

# APPLIED PALYNOSTRATIGRAPHY AND INORGANIC GEOCHEMISTRY, A TOOL FOR SOLVING THE PROBLEM OF THE GULF OF MEXICO ORIGIN

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## Abstract *in extenso*

Based on their own lithologic characteristics, redbeds and salt have been considered as azoic and problematic rocks. Nevertheless, as we are going to see, Paleopalynology and Inorganic Geochemistry proved to be two very useful sciences in order to place red beds in time and space.

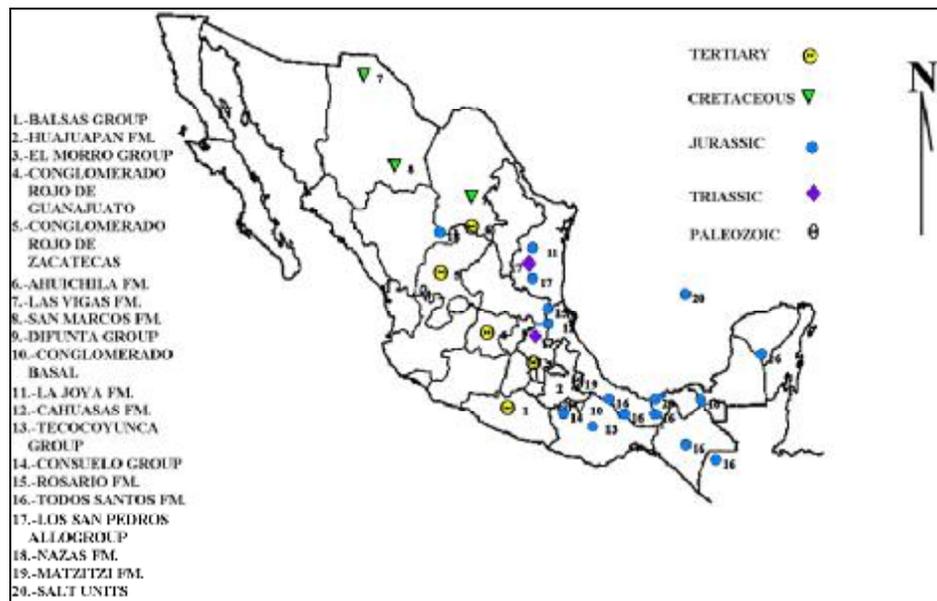


FIGURE 1 Mexican redbeds and salt units localities (Del Valle-Reyes, A., 1997).

Mesozoic Mexican red beds and salt units are mainly localized around the Gulf of México (FIGURE 1).

| ERA/THEM | SYSTEM   | SERIES | STAGE         | BUAYACOCOTLA ANTICLINORIO, TAMPICO-MISANTLA BASIN |                      | HUIZACHAL-PEREGRINA ANTECLINORIO |                     |                   |  |
|----------|----------|--------|---------------|---|----------------------|----------------------------------|---------------------|-------------------|--|
|          |          |        |               | IMLAY ET AL., 1948                                | CARRILLO BRAYO, 1961 | MIXON ET AL., 1993               | IMLAY, 1993         |                   |  |
| MESOZOIC | JURASSIC | UPPER  | OXFORDIAN     | ZULOAGA-NOBUILLO                                  | LA JOYA FORMATION    | ZULOAGA                          | ZULOAGA FM.         | ZULOAGA FM.       |  |
|          |          |        | CALLOVIAN     | HUIZACHAL GROUP                                   |                      |                                  |                     | LA JOYA FORMATION |  |
|          |          | MIDDLE | BATHONIAN     |   | CAHUASAS FORMATION   |                                  | HUIZACHAL GROUP     | LA JOYA FORMATION |  |
|          |          |        | BAJOCIAN      |   |                      |                                  |                     |                   |  |
|          |          |        | AALENIAN      |   |                      |                                  |                     |                   |  |
|          |          |        | TOARCIAN      |   |                      |                                  |                     |                   |  |
|          |          | LOWER  | FLIENSBACHIAN |   | MARIHUATLAN          |                                  |                     |                   |  |
|          |          |        | SINEMURLIAN   |   |                      |                                  |                     |                   |  |
|          |          |        | HETTANGIAN    |   |                      |                                  |                     |                   |  |
|          |          |        |               |   |                      |                                  |                     |                   |  |
|          | TRIASSIC | UPPER  | RHETIAN       |   |                      |                                  |                     |                   |  |
|          |          |        | NORIAN        |   | HUIZACHAL FORMATION  | LA BOCA FORMATION                | HUIZACHAL FORMATION |                   |  |
|          |          |        | CARNIAN       |   |                      |                                  |                     |                   |  |

FIGURE 2. Ancient chronostratigraphical position of redbeds in NE Mexico.

Up to the early last century, in the Mexican NE region, three Mesozoic redbed units were differentiated (Huizachal, La Joya and Cahuasas), chronologically placed from Late Triassic to Late Jurassic (FIGURE 2).

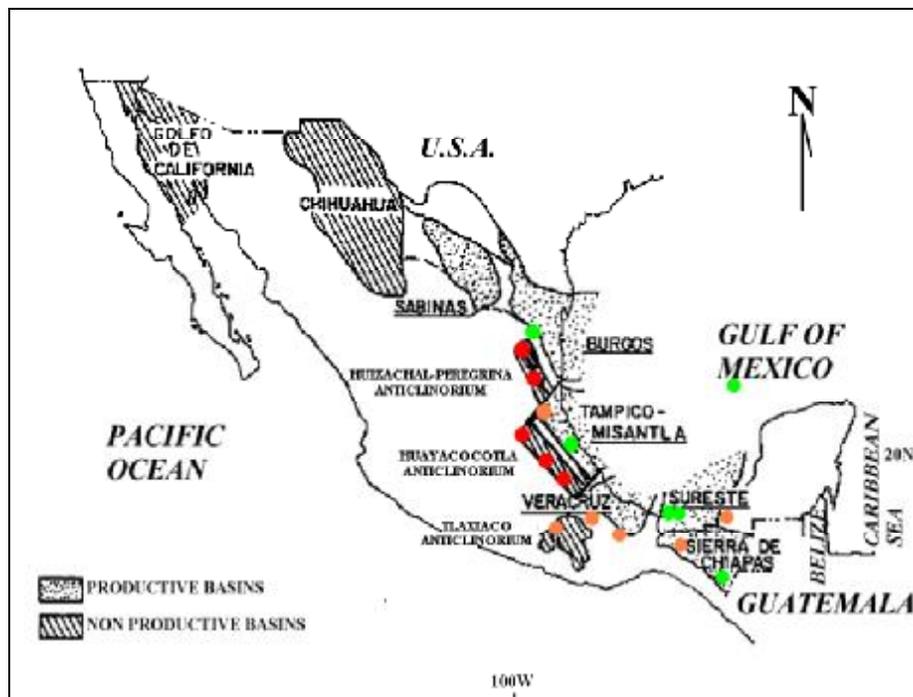


FIGURE 3. Anticlinoria, oil productive and non productive Mexican basins.

As they were considered the basement of the marine petroliferous sequence in some Mexican Gulf of Mexico sub-basins, it was important stratigraphically to place them properly, where they were found not alone. Since 1969, palynological analyses allowed to place in Middle Jurassic the Cahuasca Formation in the Tampico-Misantla sub-basin. The best outcropping of Mesozoic red beds are found in the Huizachal-Peregrina Anticlinorium, at Sierra Madre Oriental (FIGURE 3). The longest sequence of red beds is exposed at De La Boca Canyon and the redbed La Joya Formation at Huizachal Dome. From 1988 to 2004, the Redbeds and La Joya units, were described, sampled and palynostratigraphically analysed, resulting the existence of not two but three superposed redbed units. Calcareous intervals appeared among the redbeds, in fine grain rocks. These Units were formed by palynozones defined on abundance and color of palynological residues (FIGURE 4): Huizachal and La Boca alloformations and La Joya Formation.

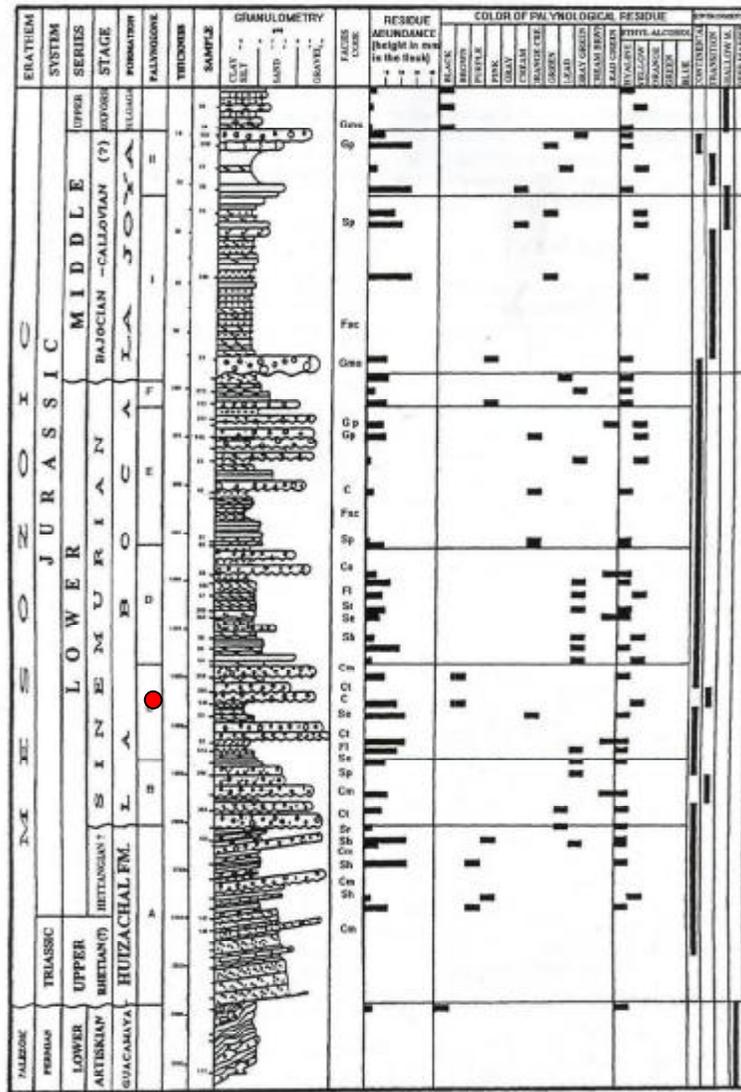
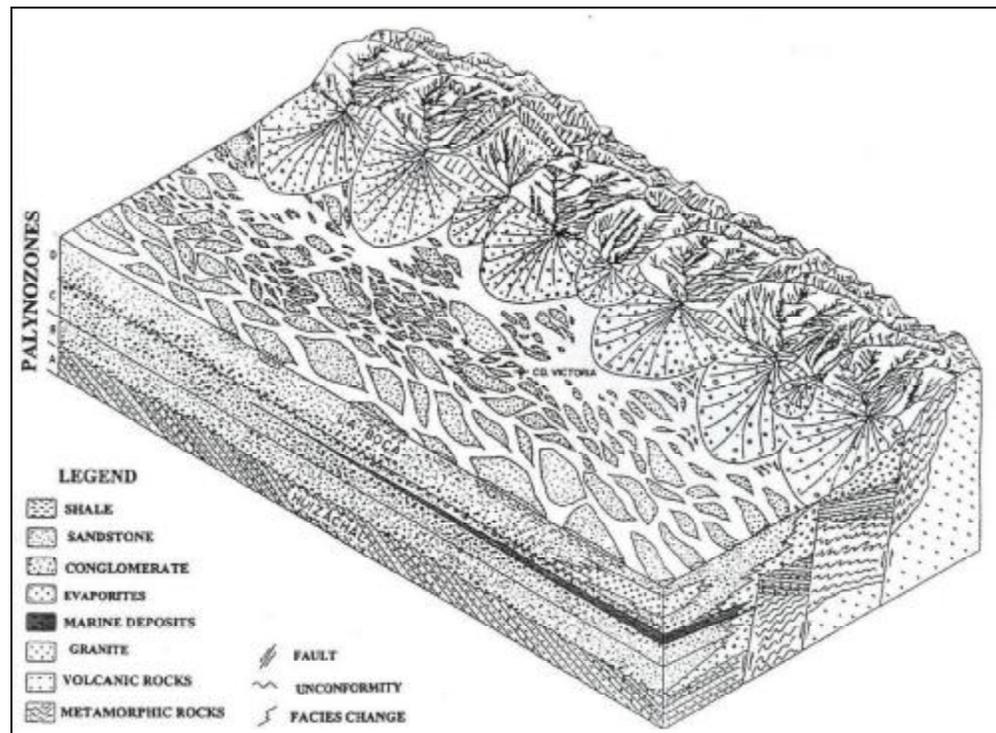


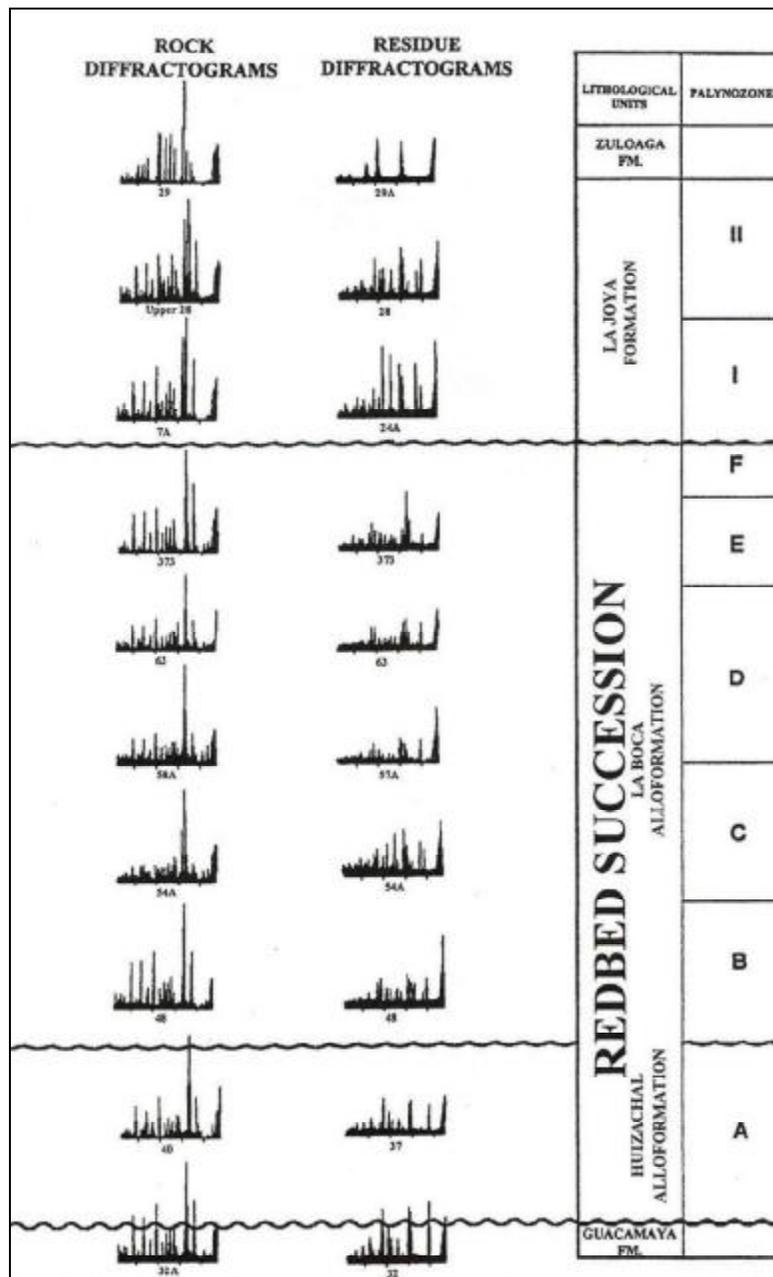
FIGURE 4. Sample 359 position (red circle) into the redbed palynozones from La Escondida- La Boca composite sequence, based on rock samples, facies code and colour and abundance of palynological residues. Columns of the right shown the colour of ethyl alcohol and depositional environment (continental, transitional, shallow and deep marine) deduced after the analyses of lithological and palynostratigraphical data (Based on Rueda-Gaxiola, J. *et al.* 1999).





**FIGURE 6.** Huizachal-Peregrina half-graben sedimentation, showing the marine transgression during Liassic.

*In order to prove the existence of an ancient marine environment among redbeds, selected rock samples and palynological residues were, from redbed units, by X ray analysed. X ray analyses proved that the palynological characterization of redbed units was well done (FIGURE 7).*



**FIGURE 7. Lithological units X ray characterization ●**

*Using the mineral and elemental contents obtained from diffraction and fluorescence X ray analyses, the complete regional sedimentary sequence was characterized. Successfully, they also proved that marine determination was correct, because of the presence of glauconite, dolomite and calcite in some greenish limolites and shales containing also abundant illite, just below the palynological sample with marine palynomorphs (FIGURE 8).*

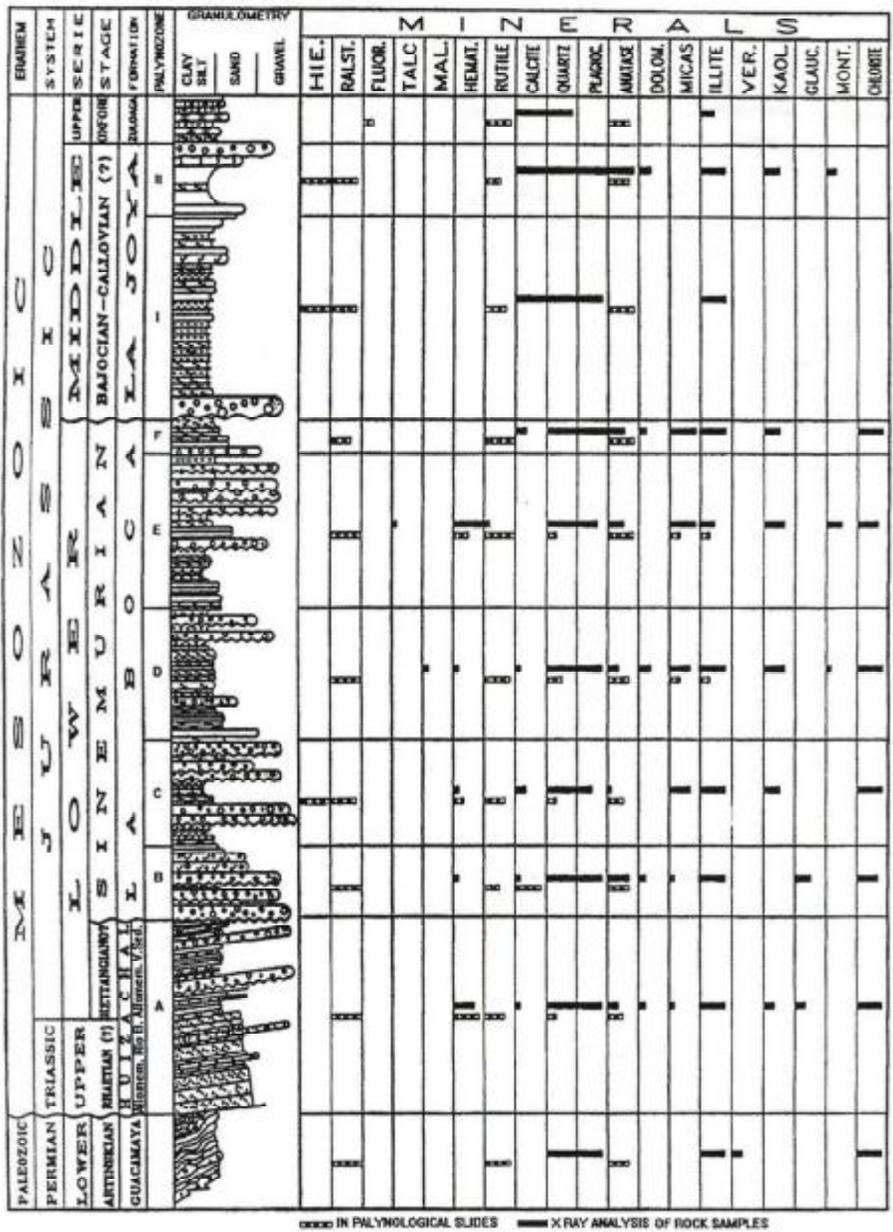


FIGURE 8. Glauconite, Hieratite and Ralstonite in selected rock and palynological residue samples from La Boca Canyon and Huizachal Dome.

*Glauconite was found at the same stratigraphic levels in La Boca Alloformation from rocks of two localities. Hieratite and Ralstonite, in palynological residues, permitted to differentiate sedimentary environments. Regional distribution of glauconite allowed explain the presence of a Liassic piscivore pterosaure at the base of the La Boca Alloformation in Huizachal Dome (FIGURE 9).*

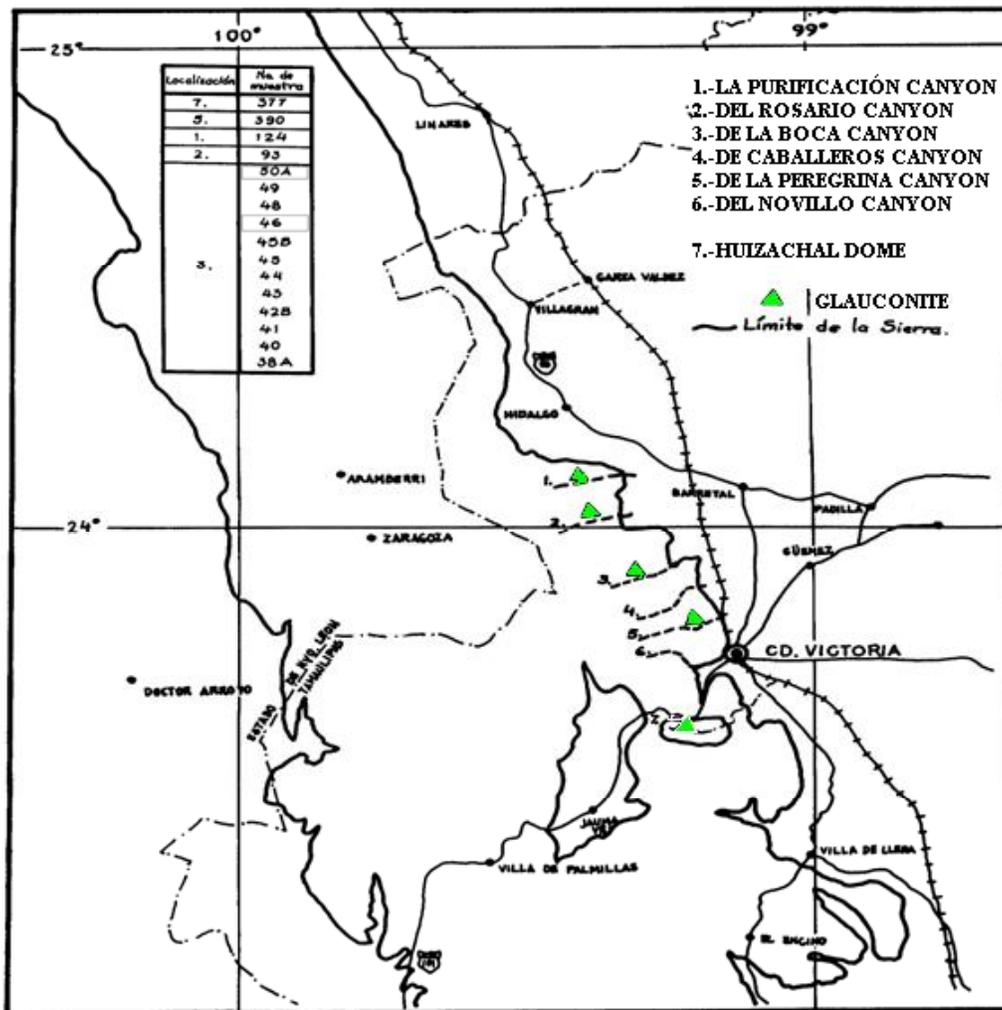
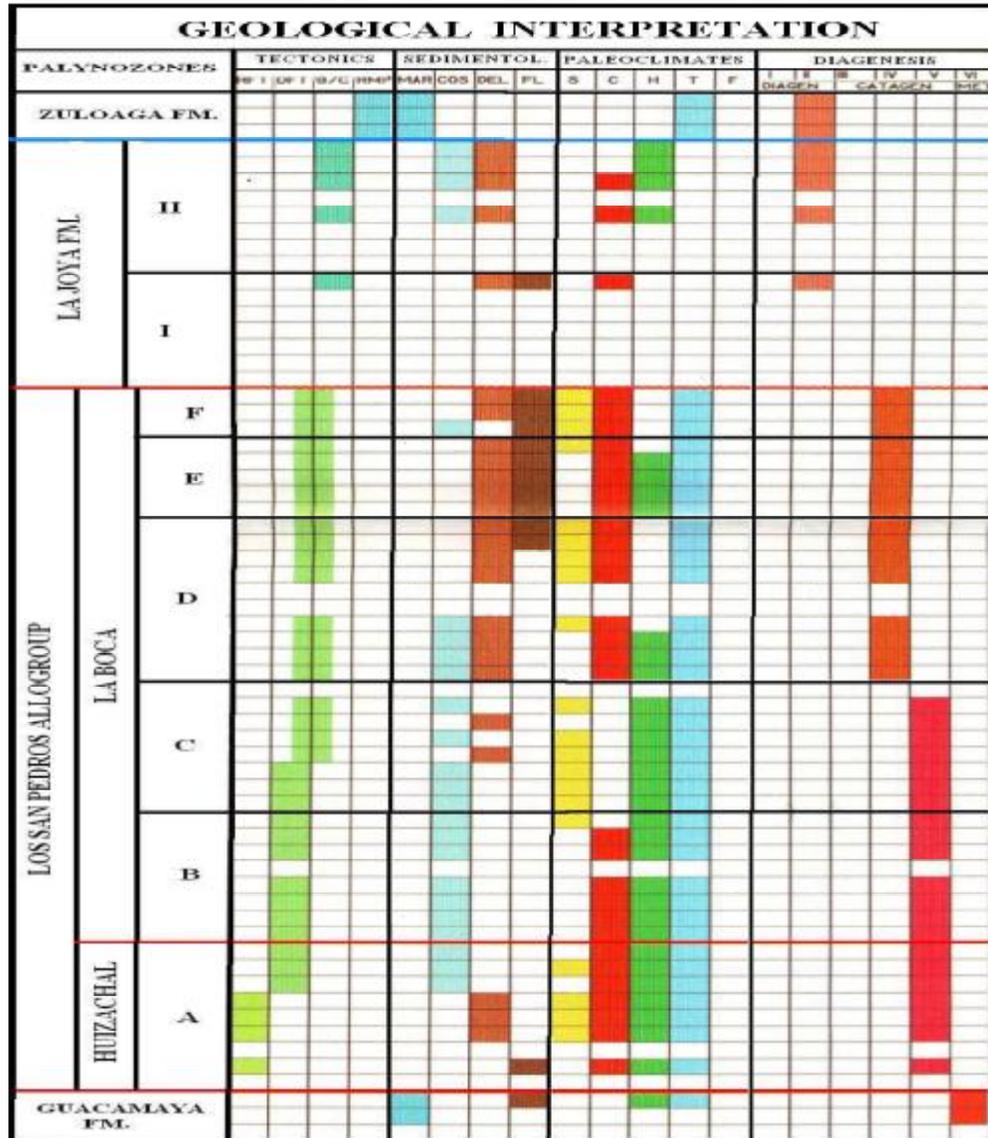


FIGURE 9. Glauconite was found in five Huizchal-Peregrina Anticlinorium localities

All X ray data were used for knowing the paleoclimatic and tectonic conditions during the origin of redbed units and the related marine transgressive-regressive sediments (FIGURE 10).



**FIGURE 10. Geological interpretation based on CHAMLEY, H., 1989 and KÜBLER, B., 1968, 1973.**

*In order to reconstruct the paleogeographic distribution of these red beds, they were correlated with other Liassic sequences, from the S and SW of Mexico, outcropping at Huayacocotla and Tlaxiaco anticlinoria (see FIGURE 3). The continuation of the Huizachal-Peregina half-graben was not found at the Tampico-Misantla Basin as it was considered, but southward in the Huayacocotla half-graben, separated by the Late Liassic Tampico-Lázaro Cárdenas Megashear (FIGURE 11). Also the Late Liassic Tezoatlán-Acapulco Megashear was later found southward, separating the Huayacocotla half-graben and the Liassic Tlaxiaco half-graben.*

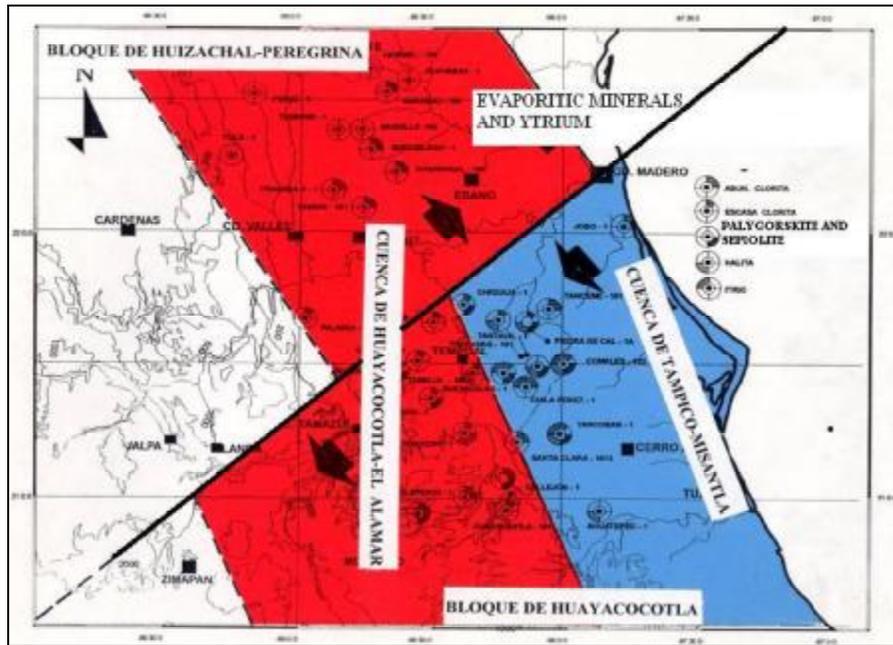


FIGURE 11. The Tampico-Lázaro Cárdenas Megashear limited the Huizachal-Peregrina and uayacocotla blocks. The SW movement of Huayacocotla Block formed the Tampico-Misantla oil basin.

*Liassic sequences correlation from three anticlinoria permitted to conclude that they were deposited in a long half-graben cut in three fragments by two Late Liassic megashears (FIGURE 12). It was now possible to reconstruct the Liassic Paleogeography, just before the Gulf of Mexico origin.*

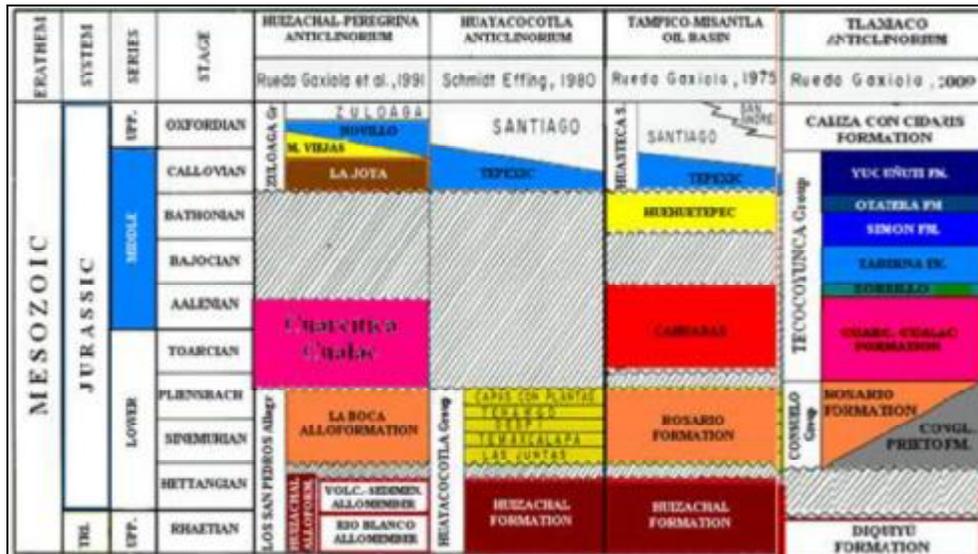
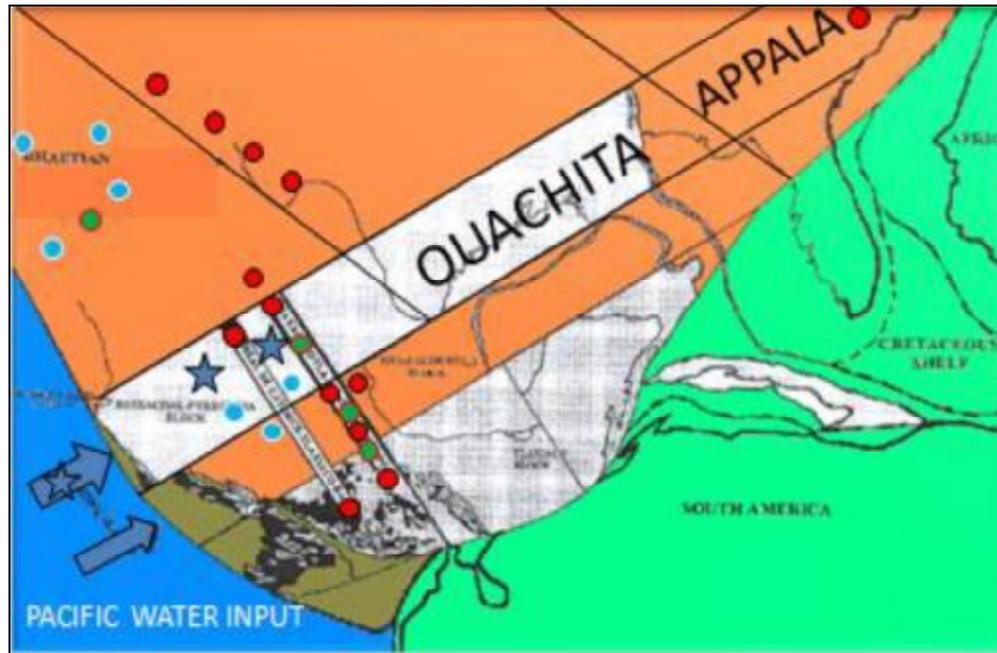


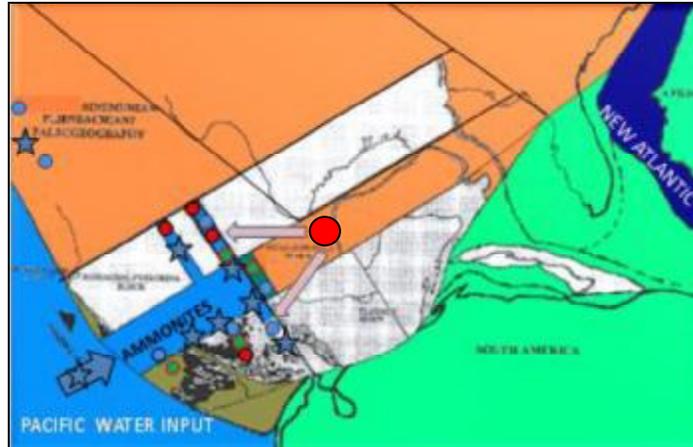
FIGURE 12. Recently, it was possible to know that in Tlaxiaco and Huizachal-Peregrina anticlinoria the Consuelo Group and the Los San Pedros Alloformation upward gradually change to a formation (Cuarcítica Cualac) constituted by mainly metamorphic quartz and other metamorphic rocks fragments. Nevertheless, only in the Tlaxiaco Anticlinorium sedimentation was continued during all the Middle Jurassic.

Stratigraphic data permitted to correlate the sedimentary sequences deposited in the three portions (outcropping at the Huizachal-Peregrina, Huayacocotla and Tlaxiaco anticlinoria) from the NE half-graben, known as the El Alamar-Tlaxiaco Basin and to interpret their origin and evolution. Initially, during Pangea, three main blocks existed separated by three Paleozoic huge faults (FIGURE 13).



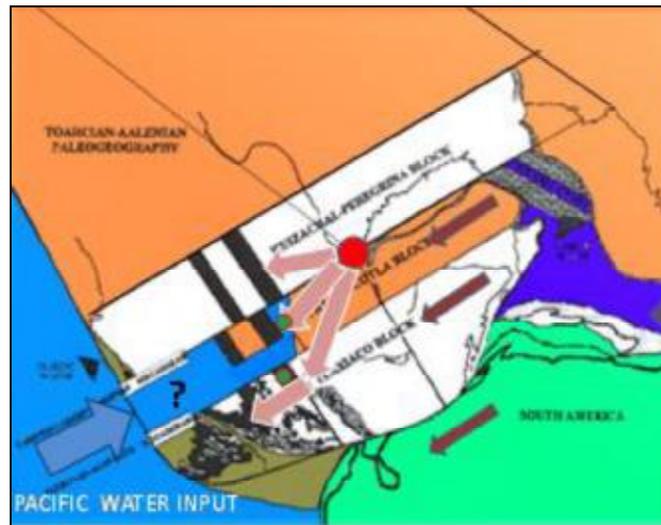
**FIGURE 13.** During Late Triassic marine influence was only present on SW North America (see blue circles); the Huizachal-Peregrina and Huayacocotla blocks permitted the Pacific Ocean transgression. The first one was a deeper epicontinental sea and ammonites (stars) were present there. Later, two graben basins originated in parallel position to the Pacific coast, and filled with volcanic and fluvial sediments (red and green circles).

Liassic units were deposited in two half-grabens (Huayacocotla-El Alamar) connected to an Epicontinental Sinemurian Sea, named the Portal del Balsas, joined at the SW with the Pacific Ocean (FIGURE 14).



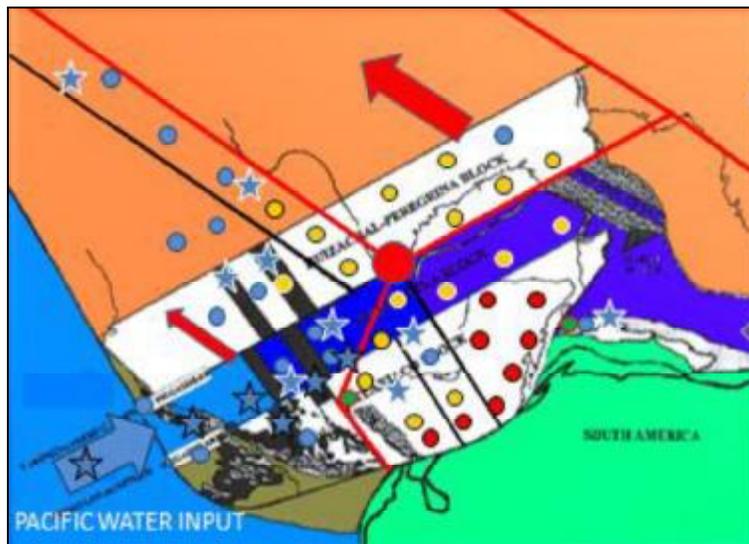
**FIGURE 14.** During Sinemurian-Pliensbachian Time, the Huayacocotla block became deeper at SW, and an epicontinental sea connected the Pacific Ocean to the graben basins depositing marine sediments among redbeds. A hot spot and a doming stage began to lift the NE region, depositing metamorphic quartz fragments among redbeds in Huizacha-Peregrina and Tlaxiaco graben basins.

*During Late Liassic, they were broken in three fractions when, originated by a hot spot, an initial RRR triple junction system was formed near NE Tampico, composed by the SE-NW Texas-Boquillas-Sabinas, the SW-NE Campeche Escarpement and the N-S Nautla-Pico de Orizaba arms, bordering the Texas-Louisiana, Western Region of Mexico, and Chiapas-Yucatán subplates. This last one was joined to South American plate and remained stable during Jurassic. So, only Texas-Louisiana and Western Region of Mexico subplates were able to be displaced northwestward, the first one faster than the second one (FIGURE 15). The Jurassic Hot Spot is still present at the central part of the Gulf of Mexico.*



**FIGURE 15.** During Toarcian-Aalenian, Atlantic waters went into the NE region from the present Gulf of Mexico. Abundant metamorphic quartz fragments were deposited above redbed sequences because of the erosion of metamorphic rocks exposed by the lifting during the doming tectonic stage.

This correlation allowed know that these units were deposited in a half-graben connected to an Epicontinental Sinemurian Sea, during the Middle Jurassic, invaded from NE by the tethysian waters coming through the Hispanic Corridor across the new Gulf of Mexico, formed by a triple junction origin (FIGURE 16).



**FIGURE 16.** During Bajocian-Oxfordian Time, the Hispanic Corridor was formed through the Gulf of Mexico, along the Huayacocotla block. Pacific and Atlantic waters permitted the mélange of ammonites from these two affinities; their fossils are found in the Taberna Formation at the Tlaxiaco Anticlinorium. This Time was represented by the end of rifting, sinking and the beginning of drifting tectonic stages.

**Keywords:** *Glauconite, X ray analyses, Palynostratigraphy, Gulf of Mexico Origin.*