[EA]Pre-Oxfordian Source Rocks on the Western Margin of the Gulf of Mexico*

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Abstract

Geochemical data on the origin of oil and gas around the western Gulf of Mexico are mainly focused on the Upper Jurassic or younger rocks (González and Holguin, 2001; Guzmán et al., 2001), and only a few studies are available to evaluate older rocks. Some data from outcrops in the Peregrina region (Figure 1), show that the Silurian Cañón de Caballeros Formation is composed of limestone and black shale, with woody and aquatic macerals (AM), Total Organic Carbon (TOC) of 0.59% to 0.53%, and Thermal Alteration Index (TAI) values of 4-/4 for thermal maturity. The Mississippian Vicente Guerrero Formation consists of sandstone and black shale containing AM kerogen, 0.5% or less of TOC, and TAI 4-/4. The Pennsylvanian limestone Del Monte Formation and the turbiditic siliciclastic succession of the Permian Guacamaya Formation have similar values of AM kerogen, 0.5% or more TOC, and TAI 4-/4 (Sandoval-Cambranis, 1980). In the Tampico Misantla Basin the Tepehuaje 1, González 101 and Zamorina 1 wells were drilled into the Guacamaya Formation without showing hydrocarbons. The Pennsylvanian Upper Santa Rosa Formation, in the Comalapa region (Figure 1), is a thick succession of shale and sandstone which is structurally deformed. The analysis of six samples of carbonaceous slate have values from 0.18% to 0.29% TOC (this study), the illite-crystallinity index is 0.3-0.42 (Hernández et al, 2019). The data of all these rocks suggests that in the Paleozoic sedimentary deposits the predominant organic matter is of type I and II, with poor TOC and high thermal evolution resulting in poor gas-prone potential (Table 1). The Triassic siliciclastic rocks (Alamar Formation) are not yet geochemically evaluated as a potential petroleum source. There are no reports of lacustrine carbonates, and floodplain facies are subordinated to fluvial or alluvial facies (Michalski, 1991; Barbosa et al., 2010), likely with a high oxidation degree of the organic matter. Reports of land plant and fossil wood (xylolite) suggest that they could be poor source rock of type III kerogen and low gas-prone.

In eastern Mexico the Lower Jurassic shale and sandstone of delta and marine facies of the Huayacocotla Formation have variable TOC values ranging from 0.1% to 9.2%, with hydrogen index from 53 to 698 mg HC/g (oil-prone), and vitrinite reflectance (Ro) from 1.4 to 1.7 (Table 1), presenting good conditions for generating hydrocarbons (Reyes and Rodríguez, 1991; Román-Ramos, 1998). Oil wells Olivo 1, Piedra de Cal 1, Molino 1, Tula 1, Tampamás 1 and Aquismón 1, have aquatic and herbaceous kerogen (types I and II), with 0.5% to 1.2% or more TOC, and

alteration rates from immature to mature (Sandoval-Cambranis, 1980). The Colmena 1 well showed gas in the Huayacocotla Formation. In Tlaxiaco region in the Oaxaca, Guerrero and Puebla states (Figure 1), the Middle Jurassic rocks are a siliciclastic succession of shallow marine and continental environments (Cualac, Zorrillo-Taberna, Simón, Otatera, Yucuñuti, Ayuquila and Tecomazúchil formations), the data about its oil potential is not yet available, but due to the presence of organic material, beds of coal sub-bituminous rank, and surficial tar evidence, suggest possible conditions for generating hydrocarbons. In Tamaulipas and Veracruz states the Middle Jurassic Cahuasas Formation and the Huizachal Group, or Los San Pedros Allogroup, are continental facies (Table 1). The Allogroup has TAI from +2 to +4 of herbal-algaceous material, the optical field macerals ranging from 1% to 55% (Rueda et al., 1997). The presence of lacustrine facies and carbonates in this Allogroup might suggest some potential as regular or good source rocks. In the Tampico-Misantla Basin the Huehuetepec 1, 2 and 3 wells, rocks of Upper Middle Jurassic were producers of oil and have a salt seal (González, 1970).

Elements of the Petroleum System of Pre-Oxfordian in Mexico suggest that favorable conditions exist for storing hydrocarbons in carbonates and siliclastic fractured rocks, and stratigraphic and structural traps. The regional seal is salt or anhydrite, which migrated in space and time, with wedges onlaping paleogeographic highs. Recognition of sequence boundaries is crucial to separate a pre-salt sedimentary prism. It is convenient to obtain more geochemical data and modeling the migration and synchrony to predict evolution of possible accumulation and evolution of hydrocarbons. Several wells have been drilled to explore pre-salt rocks in Mexico: Trinitaria 1, Trinitaria 2, Yaaxtaab-1, Calichoso 1, Negrete 1, Don Antonio 1, Minas Viejas 1, Menchaca 1, Huapango 1, Guadalcazar 1, Mirasol 1, Retama 2, Barreta 1, etc., in these wells the pre-salt rocks are composed of continental red beds, inter-tidal facies (Huehuetepec 1, 2 and 3), and metamorphic or igneous rocks. Pre-Oxfordian rocks onshore and offshore around western Gulf of Mexico have likely favorable possibilities to produce gas and oil, as a new exploration frontier.

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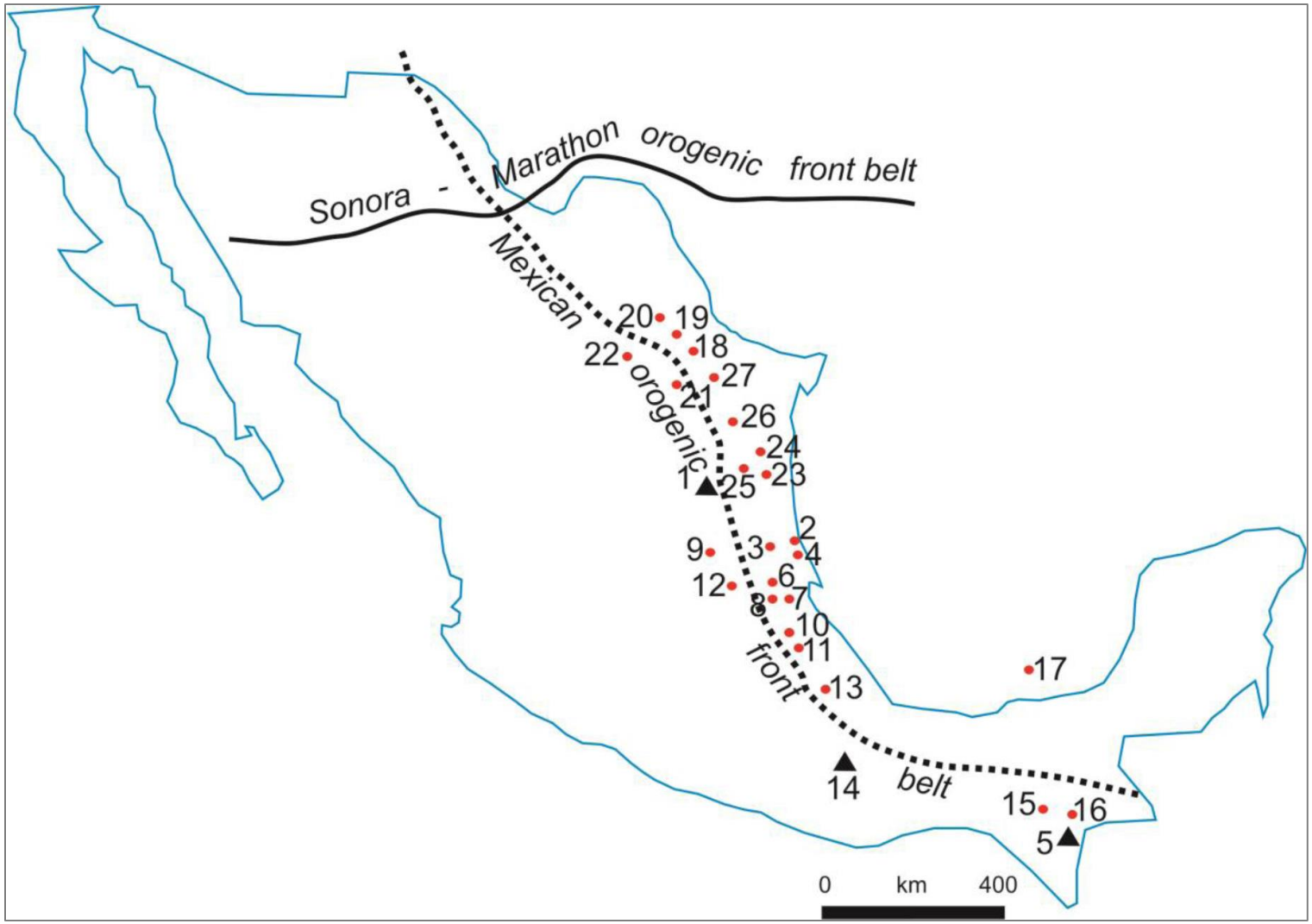

Figure 1. Localities in triangular shape: 1 Peregrina, 5 Comalapa and 14 Tlaxiaco. Oil wells in red dots: 2 Tepehuaje 1, 3 González 101, 4 Zamorina 1, 6 Olivo 1, 7 Piedra de Cal 1, 8 Molino 1, 9 Tula 1, 10 Tampamás 1, 11 Aquismón 1, 13 Huehuetepec 1, 2 and 3, 15 Trinitaria 1, 16 Trinitaria 2, 17 Yaxtaab 1, 18 Calichoso 1, 19 Negrete 1, 20 Don Antonio 1, 21 Minas Viejas 1, 22 Menchaca 1, 23 Huapango 1, 24 Guadalcazar 1, 25 Mirasol 1, 26 Retama 2, 27 Barreta 2. Full line: Sonora-Marathon orogenic front belt of Paleozoic age. Dash line: Mexican orogenic front belt of Paleogene age.

Formation	Age	Rock	AM	TOC % w	TAI/Ro	HCs
Huehuetepec-Metate	M Jurassic	L	I-II ?	?	?	Oil & gas
Huizachal Allogroup	L-M Jurassic	Ss & L	I-III	variable	2+/4 (0.5-2.0 Ro)	Oil & gas
Tecocoyuca Group	M Jurassic	Sh & L	I-to-III	?	Coal seams	Oil & gas
Huayacocotla	L Jurassic	Sh	II-III	0.1-9.2	1.4-1.7 Ro	Oil & gas
Alamar	U Triassic	Ss & Cong	III ?	?	?	?
U. Sta Rosa	Penn	Slate	II-III	0.18-0.29	?	?
Del Monte & Guacamaya	Penn Permian	Sh Sh	II II	0.53 0.53	4-/4 (2-2.5 Ro) 4-/4 (2-2.5 Ro)	Methane Methane
V. Guerrero	Miss	Ss & Sh	III	nil	4-/4 (2-2.5 Ro)	?
C. Caballeros	Silurian	L	I	0.59-0.53	4-/4 (2-2.5 Ro)	Methane

Table 1. Formations characteristics. Sh = shale, L = limestone, Ss = Sandstone, Cong = Conglomerate.