Northern Gulf of Mexico Continental Margin Deformation Proposed to Be by Simple Shear with Regional Basal Horizon Terminating Under Yucatan*

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Abstract

The northern Gulf of Mexico continental margin from Little Rock, Arkansas, to the Sigsbee Escarpment is intermittantly migrating basinward via extensional faulting. Motion-tectonic loci is along the shelfbreak-slope. The Louann Salt underlies the sedimentary wedge. This portion of detachment is denoted as a "salt-floored basin," operating semi-independently of remaining Gulf sediments, salt serving as an ideal 'lubricating" and separating detachment surface.

'Simple shear' is an idealized regional thin-skinned 3-D constant volume deformation mechanism, often characterized by normal faulting in the hanging wall volume. The foot of sliding surface separating hanging wall and footwall volumes may terminate beneath a counter-dipping wedge. Defined here, a single simple-shear mechanism describes evolution of 1,200 km of northern Gulf margin. Maximum sediment thickness is 17-19 km, which at present coincides with the juncture of continental and oceanic crust and southern limits of the Sigsbee Salt.

Presently, basinward of the salt canopy, depth to oceanic crust shallows with thinner sediment loading. The simple shear decollment is apparently interrupted by younger Gulf crust. Closer to Yucatan, with greater sediment loading, the simple shear detachment surface may continue its southward dip, before again disappearing beneath the mobile Yucatan continental fragment and interloping younger Caribbean crust.

Thus, with a single decollment, simple shear can explain Gulf-wide tectonics from Arkansas to Yucatan and probably to Colombia, a restored distance greater than 1,800 km. With active mid-ocean and back-arc seafloor spreading, younger ocean crust today interrupts and complicates the Early Jurassic simple-shear detachment.

Northern Gulf of Mexico Continental Margin Deformation, a case of Simple Shear with a Regional Basal Decollement Horizon Terminating under Yucatan?

Allen Lowrie (*Consultant, Picayune, MS*) & Richard Fillon (*Earth Studies Group, New Orleans, LA*)

The northern Gulf of Mexico continental margin, from extensional faulting illustrated at Little Rock, Arkansas, to circa the Sigsbee Escarpment, a lateral distance of some 1200 km, has been described as intermittently migrating basinward. The loci of motion and tectonics are concentrated along the shelf break and slope. The sedimentary wedge underlain by salt with the basinward expression being the Sigsbee Salt Wedge is denoted as a “salt - floored basin“ with this unit operating semi-independently from the remaining Gulf sediments, salt serving as a ‘lubricating’ and separating surface.

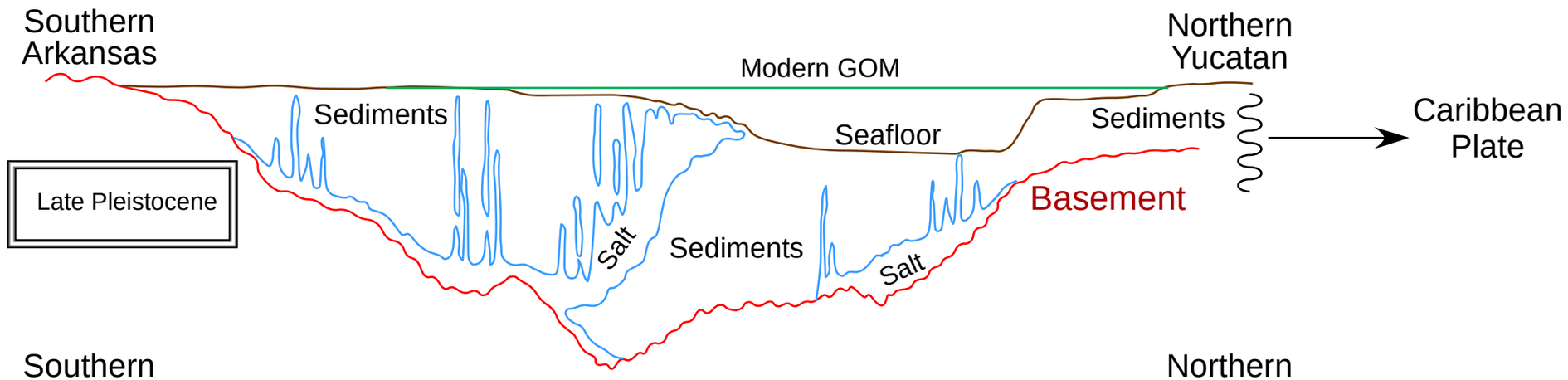
‘Simple shear’ is an idealized regional thin-skinned 3-D constant volume gravity-driven deformation mechanism often by normal faulting. The foot of sliding surface may terminate beneath a counter-dipping wedge. Defined here, a single simple shear mechanism describes the evolution of 1200 km northern Gulf margin. Maximum sediment thickness is 17-19 km which at present coincides with juncture of continental and oceanic crust and southern position of Sigsbee Salt.

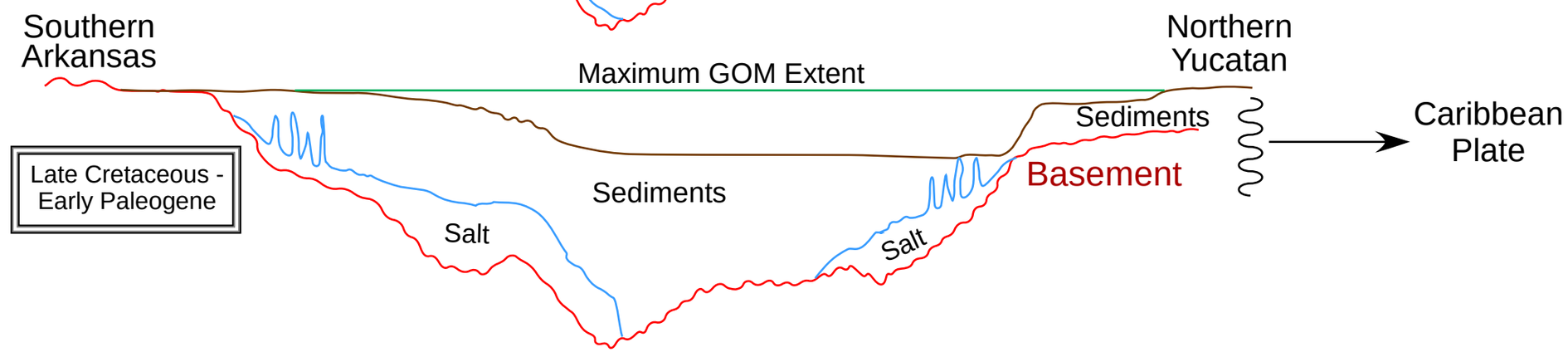
At present farther southward, depth to oceanic crust with thinner sediment cover shallows. This shallowing of crust can mark down-dip limit of simple shear.

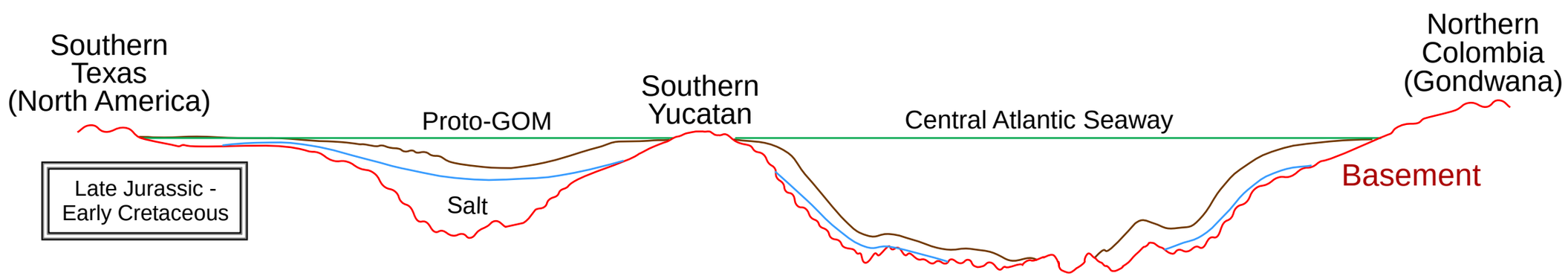
Closer to Yucatan with greater sediment cover, the same decollement surface continues and is suggested to end beneath the reef-buildups that are that peninsula.

Thus, during the Tertiary, with one offset of overall decollement, simple shear can explain Gulf-wide tectonics from Arkansas to Yucatan. a distance of some 1800 km. With active seafloor spreading, the mid-ocean ridge interrupted the simple-shear-horizon. As the ridge ceased and subsided, the simple-shear-horizon could extend from central Arkansas to Yucatan.

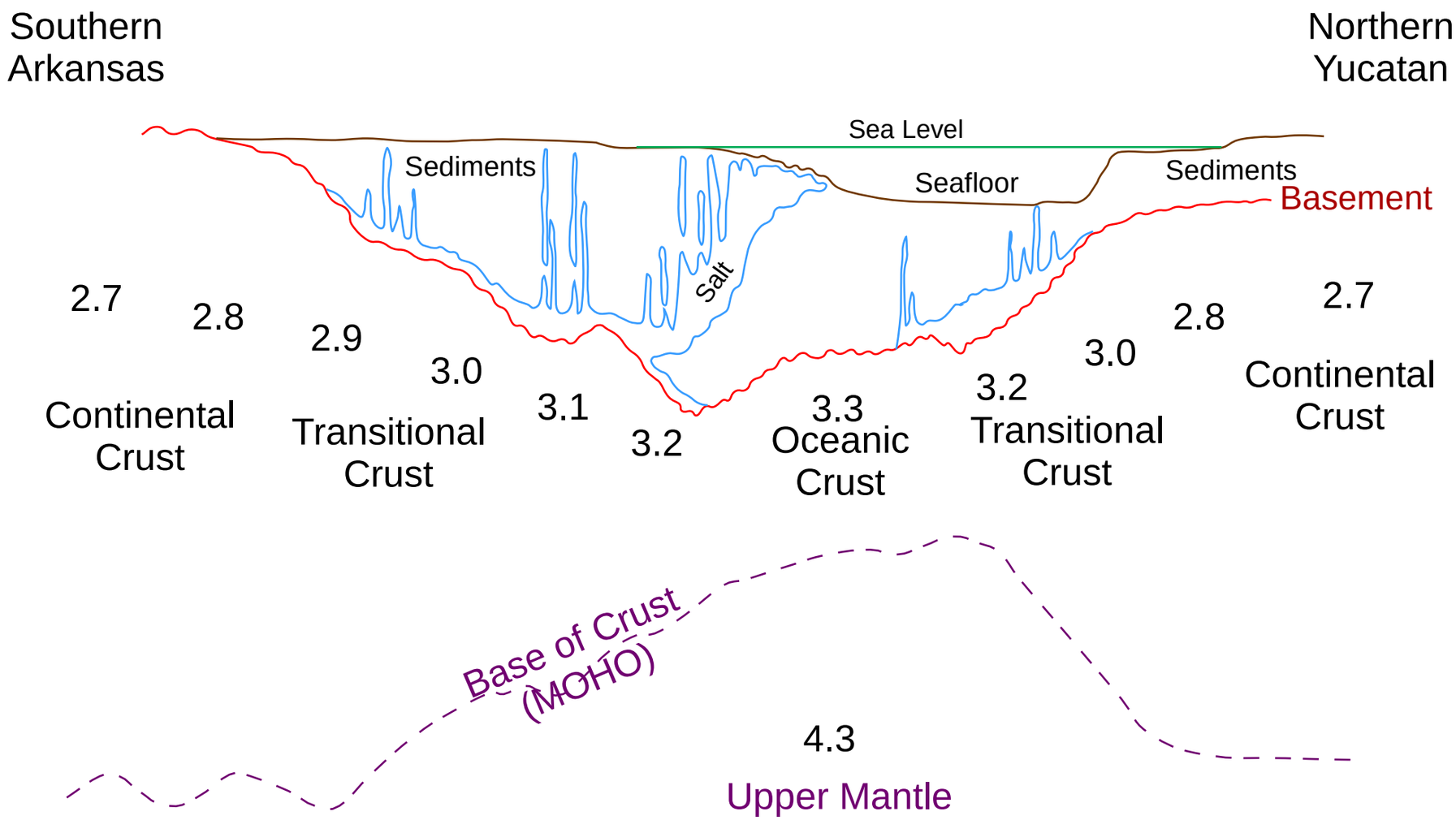
Geologic Features of the Western Gulf of Mexico and Adjacent Region During Key Periods in its Evolution



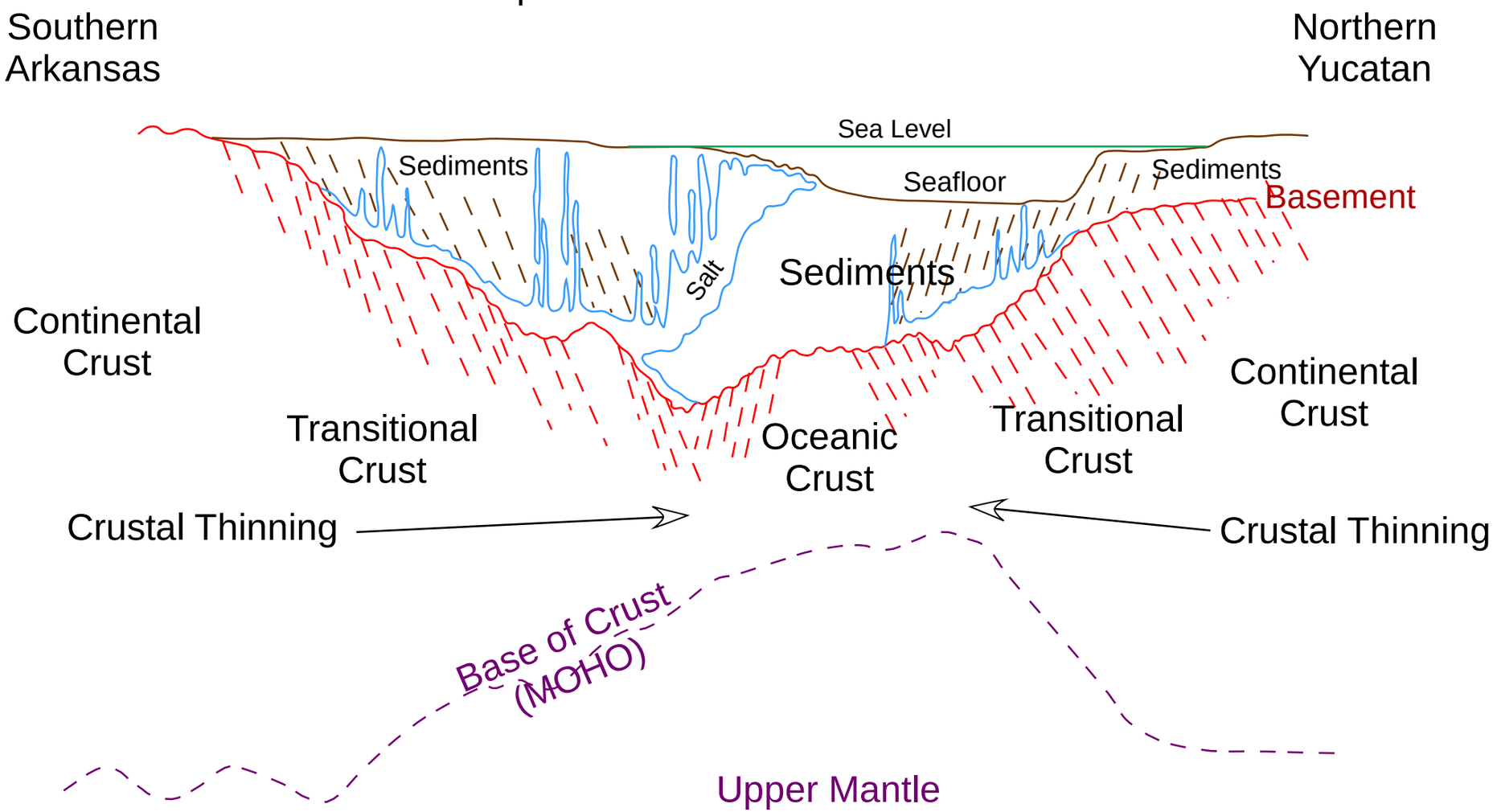




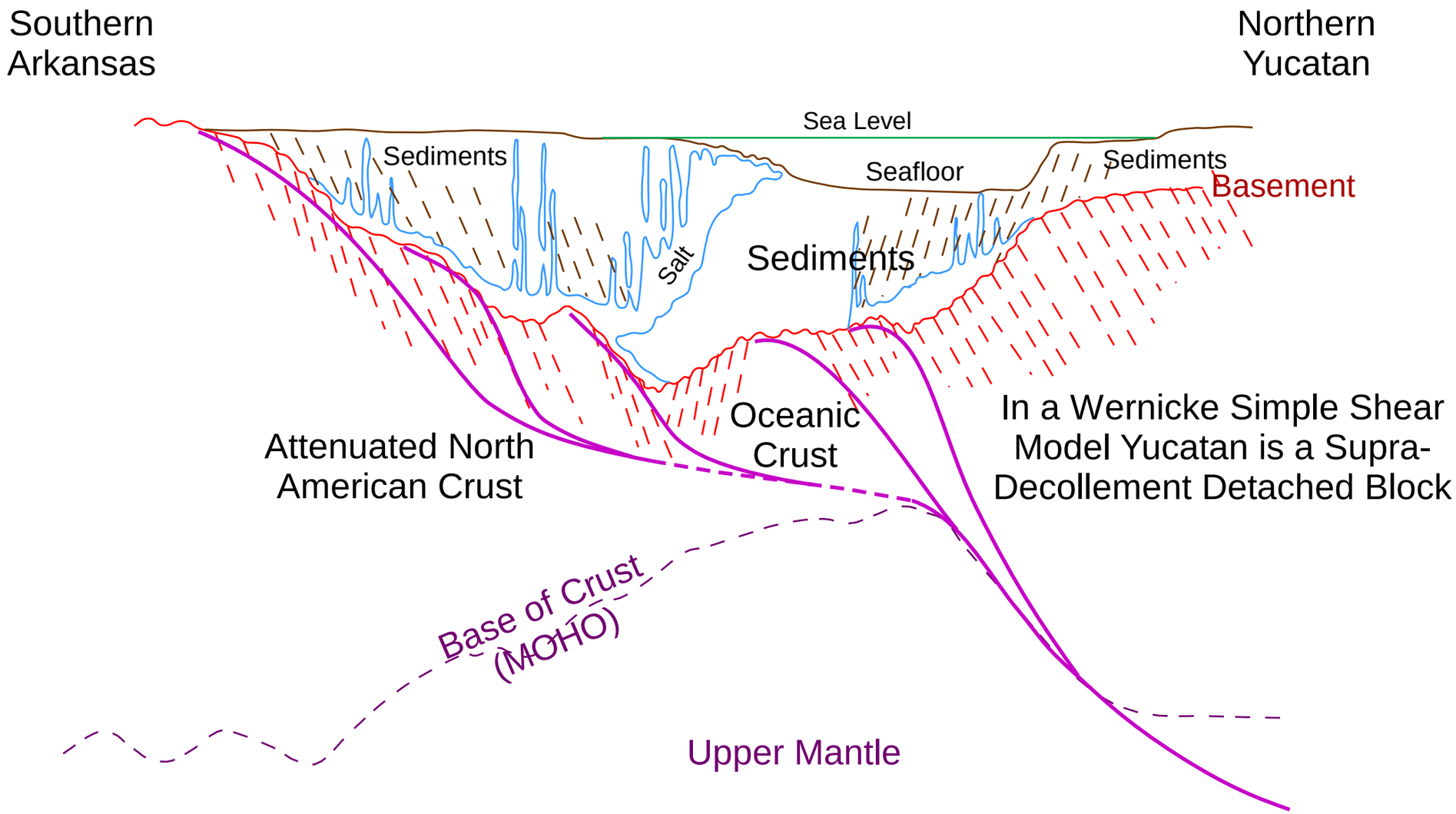
Density of the Crust and Upper Mantle beneath the Western Gulf of Mexico



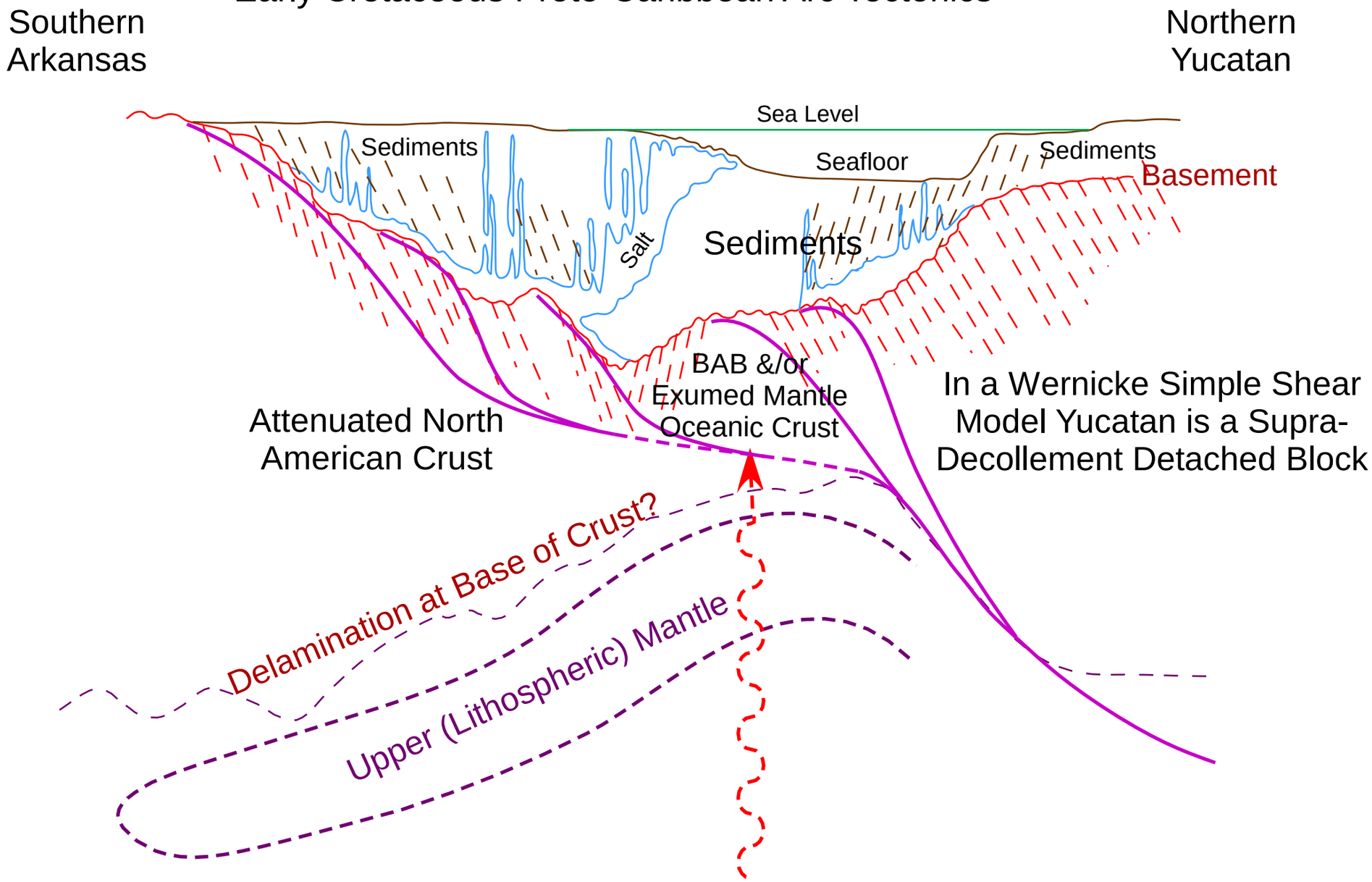
Interpretation of Crustal (Basement) Structure beneath the Western Gulf of Mexico consistent with a Wernicke Simple Shear Basin Formation Model



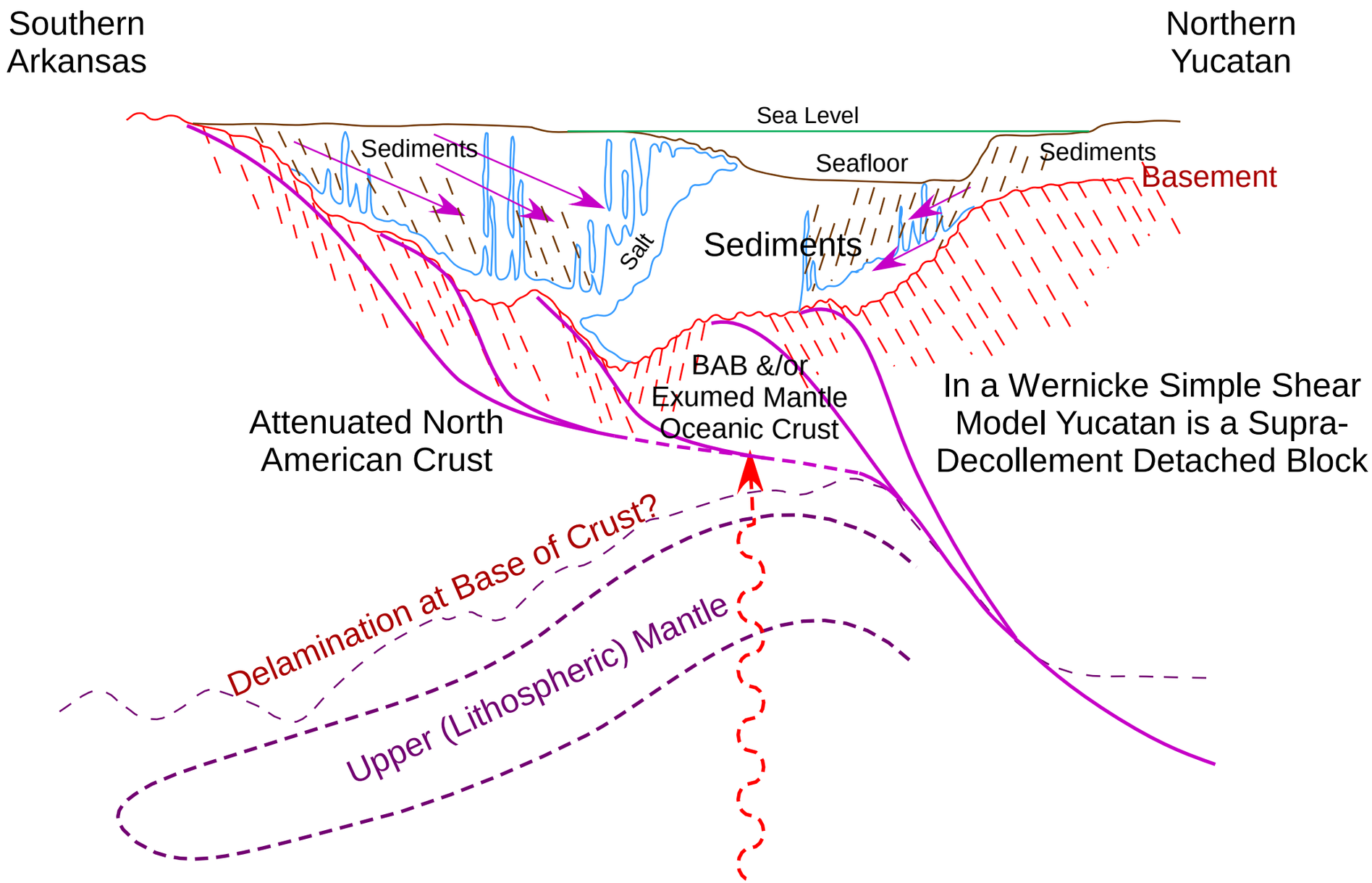
Interpretation of Mantle Structure beneath the Western Gulf of Mexico consistent with a Wernicke Simple Shear Basin Formation Model

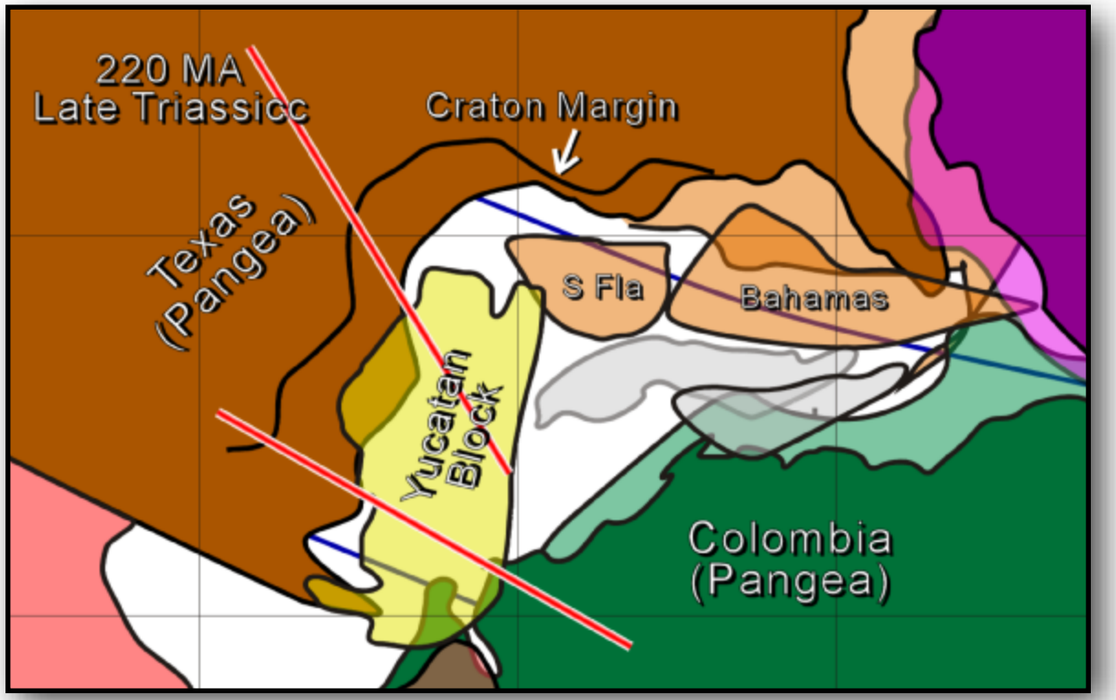


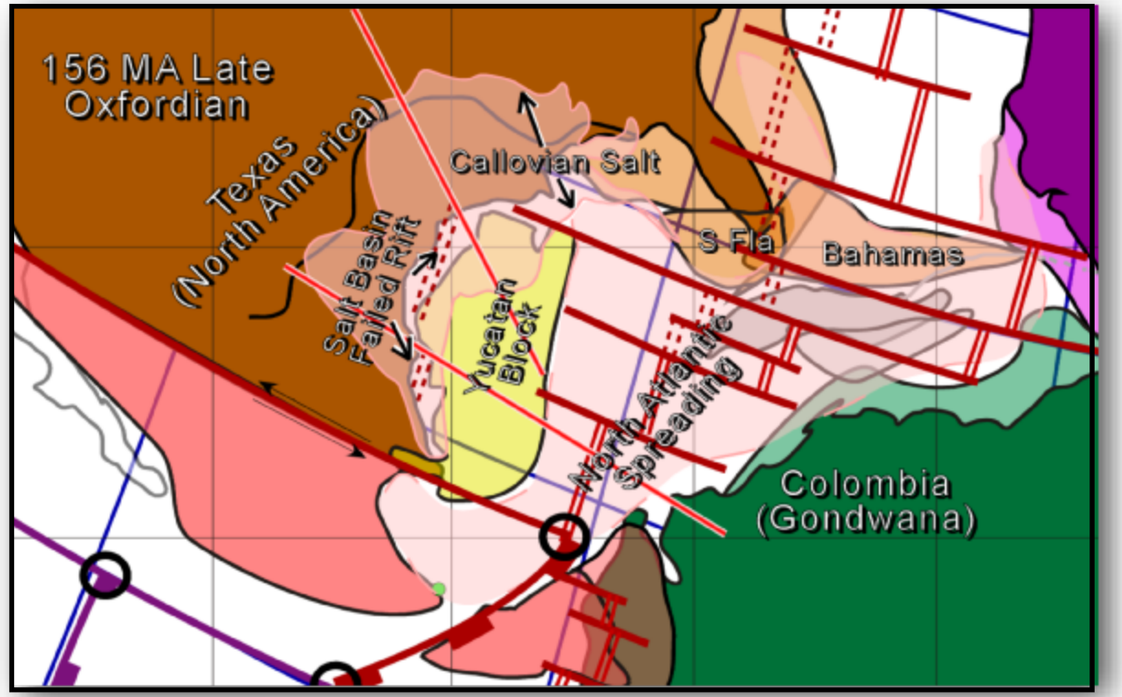
Wernicke Simple Shear Gulf Basin Complex of Middle Jurassic Age Modified by Late Jurassic - Early Cretaceous Proto-Caribbean Arc Tectonics

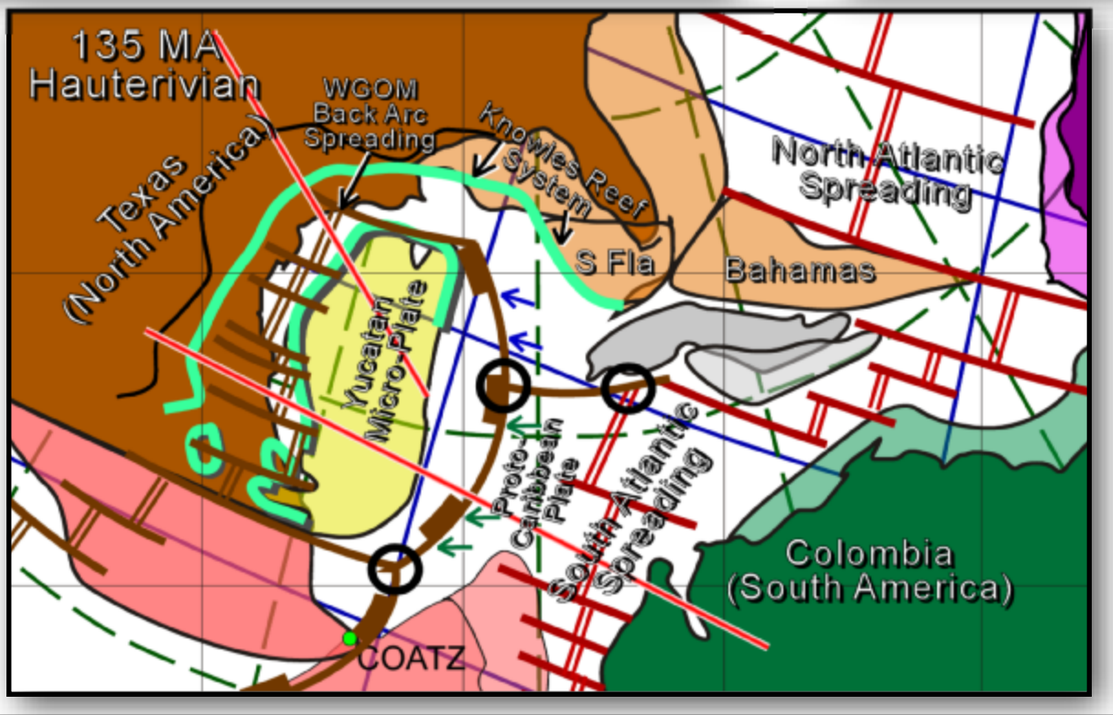


Residual Stress Directions within the Basin Fill Sedimentary Section



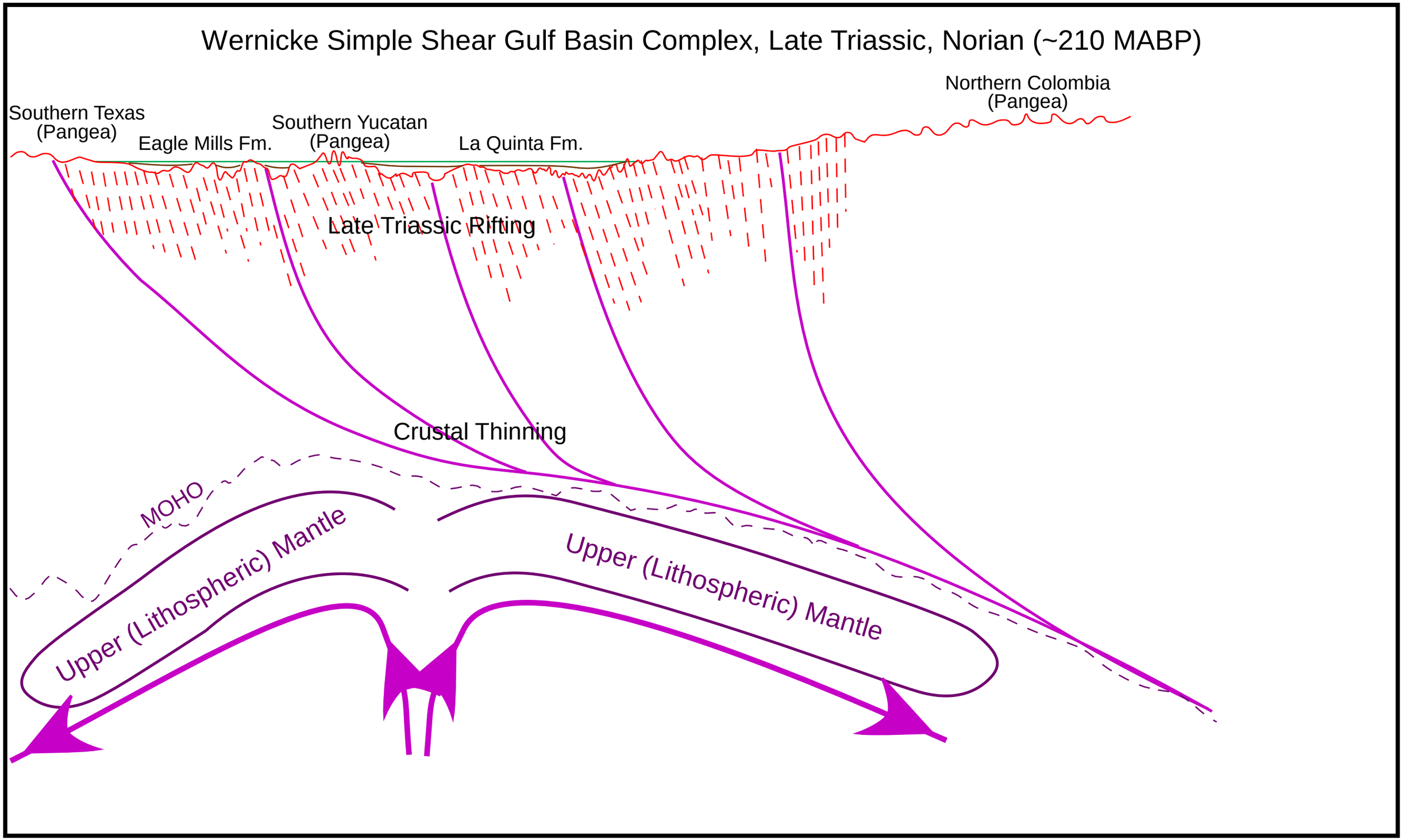


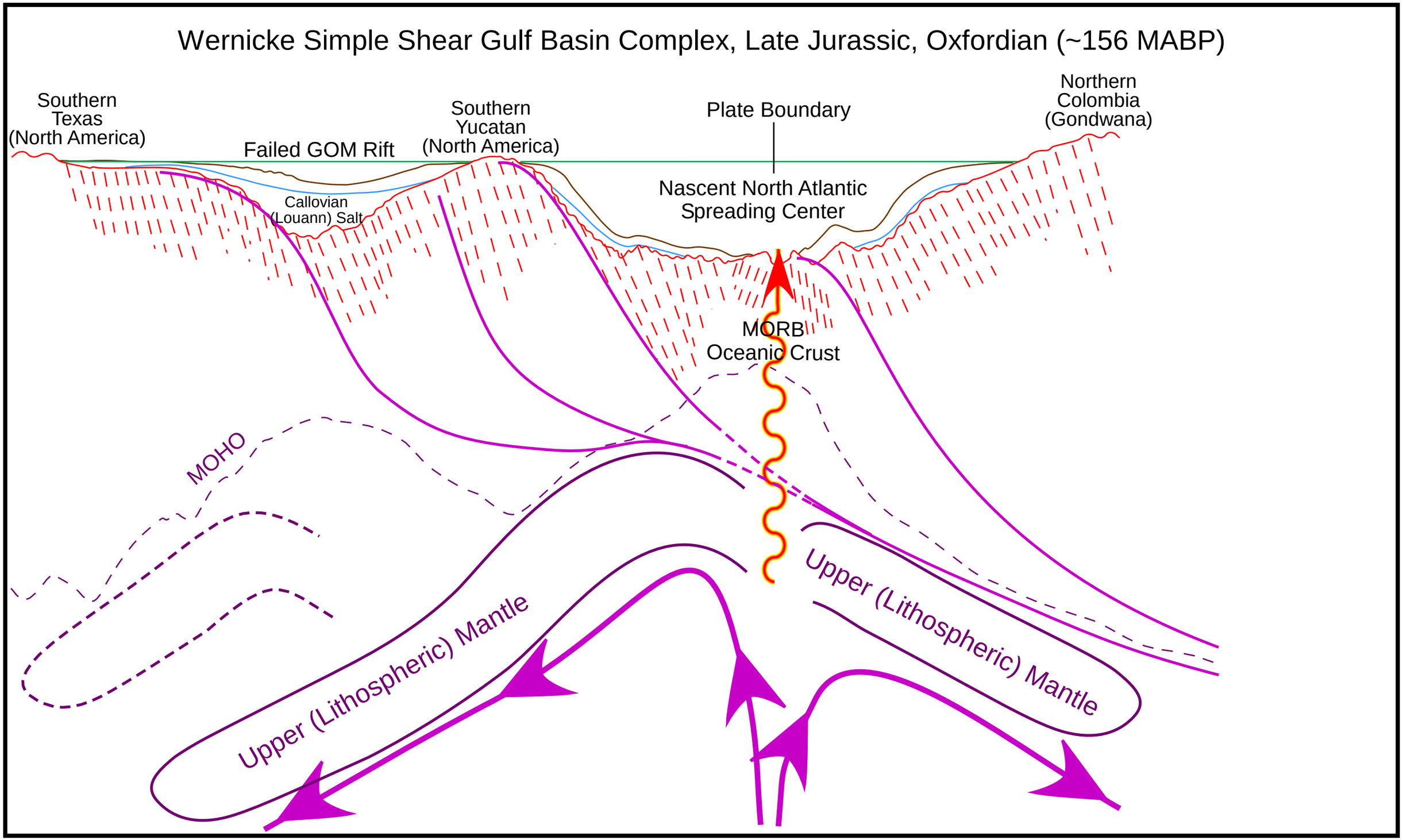


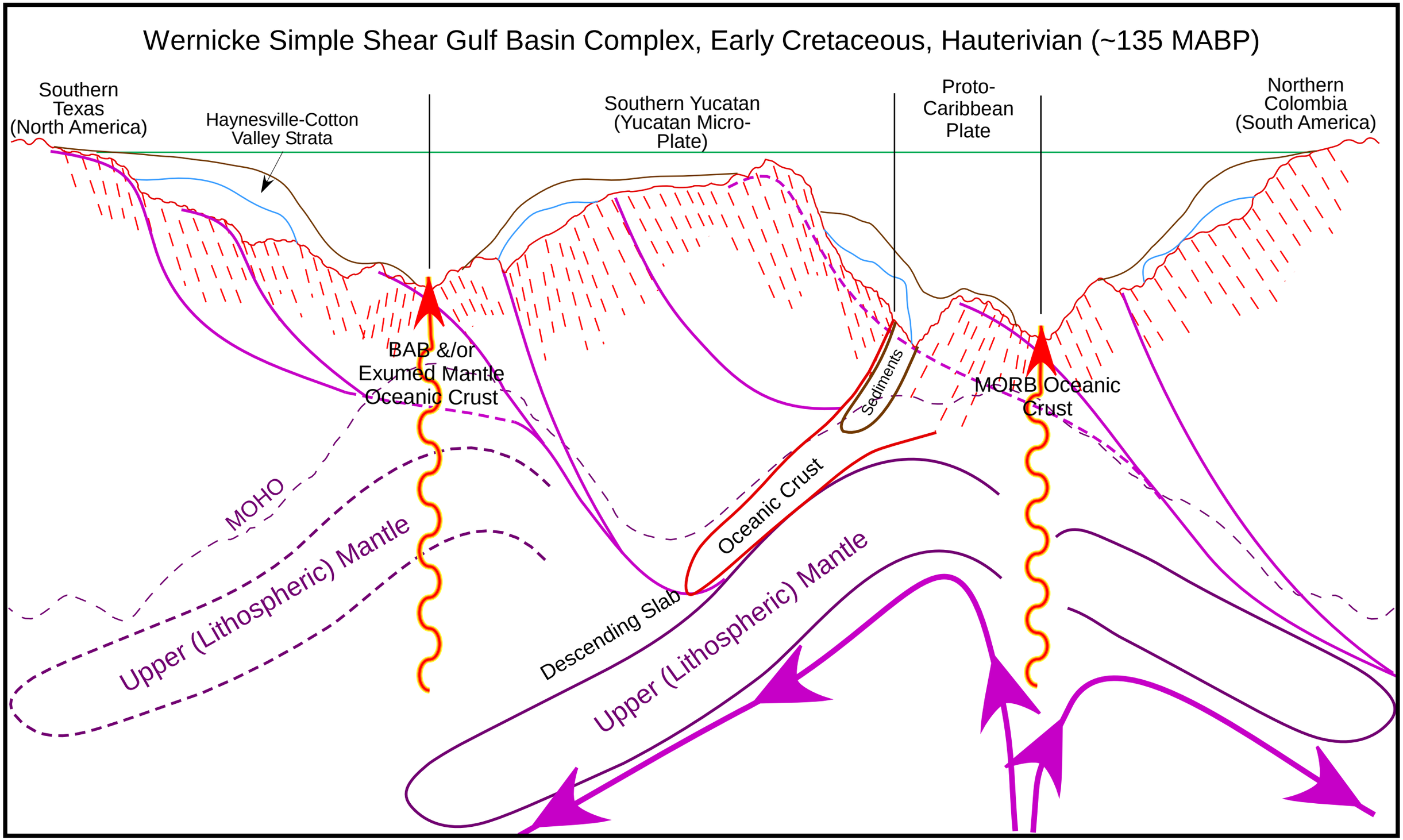


Northern and Southern Yucatan cross-section locations are shown here for three critical time periods in the development of the Gulf of Mexico Basin.

Plate kinematic maps are from Fillon (*Petroleum Geoscience*, 2007). Timing of back arc basin spreading in the western Gulf of Mexico is dictated by the initiation of South Atlantic spreading and formation of a distinct Proto-Caribbean Plate. Arc rocks created along the eastern margin of Yucatan during this period were transported northeastward (left-lateral shear) and amalgamated onto western Cuba during Eocene opening of the Yucatan Basin.

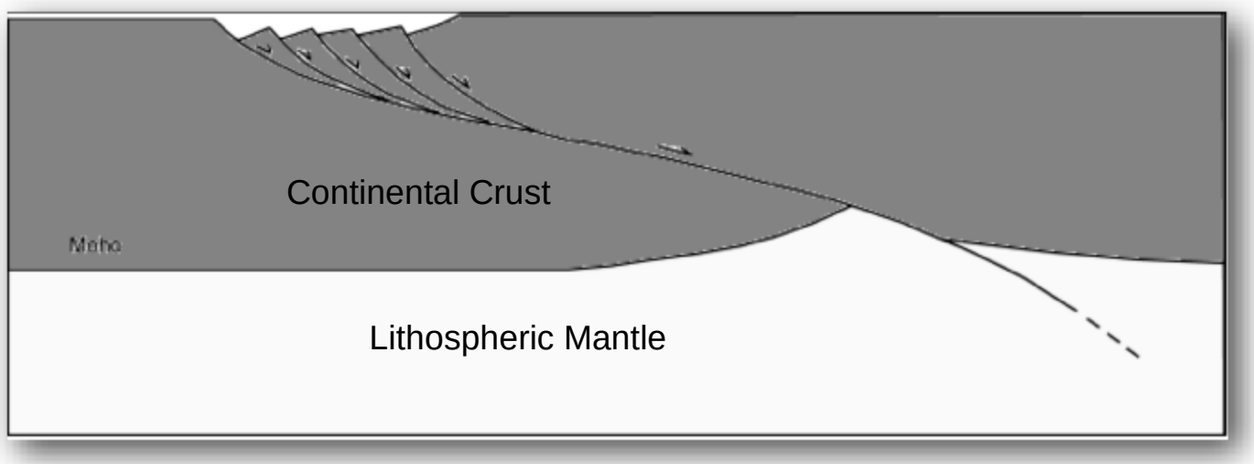

Wernicke Simple Shear Gulf Basin Complex, Late Triassic, Norian (~210 MABP)
Northern Colombia
(Pangea)
Southern Texas
(Pangea)
Eagle Mills Fm.
Southern Yucatan
(Pangea)
La Quinta Fm.
Late Triassic Rifting
Crustal Thinning
MOHO
Upper (Lithospheric) Mantle
Upper (Lithospheric) Mantle


Wernicke Simple Shear Gulf Basin Complex, Late Jurassic, Oxfordian (~156 MABP)
Southern Texas (North America)
Failed GOM Rift
Southern Yucatan (North America)
Plate Boundary
Northern Colombia (Gondwana)
Callovian (Louann) Salt
Nascent North Atlantic Spreading Center
MORB Oceanic Crust
MOHO
Upper (Lithospheric) Mantle
Upper (Lithospheric) Mantle


Wernicke Simple Shear Gulf Basin Complex, Early Cretaceous, Hauterivian (~135 MABP)
Southern Texas (North America)
Haynesville-Cotton Valley Strata
Southern Yucatan (Yucatan Micro-Plate)
Proto-Caribbean Plate
Northern Colombia (South America)
BAB &/or Exumed Mantle Oceanic Crust
Sediments
MORB Oceanic Crust
MOHO
Upper (Lithospheric) Mantle
Oceanic Crust
Descending Slab
Upper (Lithospheric) Mantle

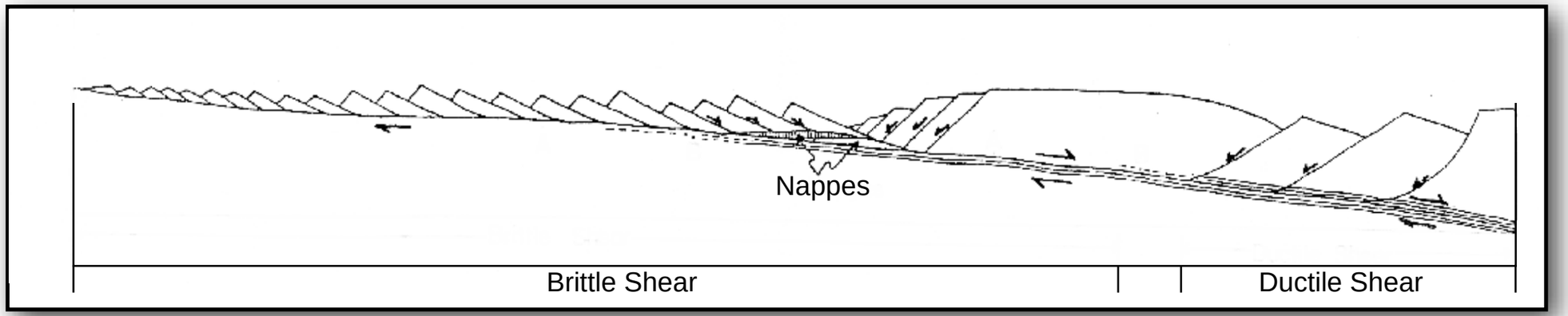
The Simplest ‘Simple Shear’ of Wernicke (1985)*

In Wernicke’s (1985) Simple Shear discussion, low-angle detachment faults that accommodate crustal extension and lead to crustal thinning can also offset the lithospheric mantle. This brings the asthenosphere closer to the surface with implications for heat flow, hydrothermal venting, serpentinization and the incorporation of mantle rocks into the fabric of oceanic crust. Notably, Simple Shear produces asymmetric continental margin structures in paired conjugate margin settings.

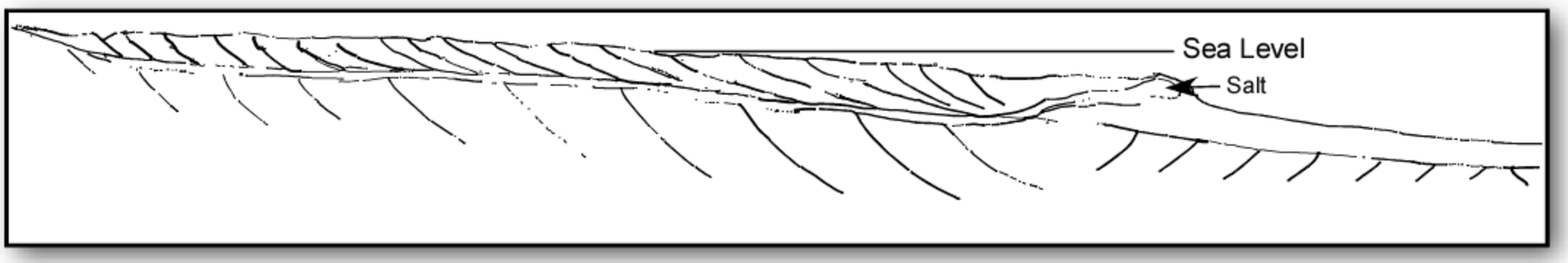


*Can. J. of Earth Sci., 1985.

More Complicated ‘Simple Shear’ Models

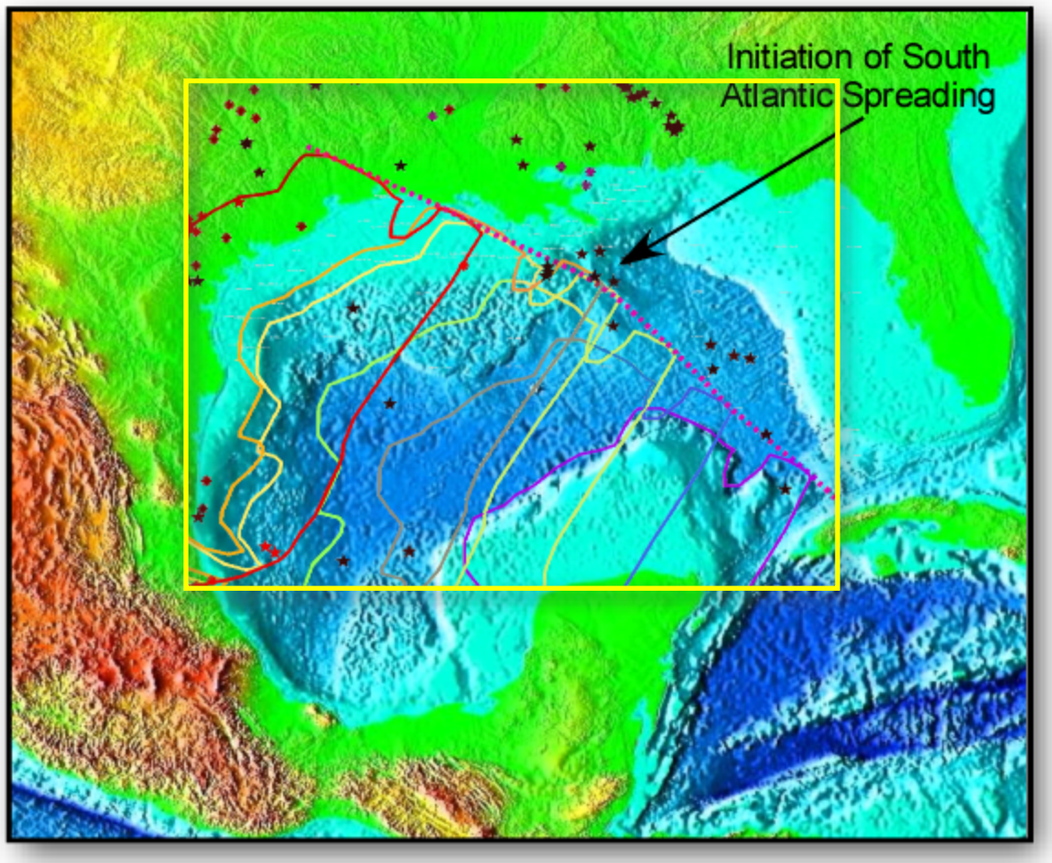


Simple Shear with a counter-dipping wedge block (from Werincke, 1981).
The diagram portrays an idealized description of thin-skinned sediment deformation with 3-D constant volume.

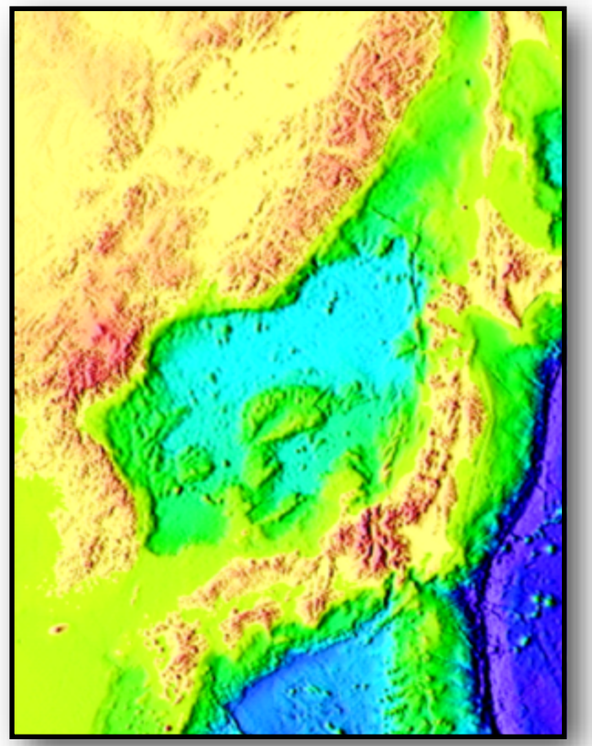


Simple Shear modified by to fit the 0 - 19 km supra-salt sedimentary section of the Gulf of Mexico

Comparison of the Gulf of Mexico with the Sea of Japan



The Gulf of Mexico was very likely an active Back Arc Basin throughout the Early Cretaceous (Fillon, 2007). The map overlay depicts computed positions of the Yucatan Block / Micro-Plate, from 200 MaBP (red) to 94 MaBP (violet). The locations of recent (1973-2010) GOM earthquakes (stars) align along the transform boundary separating the Western and Eastern GOM Basins suggesting persistent instability.



The Sea of Japan, has been an actively opening Back Arc Basin throughout the Neogene. Movement is related to subduction of Pacific Crust beneath the Japanese Island Arc System.