Sedimentary Record of the Early-Middle Jurassic Inception of the Gulf of Mexico in Tlaxiaco Basin*

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Abstract

The Tlaxiaco Lower-Middle Jurassic sequence cropping out in Oaxaca is one of the most complete pre-Callovian sequences in Mexico, and it is a key sequence for the understanding of the early rift phases that later led to the opening of the present-day Gulf of Mexico. Specifically, the tectono-stratigraphic history of the Early-Middle Jurassic sedimentary sequences exposed in the Tlaxiaco basin can be explained with the rifting theoretical model of Fichter and Diecchio (2015). According to this model, continental rifts characterized by hotspots start with an uplift phase and crustal thinning due to the hotspot-related, crustal thermal perturbation. This is typically followed by deposition of continental sediments in alluvial and possibly lake environments withing evolving horst-and-graben systems. According to this model, the first rifting episode led to the erosion of Caledonian-Appalachian terranes from the E-SE of Tlaxiaco Basin and the erosion and uplifting of Greenvillian rocks from the central part of the present-day Gulf of Mexico, with formation of horst-and-graben basins, among them the Tlaxiaco Basin, which were filled with alluvial -to- transitional siliciclastics. In the Tlaxiaco Basin, early rift deposits are represented by the alluvial conglomerates of the Early Jurassic Consuelo Group, unconformably overlain by the Triassic "Diquiyu Unit" and Caledonian- Appalachian bedrock and grading upward to the fluvial Cuarcitica Cualac Formation. A regional transgression resulted in the deposition of the transitional Zorrillo and Taberna formations. These two formations and the overlying Simon and Otatera formations complete the pre-Callovian transgressive cycle in Tlaxiaco Basin. The purpose of this contribution is to provide an improved understanding of the provenance and depositional settings of the Cuarcitica Cualac, Zorrillo and Taberna

formations, to refine the tectono-stratigraphic history of the early rift phases in the Tlaxiaco Basin. Petrographic analysis of sandstone provenance supports an initial provenance from a Caledonian-Appalachian recycled orogen for the lower-intermediate portion of the Cuarcitica Cualac Formation. A different provenance is herein suggested for the upper part of Cuarcitica Cualac Fm., as well as the Zorrillo and Taberna formations, where the great amount of metamorphic quartz and metamorphic rock clasts reflects the dismantling of an ancient interior craton, possibly represented by Greenvillian terranes belonging to the ancient, inner North American craton. Detailed sedimentological work carried out in the Rosario Nuevo ravine (Oaxaca), has led to the attribution of the Cuarcitica Cualac Fm. to a braided fluvial environment, where great amount of sediment provided by the erosion of rift-related bedrock horsts was deposited in a large braid plain. Similar deposits are also present at other locations, such as the "Cerro El Mazo" layers (Gastón-Venegas et al., 2009) in San Luis Potosi, the Huayacocotla Formation (Carrillo Bravo, 1965) in Hidalgo, the "La Boca" Aloformation (Rueda Gaxiola, et al., 2015) in Tamaulipas, and finally, the Jerico Formation (Godínez Urban, et al., 2011) in Chiapas. Consequently, all the above-mentioned stratigraphic units manifest the fluvial sedimentary record of early rift stages. The Middle Jurassic marine transgression led to the establishment of shallow-marine conditions across the former braid plain. In this framework, the transgressive Zorrillo Fm. likely deposited in a coastal embayment punctuated by estuaries. As transgression proceeded, deepening marine conditions established in the Tlaxiaco Basin, with deposition of the inner-shelf, ammonite-rich Taberna Formation. From a regional perspective, the Zorrillo and Taberna deposits document the formation of a narrow seaway in the central part of Mexico, typically referred to as "Hispanic Corridor".

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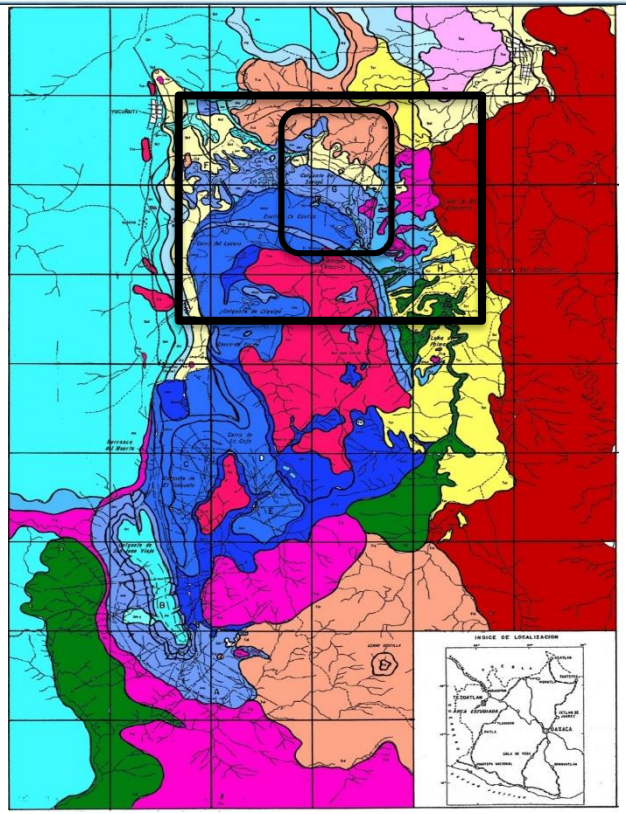
ENI Mexico & Instituto Politecnico Nacional

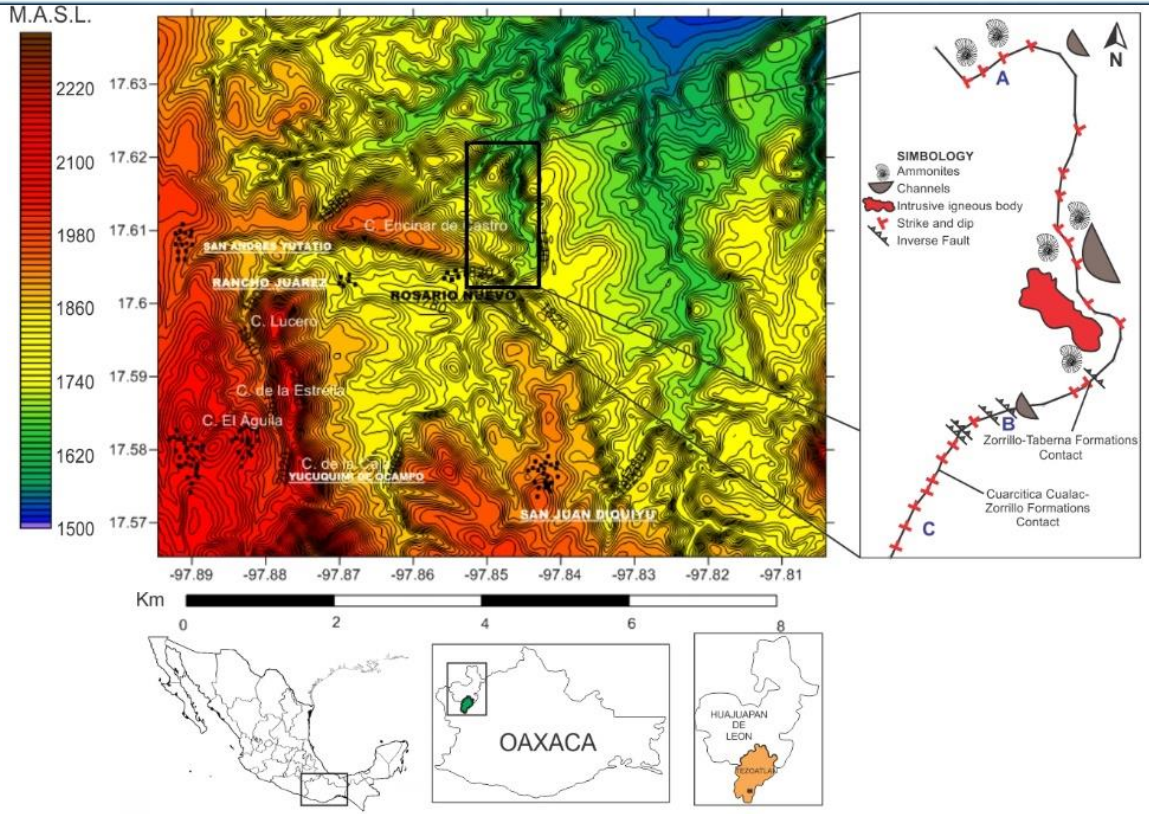
Agenda

- Location
- Stratigraphy
- Facies & Architectural Elements
- Sedimentary environments
- Transition & subsidence in the basin
- Sandstone provenance
- Hot-Spot and its sedimentary record

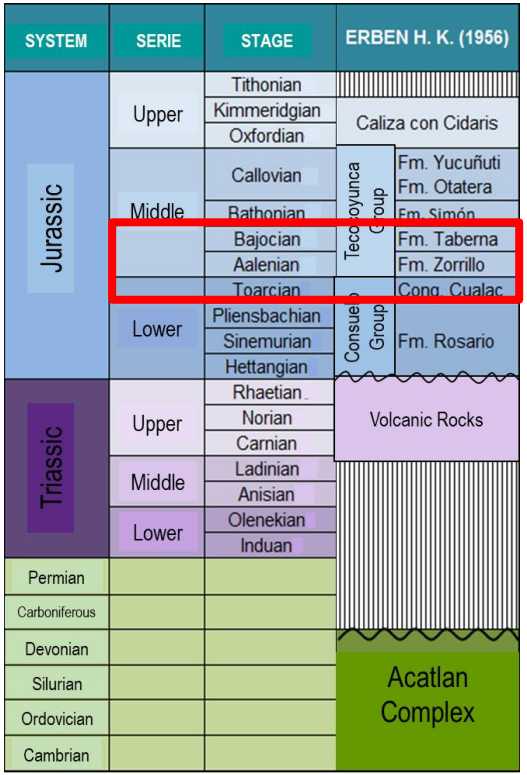
- Central GoM Pre-salt Exploration ???

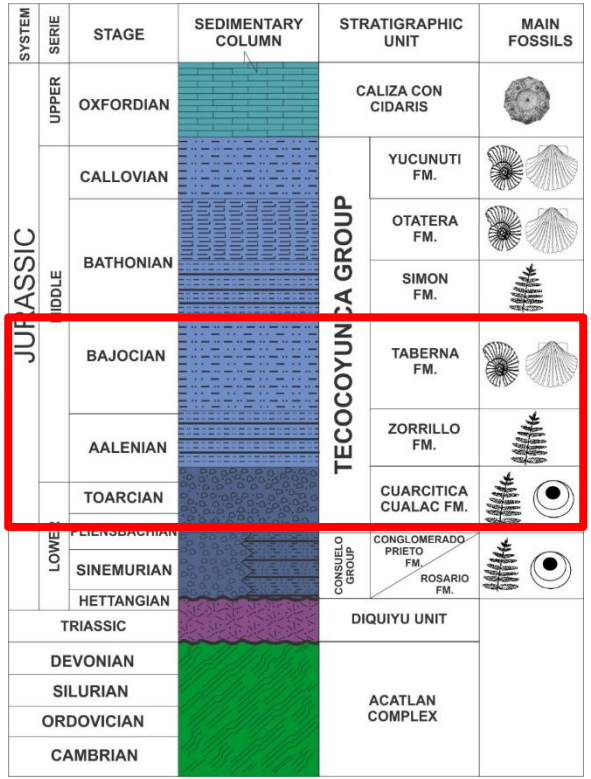


Modified from Ojeda Rivera, 1975



Location





- Source Rock ?
- Reservoir Rock ?
- Source Rock ?
- Reservoir Rock ?
- Reservoir Rock ?
- Source Rock ?

Modified from Jimenez Renteria, 2004

Stratigraphy

A) **Gp.** Breccio-conglomeratic facies with size grains from 0.2 to 5 cm, supported by matrix of sandstone.
Grains → Fragments of quartz, metamorphic rocks (schists and gneiss) and micas.

B) **Fl.** Fine sandstones, siltstones and shales, with a fining upward sequence.
Sandstones are composed, chiefly by quartz and micas.
Some leaves fossils can be appreciated.
Miall interpretation: overbank or waning flood deposits.

C) **Sh.** Total thickness of 5 m in the upper part of this formation (layers from 20 to 40 cm of thickness). Medium to coarse sandstones and they become gravelly sandstones.
It is composed by monocrystalline and polycrystalline quartz grains and metamorphic rock fragments.

FACIES of Cuarcitica Cualac Fm.

A) **Fl.** Fine sandstones with fine lamination and reddish color, however, some outcrops present a grayish color as well.
Miall interpretation: overbank or waning flood deposits.

B) **Sh.** Fine sandstones with good sorting and horizontal stratification with light gray color.
Miall interpretation: planar bed flow.

C) **Fsc**. Chaotic granulometry; grains size vary from silt to clay and fine sandstones. It has a dark gray color whose main sedimentary structure is the horizontal lamination.
Miall interpretation: backswamp deposits.

D) **C**. Carbonaceous facies is represented by two types of lithologies: a) carbonaceous shale with very dark color and abundant fossil flora, chiefly small leaves from higher plants; and b) coal layers.
Miall interpretation: sequence of marshy deposits.

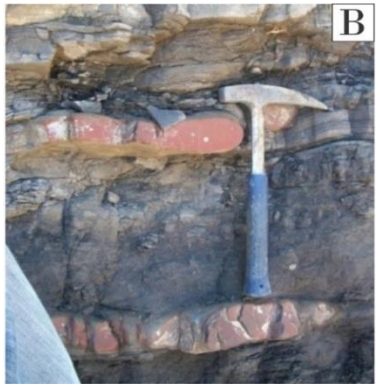
FACIES of Zorrillo Fm.

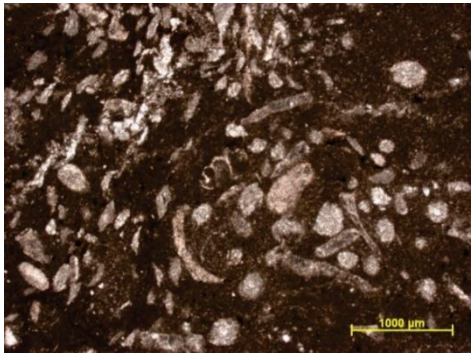
FACIES of Taberna Fm.

A) **Sh.** Fine to medium sandstones. Quartz is the predominant component in this facies and horizontal bedding is the main sedimentary structure. Remains of marine fauna as ammonites and some bivalves were found

B) **Fsc.** Fine materials; it has sediments with size grains from silt to clay. It has a dark color and an alternation with Sh facies. Its main sedimentary structure is a horizontal bedding (thickness 20 cm - 60 cm).
Marine fossils like bivalve remains, some ammonites and ichnofossils of type of planolites were identified as well.

C) **Carbonate facies.** This facies has black color with horizontal beds of 20 cm of thickness with a great amount of marine fossils as mollusks, foraminifera and some pellets were identified.





Channels

Relationship between Geometry of an individual active channel

Geometry of the resulting channel fill complex

Laminated sand sheets

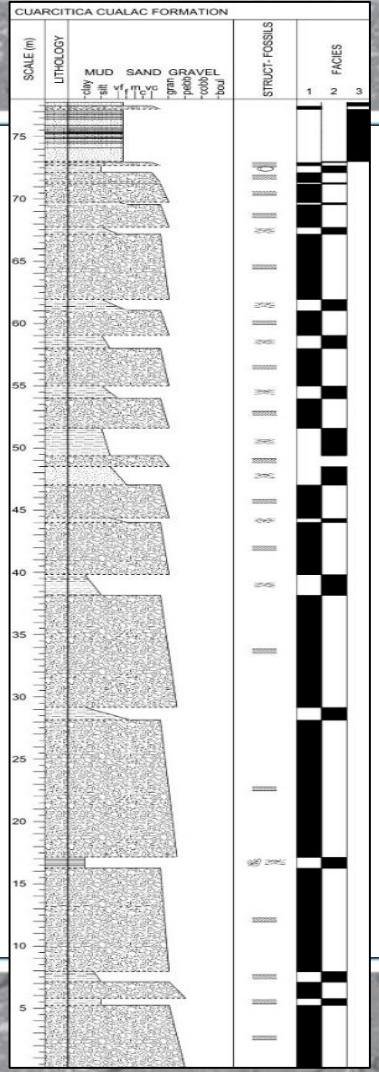
According to Miall, these sheets are formed by rapid flows caused by floods that may represent the environment transition.

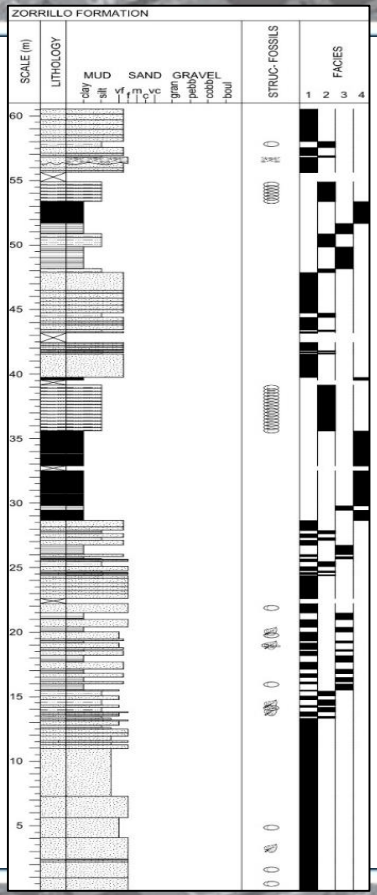
Overbank Fines

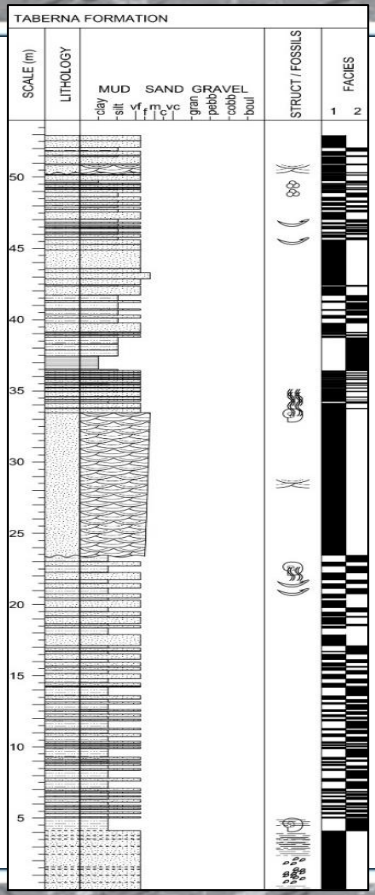
This set of facies form this element and suggests a floodplain as probable environment.

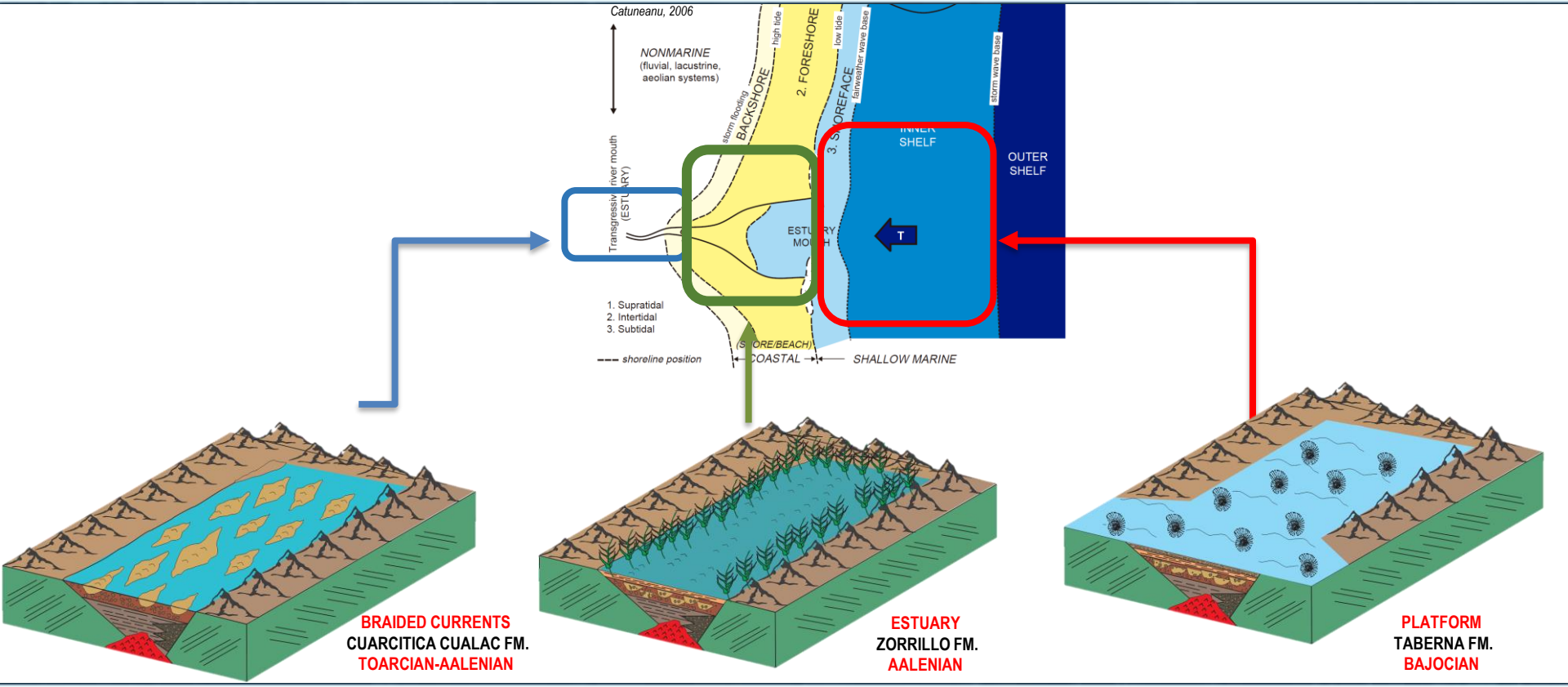
Minor Channels

As these channels are into transitional sequences, they may represent distributary channels.

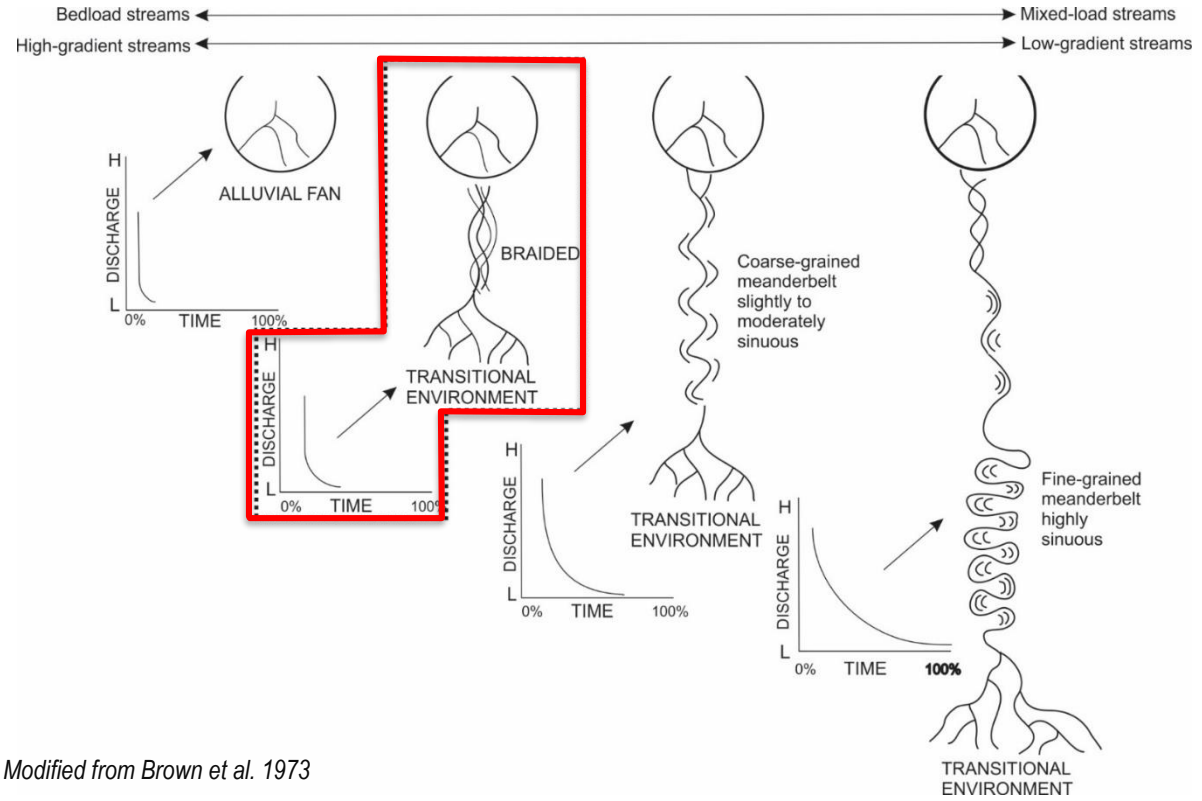

CUARCITICA CUALAC FORMATION
SCALE (m)
LITHOLOGY
MUD SAND GRAVEL
clay silt vf f m c vc gran pebb cobb boul
STRUCT- FOSSILS
FACIES
1 2 3
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5


ZORRILLO FORMATION
SCALE (m)
LITHOLOGY
MUD SAND GRAVEL
clay silt vf f m c vc gran pebb cobb boul
STRUC- FOSSILS
FACIES
1 2 3 4
60
55
50
45
40
35
30
25
20
15
10
5


TABERNA FORMATION
SCALE (m)
LITHOLOGY
MUD SAND GRAVEL
clay silt vf f m c vc gran pebb cobb boul
STRUCT / FOSSILS
FACIES
1 2
50
45
40
35
30
25
20
15
10
5

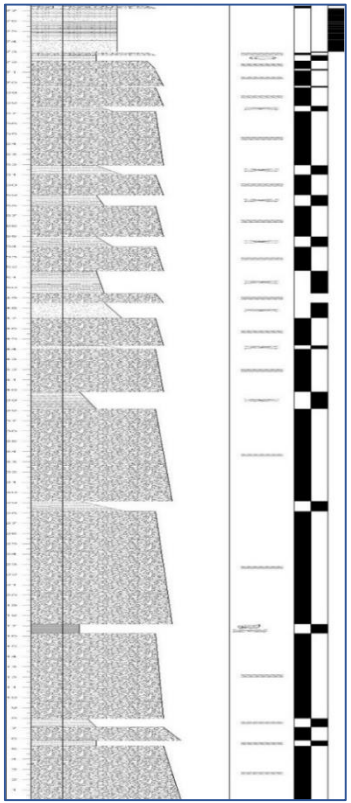


Sedimentary Environments



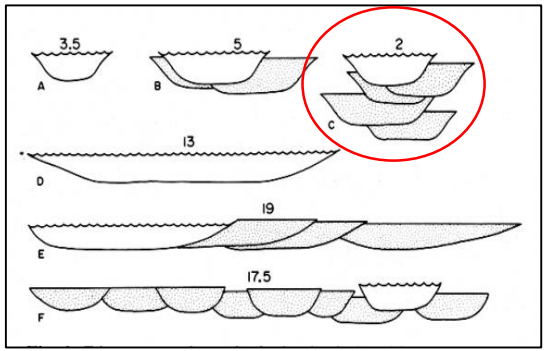
Modified from Brown et al. 1973

Transition between Environments



CUARCÍTICA CUALAC Formation
TOARCIAN-AALENIAN

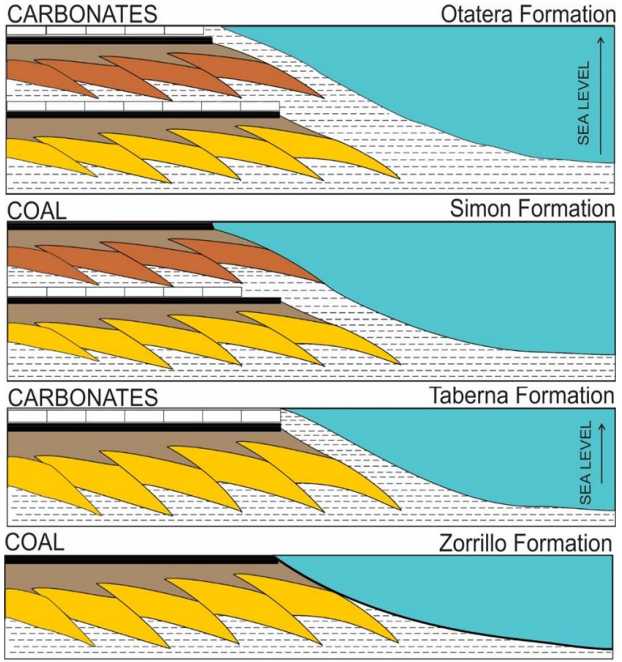
Relationship between
Geometry of an individual active channel -
Geometry of the resulting channel fill complex



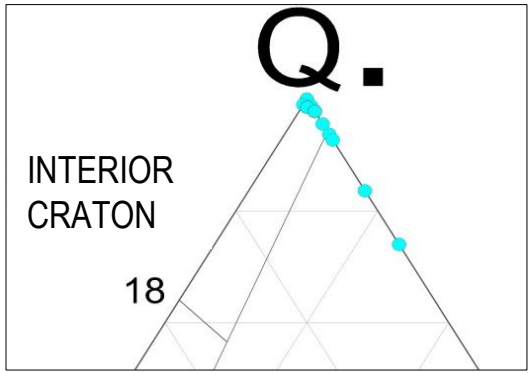
Miall, 1985

Vertical aggradation-Under conditions of
<u>rapid subsidence</u>

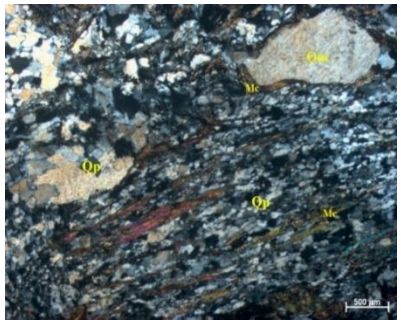
ZORRILLO-TABERNA Formations
AALENIAN- BAJOCIAN
SIMON-OTATERA Formations
BAJOCIAN-BATHONIAN

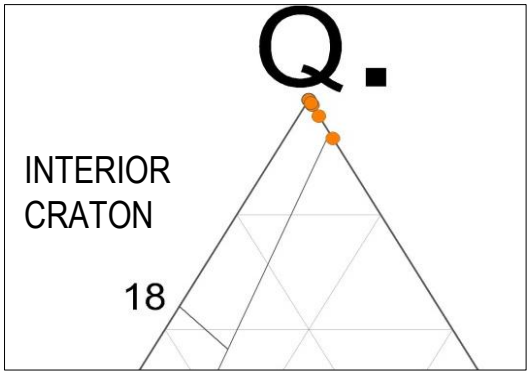


Subsidence during MIDDLE JURASSIC

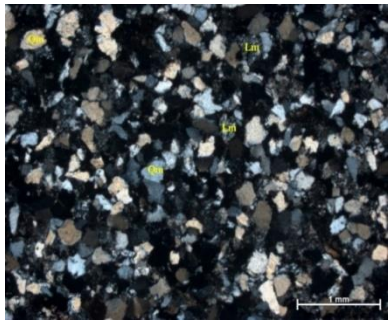


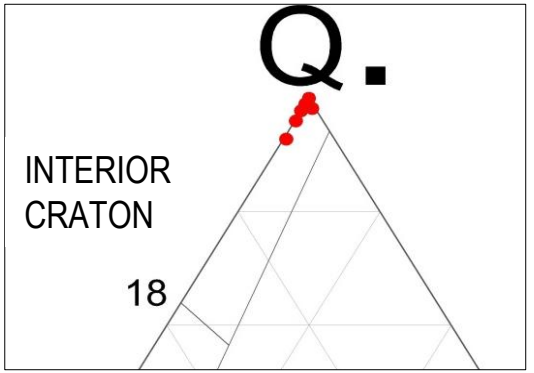
CUARCITICA CUALAC Fm.



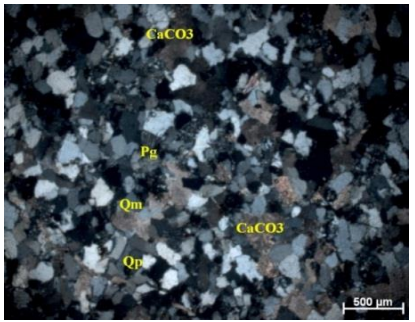


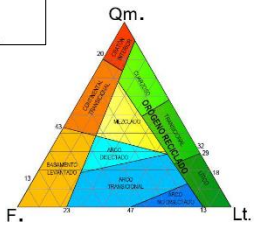
ZORRILLO Fm.





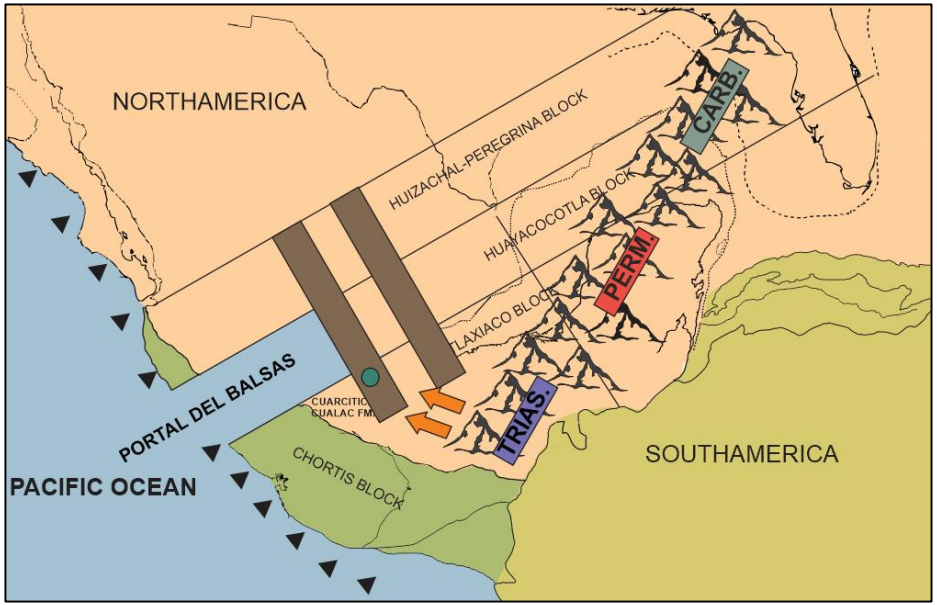
TABERNA Fm.





Tectonic Provenance of Sandstones

SINEMURIAN-PLEINSBACHIAN



Acatlán Complex

(Chazumba, Cosoltepec Fms. & Esperanza, San Miguel Granitoids)
(Ortega Gutiérrez, 1978)

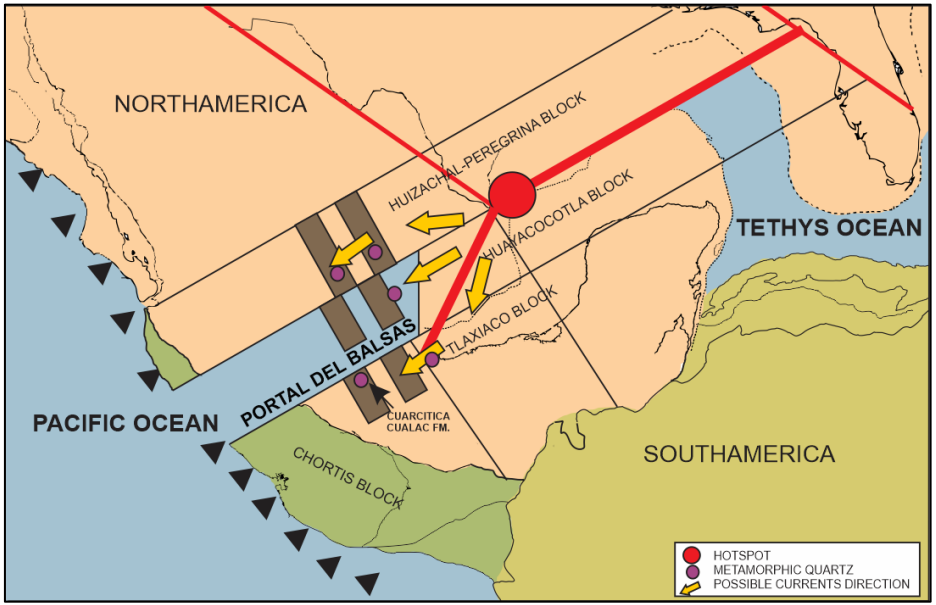
Caledonian-Appalachian Orogen
Paleozoic

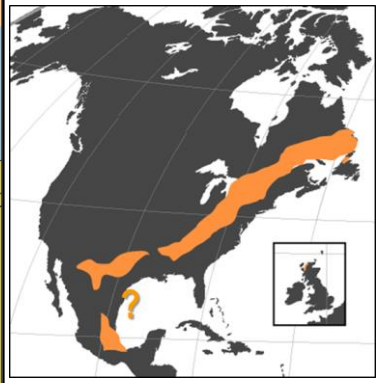
(Ortega Gutierrez, 1981;
Talavera Mendoza et.al., 2005)

Recycled Orogen

Recycled Orogenic Provenance

PLEINSBACHIAN-BAJOCIAN

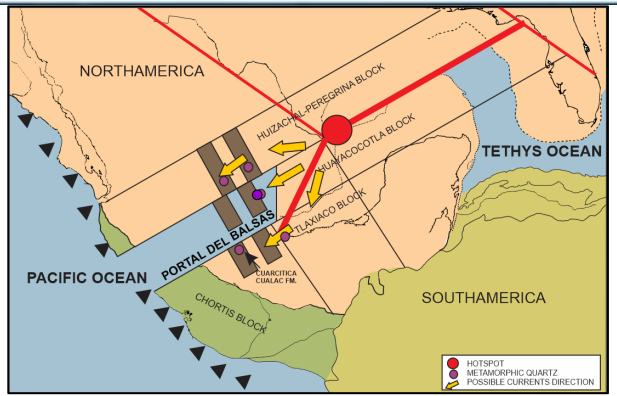




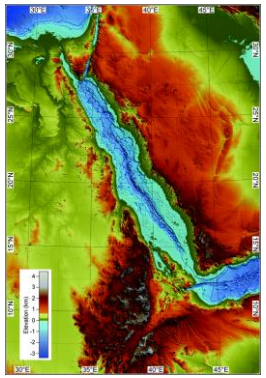
Oaxacan Complex
(Ortega Gutierrez, 1981)

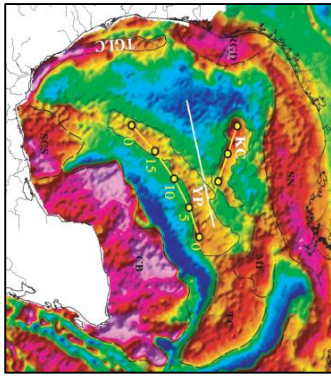
Grenvillian Orogeny
Middle-Late Proterozoic
(Ortega Gutierrez, 1981;
Tollo, R.P., et. al., 2004),

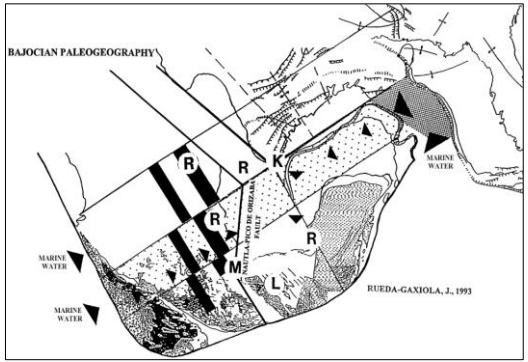
Northamerican Craton



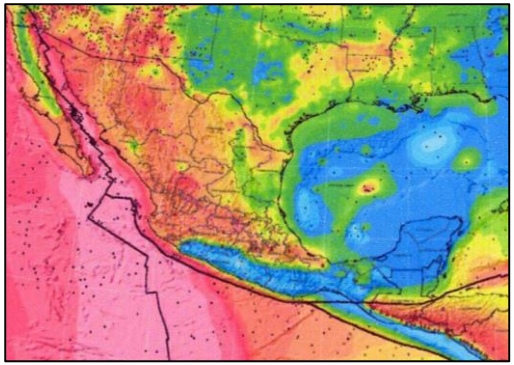
SEDIMENTOLOGICAL ANALYSIS



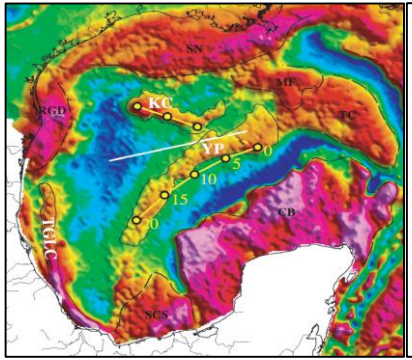


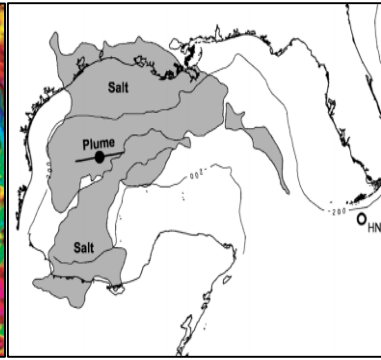


PALYNOLOGICAL STUDIES (Rueda Gaxiola, J., 1993)



GEOTHERMAL ANOMALIES (AAPG, 2004)

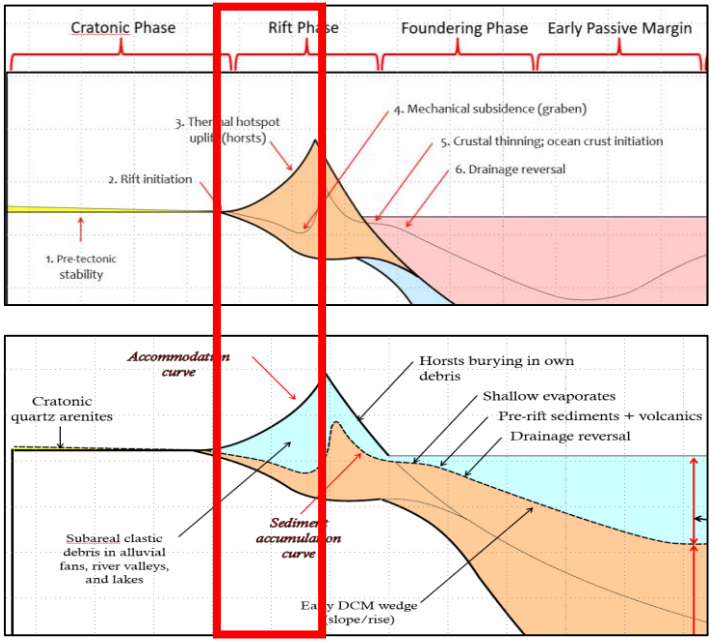




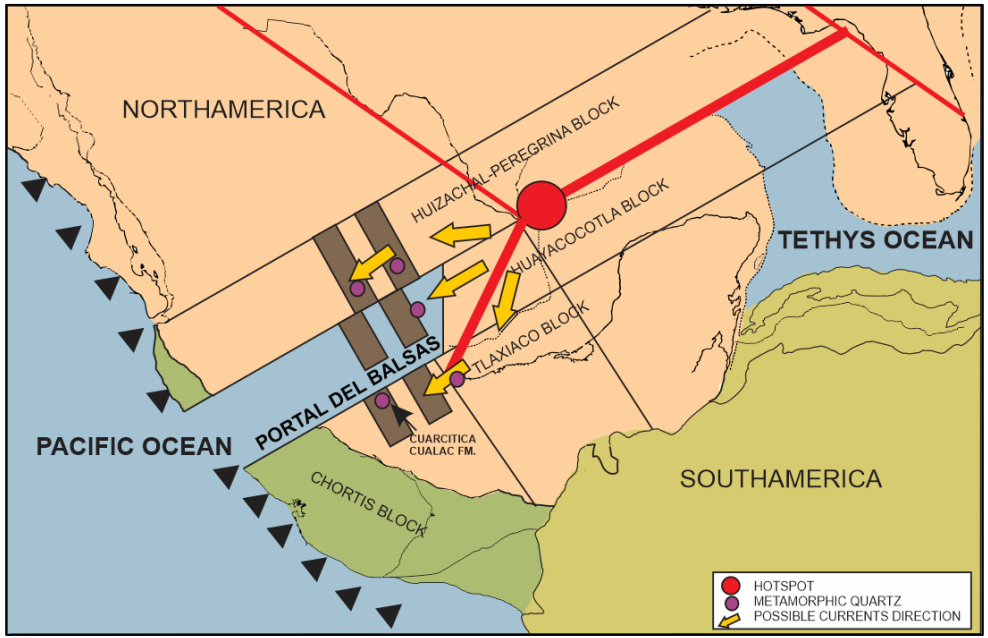
GEOPHYSICAL ANOMALIES (Bird., et al. 2005)

HOT-SPOT Presence

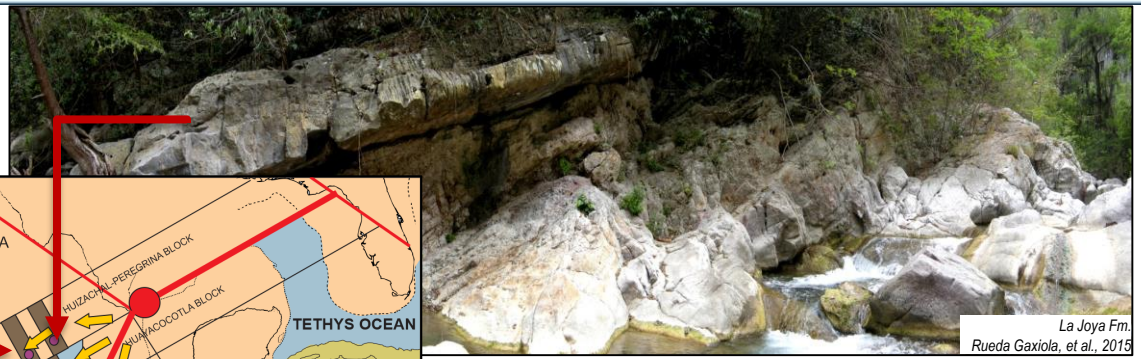
DOMING STAGE
TOARCIAN-AALENIAN



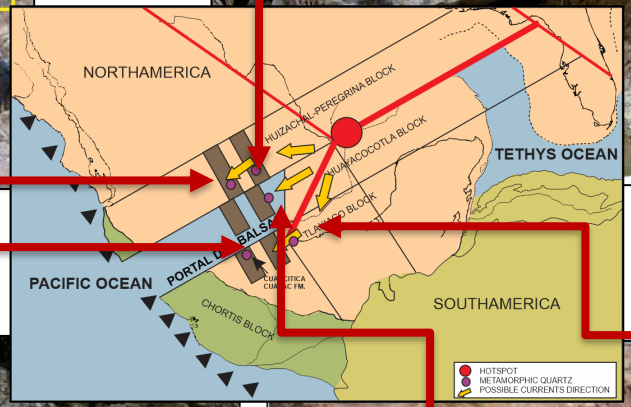
Fichter, L.S., et al., 2015



Sierra del Catorce and El Alamito
Venegas-Rodriguez, et al., 2009



La Joya Fm.
Rueda Gaxiola, et al., 2015

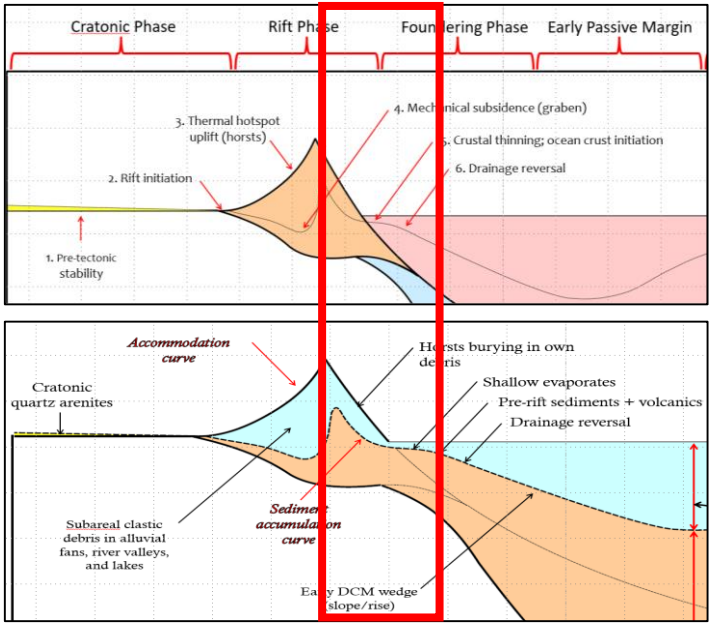


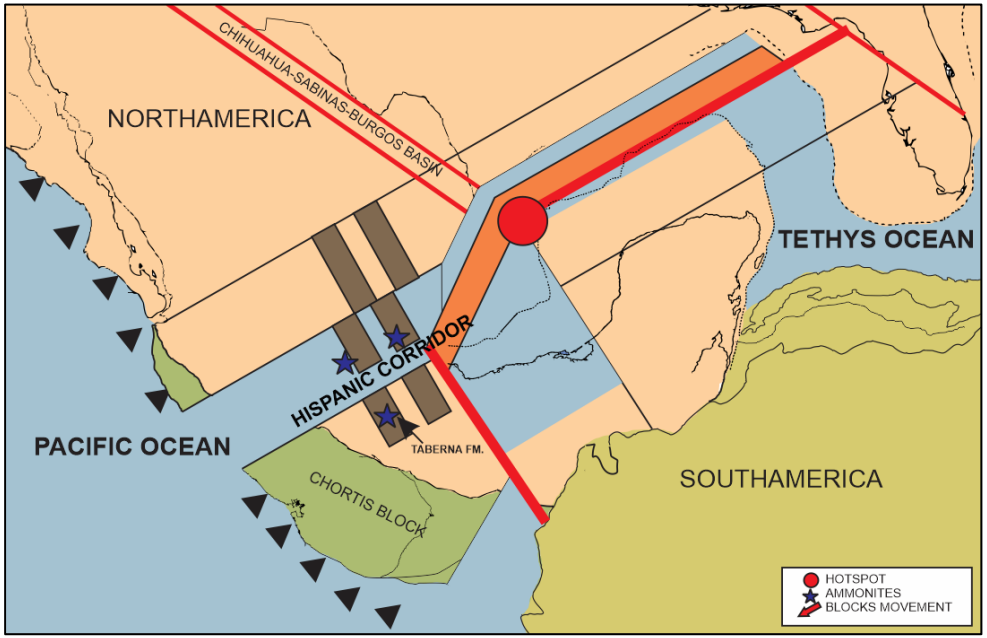
Fm. Cuarcitica Cualac (Oaxaca)
Vite del Angel, 2012

Cahuasas Fm.
Carrillo-Bravo, 1965 (In SGM)

Jerico Member (Todos Santos Fm)
Godinez-Urban, A. et al. (2011)

RIFTING-EARLY DRIFTING STAGE
BAJOCIAN-BATHONIAN





Duashnocerasfloresi

Oppelia Subradiata

Gomez Alvarez, et al., 2012

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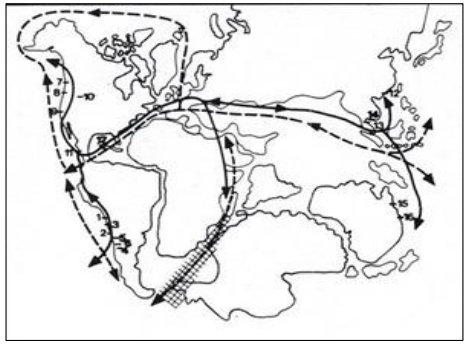

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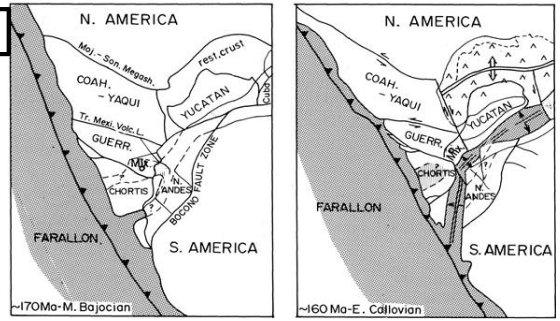

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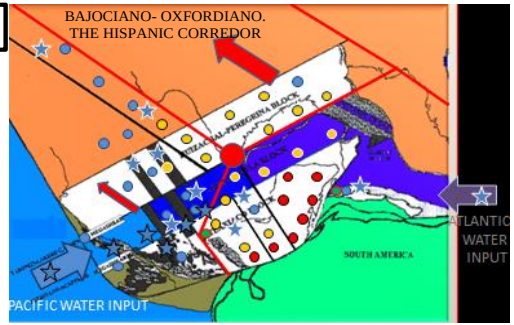
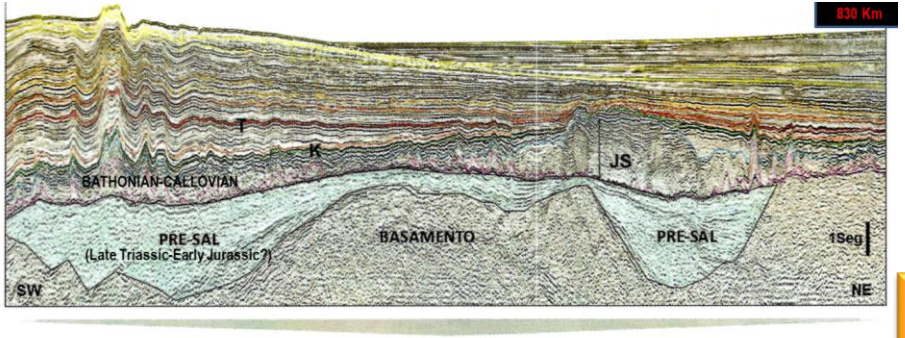
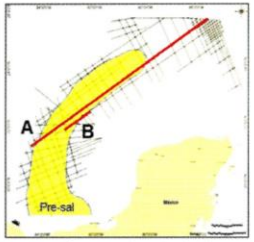


Hispanic Corridor Models

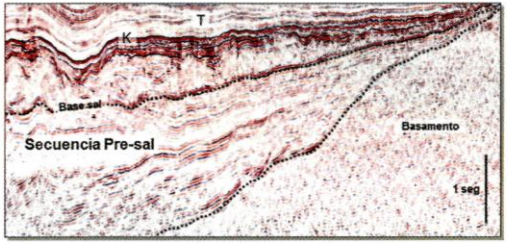
1. Hallam (1983)
2. Boltok et al (1985)
3. Westermann (1992)
4. Rueda Gaxiola, J, (2008)

PRE-SALT Sedimentary Sequence in the Central GOM (Late Triassic-Early Jurassic?)

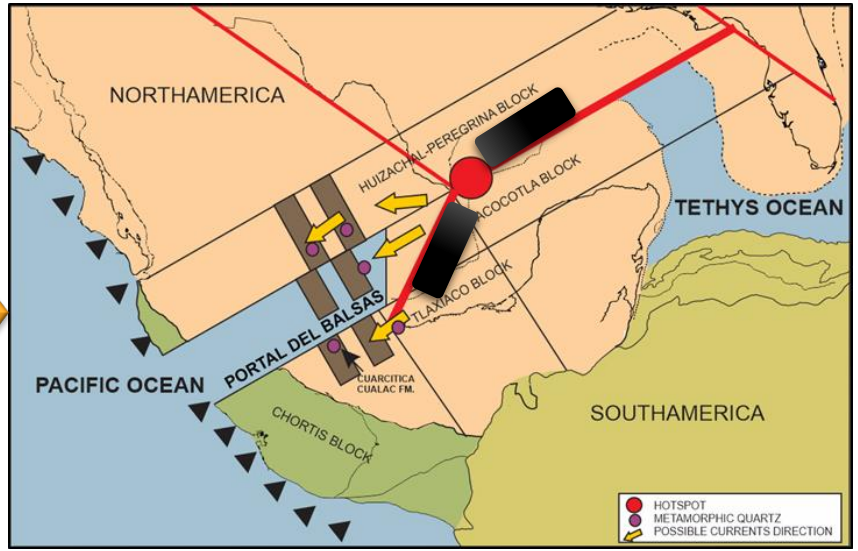




Distribución aproximada del Pre-sal



MIRANDA PERALTA, L. R. *et al.*, 2014, Ingeniería Petrolera LIV(5):254-266.



Thank you