A REVOLUTION IN APPLIED PETROLEUM GEOCHEMISTRY FOSTERED BY DIAMONDOIDS

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Introduction

Petroleum exploration is all about creating prospects that can yield new discoveries. While classical geochemical technologies; such as, standard biomarker analysis and correlation by isotopes of oils and oil fractions are extremely useful, they have already been available for more than three decades and been applied to most of the mature basins in the world. Therefore, classical analytical methods are unlikely to support new exploration ideas. Repeating the same analyses in the same basins time and time again will most likely not result in startlingly new play ideas or discoveries. New geochemical techniques based on diamondoids can provide the necessary crucial information to reach those objectives that were previously unattainable and fill mature basins with exploratory opportunities.

Diamondoid Methods Applied for Maturity and Correlation

Quantitative diamondoid analysis (QDA) is used for determining the maturity of any oil (or condensate) sample in both conventional and unconventional applications. The high degree of accuracy needed for application of this method is achieved by spiking the liquids with deuterated diamondoids and hi-grading a diamondoid enriched fraction before GCMS analysis. More recently, the ability to perform source correlations by using diamondoids has been developed. These correlation methods have an advantage over all others due to their high thermal stability and the recalcitrancy of diamondoids toward biodegradation. Thereby, all bitumen and oil samples (condensate, biodegraded oil, produced black oil, seepage oil, and extracts from source rocks and reservoirs) can be correlated by diamondoids. One method called quantitative extended diamondoid analysis (QEDA) is based on quantitative analysis of large diamondoid molecules. Eight compounds are analysed ranging from tetramantanes (3) to pentamantanes (4) to cyclohexamantane, which occur in several isomeric structures that can be displayed in a similar fashion to biomarker fingerprints and ternary diagrams (Figure 1). A second approach is to measure the diamondoid carbon-isotope ratios, which can be used similar to bulk carbon-isotope ratios, except they pertain to the most recalcitrant part of the liquid; whereas, bulk isotopes pertain to the whole liquid or a liquid chromatographic fraction thereof.

In addition to being arguably the best way to correlate highly mature oil, such as condensates, diamondoids stand out as offering a major advantage for correlation of the most mature component of an oil mixture. In the first place, the existence or presence of that most mature component of co-sourced oil may be difficult to ascertain. The use of QDA often solves that dilemma by showing high concentrations of diamondoids in oil samples that still contain liberal concentrations of biomarkers. Secondly, once that more mature component is known to be present, the ability to determine its source correlation is next to impossible without the use of the diamondoid correlation methods, CSIA-D and QEDA.

Conclusion

The ability to recognize and correlate sources of condensates and the most mature component of co-sourced oil can turn a mature basin into a new exploration playground. Basin models can now include a deep source that has been difficult to prove, previously, by decades-old technologies, even in prolific basins that have been studied repeatedly using classical geochemistry. This opens up a whole new approach to petroleum system analysis and basin modelling which, in our view, constitutes a "Revolution in Applied Petroleum Geochemistry."

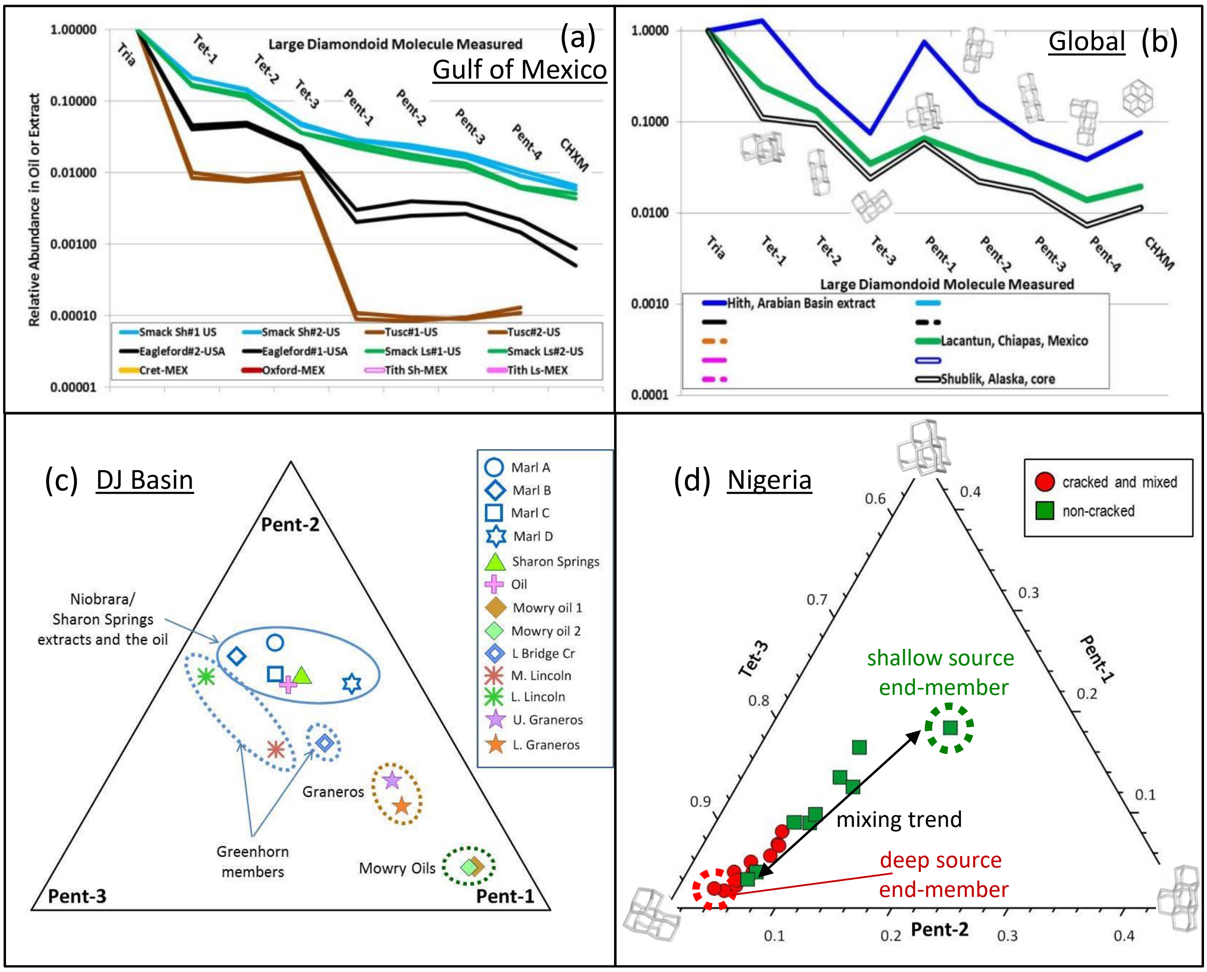

Figure 1 *Applications of the Quantitative Extended Diamondoid Analysis (QEDA) in the correlation of oils and condensates from around the world. (a) Differentiation of Gulf of Mexico oil types by QEDA fingerprint graphics. (b) QEDA fingerprints from oils showing predominant Pent-1 from fluid samples related to carbonate sources. (c) Over-mature source rocks and an oil sample (all lacking biomarkers) differentiated by QEDA displayed in a ternary diagram. The oil sample is produced by lateral drilling and fracking is shown to correlate best with Marl C of the Niobrara Formation and Sharon Springs rock samples. (d) A ternary diagram display of QEDA data from Nigerian oil samples showing a mixing trend between a source of non-cracked oil and another source of cracked oil. The differentiation by QEDA suggests that many of the oils are co-sourced by different sources or different source facies. Extent of oil cracking was evaluated by diamondoid concentrations using the QDA method.*