MISSED COMPONENTS OF PETROLEUM SYSTEMS AS DETERMINED BY DIAMONDOID CORRELATION

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Classical biomarker analysis by gas chromatography-mass spectrometry (GC-MS) falls short of giving a full accounting of the petroleum systems in mature petroleum provinces. This is due to the fact that highly mature and/or severely biodegraded oil often lacks unaltered biomarkers to be used in correlations of those altered fluids. Also, possible co-sources of mixed oil are often obscured by the overprinting of fresh biomarker-rich oil from one of the sources. Diamondoids are formed in the source rock mostly from multi-ring compounds (e.g., biomarkers), and once formed the ultra-stable diamondoid cages carry the properties of the source materials through all subsequent secondary processes of maturation and biodegradation. The relative abundances of large diamondoid molecules including triamantane, three tetramantane isomers, four pentamantane isomers and cyclohexamantane, called quantitative extended diamondoid analysis (QEDA), is used to correlate any petroleum liquids including over-mature condensates, extracts from source rocks, severely biodegraded oils and black oils (Figure 1).

Compound specific isotope analysis of diamondoids (CSIA-D) is a complimentary diamondoid correlation method. Whereas, QEDA correlation is based on molecular fingerprint comparisons, similar to biomarkers; CSIA-D is based on isotope ratio comparison, similar to other isotope ratio correlation methods. However, the diamondoid cage survives into and through the dry gas window to at least Vr of 4 % Ro, making it ideal for condensate correlation. QEDA and QDA are the only methods to arrive at a confident correlation of condensate and very mature hydrocarbon liquids versus black oil of oil-window maturity (Moldowan et al, 2015; Dahl et al., 2017).

It is critical to obtain accurate and precise analyses of the diamondoids. Deuterated internal standards, consisting of the same diamondoids labeled with deuterium, are added to the oil in precise accurate amounts. A diamondoid fraction is then isolated and analyzed by GCMS with using the internal standard as a quantitative calibration method. Like biomarkers, the fingerprints generated from analysis of these diamondoids relate to the source rock, but unlike biomarkers large diamondoid fingerprints are ubiquitously applicable to all petroleum liquids. Meanwhile, QEDA, when applied in combination with other methods such a compound specific isotope analysis of biomarkers (CSIA-B) and of diamondoids (CSIA-D), becomes part of a powerful tour de force to determine constituents of co-sourced oil mixtures. These advanced tools for geochemical analysis are exemplified by studies that have delineated new features of the petroleum systems of North (Figure 1), Central and South America pertaining to Mexico, Brazil, Colombia and Eastern Venezuela, and basins in the Middle East, Europe, Asia, and S. E. Asia. The resulting knowledge gleaned from these applications enhances exploration prospect evaluation while reducing the risks involved with exploration in mature basins.

Unconventional exploration has been a major focus of attention in the USA. Unconventional plays rely on laterally drilled wells that often target post mature hydrocarbons. It is important to determine fluid migration and the extent of fracking channels in unconventional plays where various stacked source rocks and reservoirs might participate. Targeting the most

prolific hydrocarbon source formation for setting laterally drilled wells can have a major impact on production. Some of the most prolific US basins where this phenomenon occurs include the Williston, Permian (Dahl et al., 2017) and the Denver-Julesburg (or DJ) Basins, among many others. Whereas, wide ranges of maturity encountered in these ventures limit the application of conventional geochemistry, the diamondoid correlation methods described here provide a reliable approach to correlation of unconventional fluids.

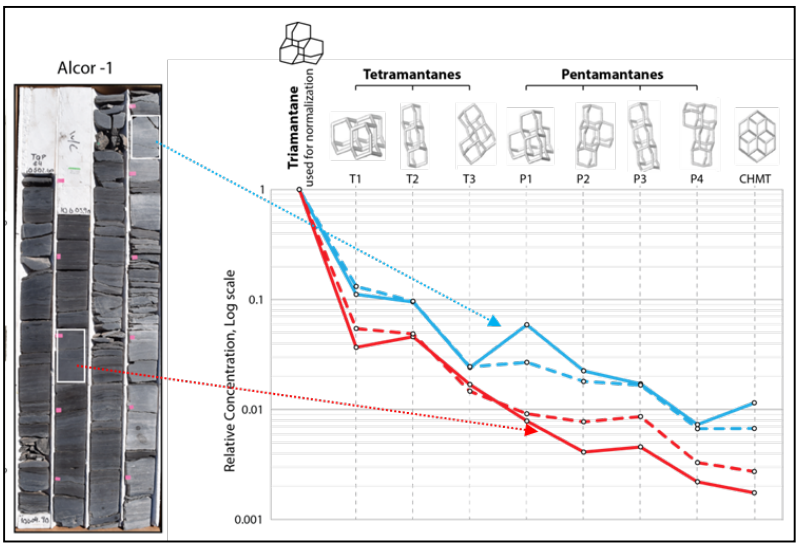

Figure 1. An example of differentiation of faces in an over-mature Triassic Shublik core (estimated Vr is > 1.4 %, no biomarkers in the extracts!) from the Alaska North Slope (Yurchenko et al., 2017) using large-diamondoid molecular distributions (QEDA). Two Shublik oil samples (dashed lines) are plotted for comparison. The oil sample having biomarkers for a calcareous source (blue) shows more similarity to the calcareous-Shublik core extract; whereas, the oil sample with a more shaley biomarker signature (red) more closely resembles the shaley-Shublik core sample. However, both oils show intermediate trends indicating they are mixtures with predominance of one facies or the other.

References

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