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International Explorationists Dinner Meeting

by J. Alejandro Morelos-Garcia and Wallace Dow

A Review of the Petroleum Systems of the Gulf of Mexico with Emphasis on the Mexican Sub-basins:

Oil Quality Distribution, Recognition of a New Petroleum System, and Remaining Petroleum Potential

The Gulf of Mexico is a prolific basin with multiple source rocks that are Jurassic, Cretaceous, and Tertiary in age. Oil quality distribution in the subsurface is controlled primarily by the characteristics of the source rocks. For example, carbonate source rocks contain marine, sulfur-rich organic matter and yield oils high in asphaltene compounds and sulfur. In contrast, siliciclastic source rocks contain a mixture of marine and terrestrial organic matter and yield waxy, low-sulfur oils with greater gas/oil ratio. In the Gulf of Mexico, the Mesozoic source rocks are generally carbonate whereas Tertiary source rocks are siliciclastic. In the northern Gulf of Mexico, petroleum generated from Jurassic and Cretaceous source rocks has been recognized in the inner onshore region, whereas Tertiary sourced oils and gases are found in the onshore and continental shelf areas (Figure 1). Oils generated from Mesozoic sequences are pervasive in the deep Gulf of Mexico (Gross et al., 1995). On the Mexican side of the Gulf of Mexico, sub-basins also contain oil and gas of different origins.

Burgos Basin

The Tertiary Burgos Basin produces gas and condensate from reservoirs that consist of sand deposited as bars and wide, thin-bed deposits at the front of Paleocene, Eocene, Oligocene, and Miocene prograding deltaic systems.

Although the Mesozoic sequences, such as the Kimmeridgian – Tithonian La Casita Fm., Aptian La Peña Fm., and Turonian Eagle Ford Fm., are rich in organic matter, they are spent source rocks, and did not contribute to the commercial accumulations in the basin. Active source rocks are the Paleocene-Eocene Midway-Wilcox Fms. and Oligocene Vicksburg Fm. that contain a gas-prone Type III kerogen (Echanove-Echanove, 1986; Gonzalez-Garcia y Holguin-Quiñones, 1992).

The trapped hydrocarbons have been generated at more than 4 km depth and migrated along the listric and growth fault systems that affected the whole Tertiary section. Exploration in this basin is being revitalized with the search for gas in deeper traps, secondary recovery techniques, infill drilling and looking for new prospective areas offshore where there is great potential for accumulations of hydrocarbons (Yañez-Mondragon, 2001).

Tampico-Misantla Basin

The Tampico-Misantla basin produces high-sulfur oil of variable quality (e.g., 15° to 40° API gravity) and associated gas. Production comes from stratigraphic, and mixed structural-stratigraphic traps with naturally fractured carbonate reservoirs in Upper Jurassic San Andres Fm., Cretaceous El Abra , Tamabra and Tamaulipas Superior Fms., and clastic reservoirs in the Eocene Chicontepec Fm. In the central part of the basin, oil and associated gas were generated from Upper Jurassic source rocks, whereas to the west, light oil, condensate, and gas were generated from the Lower Jurassic Huayacocotla Fm. (Morelos-Garcia, 1996; Roman-Ramos y Holguin-Quiñones, 2001). In the Sierra Madre Oriental, an oil seep sample suggests that oil charge must have come from a carbonate source rock deposited in an anoxic, hypersaline, shallow water environment (platform). This new evidence suggests that within the Cretaceous Valles San Luis Potosi Platform, there are source rocks that could have charged the Sierra Madre Oriental and adjacent regions. In the Sierra

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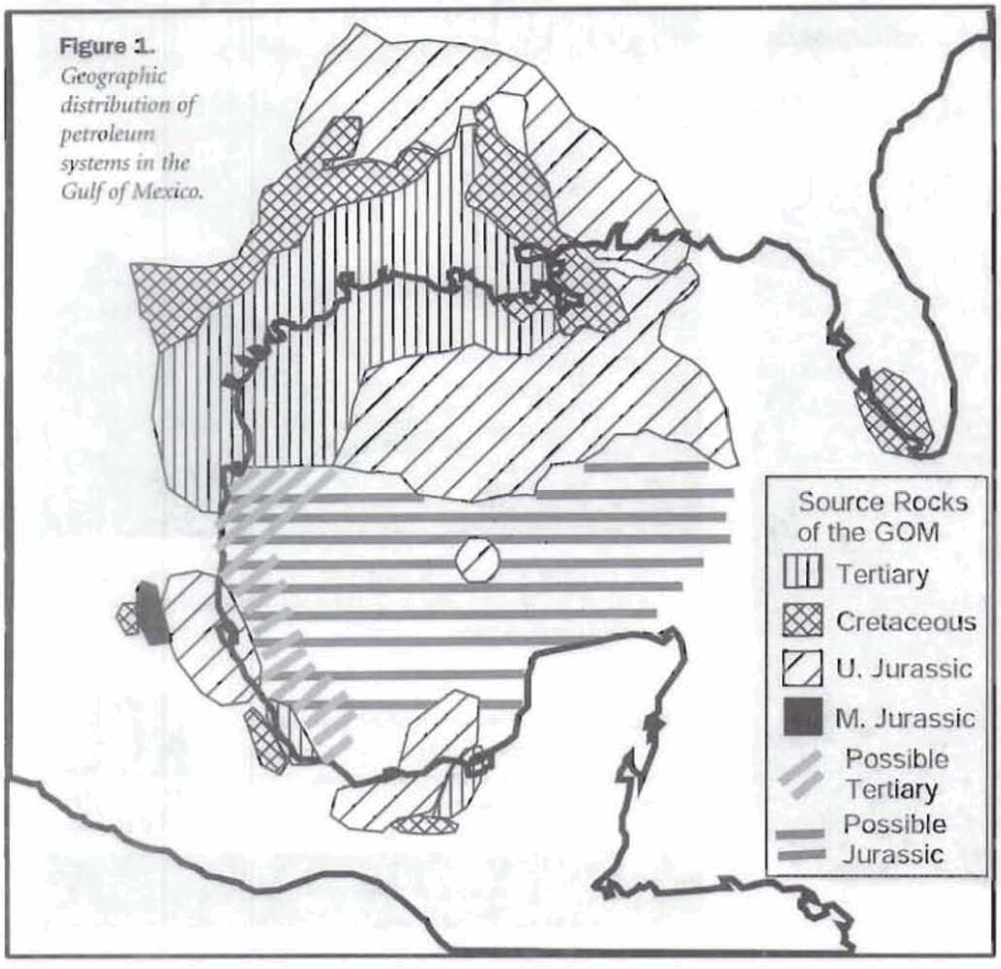

Figure 1. *Geographic distribution of petroleum systems in the Gulf of Mexico.*

Tertiary Sedimentary Basin.
The stratigraphic section of the Veracruz Sedimentary Basin includes a thickness of more than 8 km of Tertiary terrigenoclastic sediments, and Cretaceous and Upper Jurassic sequences that have not been penetrated. This region produces mainly gas and minor volumes of condensate and oil from Miocene and Pliocene stratigraphic reservoirs. Although it is inferred that Mesozoic source rocks are present, they are most likely spent and may have contributed only minor gas and some oil. Paleocene-Eocene and Miocene sedimentary sequences contain fair to good source rocks with gas-prone Type III kerogen, and are the most likely source of the hydrocarbons trapped locally (Roman-Ramos y Holguin-Quiñones, 2001).

Exploration in the Veracruz basin is concentrated in the Tertiary Sedimentary Basin, which has great potential for gas discoveries.

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El Abra, an exhumed reservoir contains oil in the moldic porosity of rudist build-ups of the El Abra Fm. This reservoir shows a complex hydrocarbon charging history (Pottorf et al., 1996). Petroleum activity in this basin is focused on the rehabilitation of mature oil fields, development of the Chicontepec trend and offshore exploration (Yañez-Mondragon, 2001).

Veracruz Basin

The Veracruz Basin is divided into the Tectonic Buried Platform and Veracruz Tertiary Sedimentary Basin.

Tectonic Buried Platform

The stratigraphic section of the Tectonic Buried Platform comprises Upper Jurassic to Early Eocene sequences that were deformed and thrusted during the Middle Eocene. This region contains high sulfur oil and associated gas in structural traps of Cretaceous age (Orizaba, San Felipe and Guzmantla Fms). Active source rocks have been identified in the Upper Jurassic Tepexilotla Fm., Turonian Maltrata Fm. and Aptian-Albian Orizaba Fm.

Southeastern Basins and Campeche Bay Region

The southeastern basins include the contiguous Salina del Istmo, Chiapas-Tabasco, and Macuspana basins, and the Campeche Marine Platform. These basins have a common geological history during the Mesozoic, and a different structural and stratigraphic development since the Tertiary. Source rocks have been identified in the Upper Jurassic (Tithonian), Middle Eocene, Oligocene and Middle Miocene sections (Sosa-Patron y Clara-Valdez, 2001)

Salina del Istmo

Several giant oil fields in the Salina del Istmo Basin produce oil of about 35° API and associated gas. The main reservoirs are Miocene and Pliocene sequences in stratigraphic-structural traps developed by salt tectonism. Source of these hydrocarbons has been identified as Upper Jurassic (Guzman-Vega and Mello, 1999).

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Chiapas-Tabasco Basin

The Chiapas-Tabasco Basin produces oil and associated gas from combined stratigraphic-structural traps of Upper and Lower Cretaceous reservoirs. These hydrocarbons were generated from Upper Jurassic source rocks. To the south, some oils correlate with Cretaceous carbonate source rocks that were deposited in a platform environment of hypersaline conditions (Guzman-Vega and Mello, 1999).

Macuspana Basin

The Macuspana Basin is a gas producing basin with minor production of condensate and oil. Gases are a mixture of biogenic and thermogenic, and the thermogenic gases are of variable maturity. Thermogenic gases were produced from primary cracking of Tertiary source rocks and probably secondary cracking from Upper Jurassic source rocks (Sosa Patron et al., 2001).

Campeche Marine Platform

The Campeche Marine Platform is the richest oil region in Mexico, and contains several giant oil fields, including the Cantarell Trend. Three stratigraphic sections have been identified as source rocks in this region: Oxfordian, Tithonian and Miocene sequences (Santamaria, et al., 1998; Sosa-Patron and Clara-Valdez, 2001). The Oxfordian source rock appears to be of limited geographic extent, and is only active in the north, whereas the potential Miocene source is more widespread. However, the Tithonian is clearly the source of most of the hydrocarbons trapped in the region (Romero-Ibarra et al., 2001).

The southern basins have been producing oil and gas since the early 70s and this region has still great potential for new discoveries.

Offshore Mexico as well as the deep and ultradeep regions of the Gulf of Mexico are frontier regions of oil exploration. Regional work on the petroleum systems suggests that the Tertiary section will be an important source of hydrocarbons on the western side of the Gulf of Mexico, close to the shoreline (Figure 1). Likewise, evidence of oil from the Challenger Knoll and regional trends suggest that the Mesozoic section (e.g., Upper Jurassic) will be the most important source of hydrocarbons in the deep and ultradeep regions of the Gulf of Mexico.

Biographical Sketch

J. Alejandro Morelos-Garcia graduated with a BS in Geological Engineering from the Instituto Polytecnico Nacional (Mexico) and a PhD in Geosciences from the University of Texas at Dallas. His dissertation covered the petroleum systems of the Veracruz and Tampico-Misantla basins in Mexico. His areas of expertise include geochemistry, basin modeling and petroleum system analysis, with special emphasis on integrating geochemical data into regional geologic models. He has worked with several integrated oil companies, independents, and service companies, including the deepwater Gulf of Mexico assessment team for Spirit 76 (Unocal). His areas of geographic expertise include Central and South America, Central and South Asia, and the Gulf of Mexico. Alex is currently a consultant dedicated to basin evaluation, petroleum systems assessment, and reservoir characterization. ☐

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