Crustal Framework and Tectonic Evolution of the Gulf of Mexico Basin: Deep Image Seismic Reflection Data, A New Reflection-refraction Profile, and Aeromagnetic Data

James Pindell[1] and Brian Horn[2]

[1]Rice University
[2]ION Geophysical

ABSTRACT

Deep penetration seismic data, reprocessed pre-stack depth migrated seismic data from Mexican water, and a regional reflection-refraction profile (East Texas to the abyssal plain) are integrated and used to evaluate basement structure and type around the Gulf of Mexico in relation to models for passive margin formation. We interpret 3 stages of tectonic development: 1) Triassic-Callovian NW-SE rifting; 2) Callovian-Early Oxfordian amagmatic “outer marginal collapse” during which accommodation space (3 km) is rapidly created (<3 Ma) for salt deposition on pre-stretched continental margins, accompanied by basinward tilting and slumping of salt on the planar post-rift base-salt unconformity, establishment of abyssal depths where salt is thin/absent, probable exhumation of mantle from beneath thinned continental crust, and formation of the basement step-up as exhumed mantle evolves into the future oceanic crust of the central deep GoM; and 3) Late Ox-fordian-Berriasian CCW rotational seafloor spreading.

The SW Florida-NE Yucatan conjugate and the Tuxpan-Veracruz transcurrent margins have no salt, as they post-date salt deposition. Basement step-ups, or basinward shoulders of outer marginal troughs, define the original limit of mother salt and of the outboard ocean crust. Merged reflection-refraction data constrain the position of the step-up in offshore East Texas, show a planar base salt unconformity and sub-salt rift basins landward, and suggest lithospheric syn-rift extension on the US margin of about 300 km. In SW Florida, lower crust appears to pinch out landward of the upper crust, allowing upper crust to lie directly on mantle that continues to rise to the paleo-seafloor where it was likely exhumed. Also, brittle faults cross this elevated Moho and enter the elevated Moho, denoting crustal-mantle coupling. NW Florida has been considered as a magmatic margin, but is here interpreted as amagmatic because syn-rift magmatism pre-dated our stage-2 outer marginal collapse which is when SDRs are normally formed at magma rich margins.

The western GoM margin is narrow due to its transform nature. Along Yucatan the outer marginal trough (basement step-up) shows no magmatism during outer marginal collapse. We deduce that rapid outer marginal collapse is a distinct stage between rifting and drifting, achieved by low-angle shear of pre-stretched continental crust off rising sub-continental mantle at outer marginal detachments. The rapid creation of accommodation space leading to deep water or thick salt (or a combination) is a post-rift, yet tectonic, process, where outer margins act as hanging walls detaching on outer marginal detachments, belts of exhumed mantle are the footwalls, and the straddling outer marginal troughs can be viewed as crustal scale half grabens. This marginal architecture can be used to predict initial heat flow patterns around the GoM.

The subsequent creation of oceanic crust, our third stage of evolution, is well constrained by an aeromagnetic map of the entire GoM. Seafloor spreading occurred about a southeasterly migrating, or jumping, pole of rotation in the SE GoM, whose kinematics can be satisfactorily modeled in terms of two poles of rotation. Spreading likely ended in the earliest Cretaceous, and the remnant spreading center can be imaged today in new vertical gradient gravity imaging. The gravity-derived image of the dead ridge corresponds closely to the inferred spreading pattern from the aeromagnetic data.