Constraints on Opening of the Gulf of Mexico from Seafloor-Spreading Magnetic Anomalies*

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Search and Discovery Article #30348 (2014)**
Posted August 11, 2014

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Houston, Texas, April 6-9, 2014
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Abstract

Opening of the Gulf of Mexico is poorly constrained due to a lack of recognized seafloor-spreading magnetic anomalies and an absence of drilling to constrain ocean-floor composition and ages. Recently identified lineated magnetic anomaly patterns in the eastern Gulf between Yucatan and Florida provide new evidence of the age and pattern of seafloor spreading. The magnetic anomalies correlate with chron M21n to M10r, indicating creation of ocean floor at a full spreading rate of 17 mm/yr between 148-134 Ma. The oldest anomalies are located against stretched continental crust beneath the western Florida shelf on the east and the Yucatan shelf on the west. The youngest anomalies form a conjugate pair that mark the location of an extinct spreading ridge between Yucatan and Florida. Paleogeographic restoration of the magnetic anomaly pattern indicates a 4-phase model for opening of the Gulf. During phase 1 (Early Permian-Late Triassic), Yucatan and associated tectonic blocks that now comprise eastern Mexico were translated eastward from the Pacific realm into positions near the modern western Gulf. During phase 2 (Late Triassic-ca. 160 Ma) Yucatan and the South Florida block were translated southeastward relative to North America, rotating 6.7° counterclockwise about a pole located at 34°N, 74°W. This resulted in ca. 430 km of southeastward extension on the North American coastal plain, 120 km of southward extension on the northern Yucatan shelf, and displacement of the South Florida Block from a pre-rift position on the northwest Florida shelf to its modern position. During phase 3 (ca. 160-149 Ma), Yucatan rotated counterclockwise 46° relative to North America about a pole located at 27.6°N, 84.0°W. Phase 3 may have coincided with seafloor spreading in the central and western Gulf, but predated seafloor spreading in the eastern Gulf. During phase 4 (148-134 Ma), Yucatan moved southwestward relative to North America, rotating counterclockwise 2.2° about a pole located at 17.6°N, 74.2°W and completing opening of the Gulf.

Selected Reference

http://www.ig.utexas.edu/research/projects/plates/recons.htm
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Challenges

Limited deep seismic refraction
Challenges

Limited deep seismic refraction

No basement drillholes
Challenges

Limited deep seismic refraction

No basement drillholes

No basement dredging
Challenges

Limited deep seismic refraction

No basement drillholes

No basement dredging

No recognized seafloor-spreading magnetic anomalies
Challenges

⇒ No ages!
Challenges

⇒ No ages!
⇒ No composition!
Challenges

⇒ No ages!

⇒ No composition!

⇒ No direct constraint on reconstructing plate motions!
360–250 Ma
Pangea
150 Ma
Volgian (Late Jurassic)
Eastern Ouachitas and Gulf of Mexico

Ordovician

Mississippi (early Ouachita orogeny)

Pennsylvanian (late Ouachita orogeny)

Triassic (rifting)

V.E. 2:1
Tectonic Elements of the GOM

Laurentia

Pz Rift Margin

Pz Transform Margin

Precambrian Rift System
Tectonic Elements of the GOM
Tectonic Elements of the GOM
Constraints on Gulf Opening
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Approximate age of onset of rifting (L. Tr. or E. Jr) – dating of redbed deposits in half-grabens surrounding the E, N, NW gulf.
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Cessation of rifting and onset of spreading assumed to coincide with end of salt deposition (L. Jr.).
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Fit of YUC and U.S. NAM basement hinges
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Loose constraint on amount of extension on U.S. and YUC margins from tectonic subsidence models and crustal thickness variations.

~450 km extension on S. U.S. Coast
~120 km extension on N. Yucatan shelf
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Fit of Pangean continents
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Fit of Pangean continents

And new data ... SFS Anomalies
Paleogeography – Central Gulf Origin for Yucatan?

- Initial Southward rift ing
- Later counterclockwise rotation
Paleogeography – Or Western Gulf Origin for Yucatan?
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Yucatan starts in central Gulf (requires rotation pole change)

Yucatan starts in western Gulf (no rotation pole change)
Reduced to Pole Total Magnetic Field

Magnetic Intensity Anomaly (nT)
Reduced to Pole Total Magnetic Field
Newly Identified Seafloor-Spreading Magnetic Anomalies
Free Air/Bouguer Gravity Field
Chron Identification (P&K Model)

Line 1

Line 4

M20  M16  M11  M11  M16  M20

Line 9

100 nT

100 km
Closing the Eastern Gulf

148-133 Ma

P&K Model

154-170 Ma

K&J Model
Rotation of Yucatan

E. Jr. – 148/154 Ma

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- Heavily intruded extended “continental” crust (e.g., Afar)
- Intruded new sediment/gabbroic crust (e.g., Gulf of California)
- Exhumed mantle (low-angle detachment fault, e.g., Iberia/Newfoundland?)
SUMMARY
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- 3-PHASE OPENING MODEL
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  - PHASE I (L. Tr. – M. Jr.) – Extensional Rifting and stretching of southern U.S. shelf, Florida Shelf, and Yucatan Shelf.
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  - PHASE II (L. Jr.) – Counter-clockwise rotation of Yucatan to modern orientation.
  - PHASE III (148-134 Ma? Or ~170-154 Ma) – Near Orthogonal spreading between Yucatan and Florida