High Resolution Geochemical Technology Can Redirect Exploration in Mature Petroleum Provinces

J.M. Moldowan1,2*, J. Dahl1,2, M.R. Mello3, M. Limon4, F. Fuentes4 A. Vera5

1Department of Geological and Environmental Sciences, Stanford University, Stanford, CA 94305-2115 USA. E-mail: Moldowan@pangea.stanford.edu
2BIOMARKER TECHNOLOGY, 2501 Blucher Valley Road, Sebastopol, CA 95472 USA
3ANALYTICAL SOLUTIONS, Rua Professor Saldanha, 115, Jardim Botânico, Rio de Janeiro, RJ, Brazil, 22461-220.
4PEMEX, Ed. Piramide Tab. p.6, Boul. Adolfo Ruiz Cortines 1202, Col. Fracc. Oropesa, Villahermosa, Tab. 86030, Mexico
5Helipuerto PEMEX Piso. Antigua Carr. Carmen PTO. Real S/N, Col., Ciudad del Carmen, Campeche, 24190, Mexico

Geochemistry makes a major impact on exploration strategy when new petroleum systems or combinations of petroleum systems are documented. Prolific petroleum basins typically have multiple source rocks, and establishing these sources and their contributions, especially to mixed petroleum accumulations, can be a challenge. In mature basins, retrenching with well-established molecular and bulk analyses rarely elevates understanding of the petroleum systems to the new levels necessary to make a major impact on exploration. We investigated petroleum systems in the prolific producing basins of Mexico using high resolution geochemical technologies (HRGTs) that include (1) diamondoid analysis for thermal cracking of oil to gas, (2) age-related biomarkers, (3) compound specific isotope analysis of biomarkers (CSIA-B), and (4) compound specific isotope analysis of diamondoids (CSIA-D).

In Mexico, gas is an important exploration target, but the origins of some gas accumulations are not clearly defined. Gas often occurs in Tertiary reservoirs, but is it generated from Tertiary gas-prone sediments at moderate maturity, from the deep underlying Mesozoic oil-prone source rocks at very high maturity, or from bacterial gas sources? In the Veracruz Basin, age-related biomarkers in conjunction with diamondoid cracking analyses were used to understand hydrocarbon accumulations. Tertiary oil was identified in some fields based on the presence of high oleanane/hopane ratios. However, these liquids can also have high diamondoid concentrations, which is inconsistent with a simple origin from Tertiary sources at low to moderate thermal maturity in the oil window. High diamondoids together with significant biomarker contents are explained by infiltration of highly cracked liquids (condensates) generated from very deep sources and mixed with Tertiary oil. This provides a model in which gas generated from very deeply buried Mesozoic source rocks migrated into the relatively shallow Tertiary reservoirs. Support for this conclusion is found using gas isotopic and compositional data. In other areas the oil accumulations show age-related biomarkers that indicate Mesozoic sources without admixture of cracked hydrocarbon liquids. These results promote the idea of deep drilling for gas exploration in areas with cracked liquids from very deep sources. However, it is also important to establish the sources of both the “normal” and cracked portions of the liquids.

Using CSIA-B it is possible to distinguish between oil samples of different ages within the Mesozoic section, which is very difficult to accomplish by any other method. Thus, CSIA-B is an age-specific correlation tool in Mexico. CSIA-D is probably the only available method to correlate the cracked portion of the oil with specific source families. In this method isotopes of the diamondoids are measured in established end-member non-cracked singly sourced oil samples. These results form a database for comparison of the diamondoid-isotopes from cracked oil or from mixed “normal” and cracked oil.