assume that all salt is Jurassic.

The isostatic response of lithosphere to water drawdown and flooding is potentially important. For every kilometer of water removed/added from/to the Gulf by evaporation/flooding, the lithosphere (and the remaining water in the Gulf) will rebound/subside by about 300 m. Rebound/subsidence will be progressively less within the flexural half-wavelength (~200 km) in the landward direction at the margins, where original water depths were less than 1 km. Rivers would cut into the rising area to reach the Gulf, and areas such as Florida would become better sea barriers by this process.

These considerations would reverse upon re-flooding: once flooding began, added water would load the Gulf floor and margins and cause them to subside, renewing marine deposition across the formerly subaerial and progradational shelves/upper slopes. The Big Shale and Upper Chicontepec formations would be one such interval; others could be the Yoakum, Reklaw, Weches, Cook Mountain, and Moodys Branch formations (Galloway et al., 2000).

### Implications

Our hypothesis carries the following implications for hydrocarbons:

- (1) one or more ubiquitous circum-Gulf unconformities that correspond to time(s) of lowered water level;
- (2) extensive exposure/karsting of carbonate platforms (Florida, Yucatán, Córdoba, Tuxpan);
- (3) silty/fine-grained turbidite filled canyons with stratigraphic trapping potential;
- (4) slumping and landsliding of exposed canyon walls and poorly consolidated upper slope deposits;
- (5) fluvial thalweg deposits (braided channels and fluvial sandbars) on the floors of subaerially eroded canyons during lowered water level;
- (6) sandy low-stand deltas and basin slope and floor fans basinward of the canyon systems providing important reservoirs and migration pathways: the Chicontepec Formation is saturated with hydrocarbons (Bitter, 1993), possibly due to physical contact with Upper Jurassic source rocks at the canyon base. Recently discovered sands in the deepwater Perdido Belt (e.g. Unocal's Trident well) may be a specific example.

### References:

- Angstadt, D.M., Austin, J.A., Jr., and Buffler, R.T., 1983, Deep-sea erosional unconformity in the southeastern Gulf of Mexico, *Geology*, 11:215-218.
- Ball, M.M., Martin, R.M., Bock, W.D., Sylvester, R.E., Bowles, R.M., Taylor, D., Coward, E.L., Dodd, J.E., and Gilbert, L., 1985, Seismic structure and stratigraphy of northern edge of Bahaman-Cuban collision zone, *American Association of Petroleum Geologists Bulletin*, 69:1275-1294.
- Barber, P.M., 1981. Messinian subaerial erosion of the proto-Nile Delta. *Marine Geology*, 44:253-272.
- Bitter, M.R., 1993, Sedimentary and Provenance of Chicontepec Sandstones with Implications for Uplift of the Sierra Madre Oriental and Teziutlan Massif, East-Center Mexico, in J.L. Pindell and R.F. Perkins (eds.), *Mesozoic and Early Cenozoic Development of the Gulf of Mexico and Caribbean Region: A Context for Hydrocarbon Exploration*, 155-172, Gulf Coast Section Society of Economic Paleontologists and Mineralogists Foundation.
- Busch, D.A., 1974, Stratigraphic Traps in Sandstones- Exploration Techniques: AAPG Memoir 21, 157 p.
- Busch, D.A., and A.S. Govela, 1978, Stratigraphy and Structure of the Chicontepec Turbides, Southeastern Tampico-Misantla Basin, Mexico: AAPG Bulletin, v. 62, p. 235-246.
- Cantú-Chapa, A., 1985, Is there a Chicontepec Paleocanyon in the Paleocene of Eastern Mexico?: *Journal of Petroleum Geology*, v. 8, p. 423-434.
- Carillo-Bravo, J., 1980, Paleocañones terciarios de la planicie costera del Golfo de México: *Asociación Mexicana de Geólogos Petroleros Boletín*, v. 32, p. 27-55.
- Enos, P., 1988, Evolution of pore space in the Poza Rica trend (mid-Cretaceous), Mexico: *Sedimentology*, v. 35, p. 287-325.
- Galloway, W.E., Bebout, D.G., Fisher, W.L., Dunlap, J.B., Jr., Cabrera-Castro, R., Lugo-Rivera, J.E., and Scott, T.M., 1991, Cenozoic, in A. Salvador (eds.), *The Gulf of Mexico Basin, The Geology of North America*, J: 245-324, Geological Society of America, Boulder, Colorado.
- Galloway, W.E., Ganey-Curry, P., Li, X., and Buffler, R.T., 2000, Cenozoic depositional evolution of the Gulf of Mexico Basin: AAPG Bulletin, v. 84, p. 1743-1774.
- Halley, R. B., Pierson, B. J. and Schlager, W., 1984, Alternative diagenetic models for Cretaceous talus deposits, DSDP site 536, Gulf of Mexico, Initial Reports of Deep Sea Drilling Project, 77, p. 397-408.
- NGDC (National Geophysical Data Center), 2000. DSDP Marine Geological and Geophysical Data, World Data Center for marine geology and geophysics Boulder Seafloor Series, Volume 1.
- Pardo, G., 1975, Geology of Cuba, in A.E. Nairn and F.G. Stehli (eds.), *The Gulf of Mexico and the Caribbean, The Ocean Basins and Margins*, 3: 553-615, Plenum Press, New York.
- Pindell, J.L. and Kennan, L.J., 2001, Kinematic Evolution of the Gulf of Mexico and Caribbean. Proceedings of 21st Bob F. Perkins Research Conference: to be published in *Gulf Coast Geological Societies Transactions*.
- Pszczolkowski, A., 1999, The exposed passive margin of north America in western Cuba, in P. Mann, ed., *Caribbean Basins: Sedimentary Basins of the World*, v. 4, Elsevier, p. 93-122.
- Rosencrantz, E., 1990, Structure and tectonics of the Yucatán Basin, Caribbean Sea, as determined from seismic reflection studies, *Tectonics*, 9, 1037-1059.
- Ryan, W.B.F., and Cita, M.B., 1978. The nature and distribution of Messinian erosional surfaces: indicators of a several-kilometer-deep Mediterranean in the Miocene. *Marine Geology*. v. 27, p. 193-230
- Smith, W.H.F. and Sandwell, D.T., 1997, Global seafloor topography from satellite altimetry and ship depth soundings, *Science*, 277, 1957-1962.
- Viniegra, O.F., 1966, Paleogeografía y tectónica del Mesozoico en la provincia de la Sierra Madre y macizo de Teziutlán: *Asociación Mexicana de Geólogos Petroleros Boletín*, v. 18, p. 145-171.
- Ziegler, A.M., and D.B. Rowley, 1998. The vanishing record of epeiric seas with emphasis on the Late Cretaceous "Hudson Seaway". In: *Tectonic Boundary Conditions for Climate Reconstructions*, T.J. Crowley and K. Burke (eds.), pp. 147-165. Oxford: Oxford University Press.

If you would like more information on our reports for the Gulf of Mexico region and elsewhere, please contact us:

**WEB:** <http://www.tectonicanalysis.com>

**Email:** [jim@tectonicanalysis.com](mailto:jim@tectonicanalysis.com)

**Phone/Fax:** +44-1798-343517

**Mail:** James Pindell, Director,  
Tectonic Analysis Ltd.  
Chestnut House, Burton Park,  
Duncton, West Sussex,  
GU28 0LH, UK