OIL-SOURCE ROCK CORRELATIONS – HOW DO WE MEASURE SUCCESS?

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A rigorous, defensible and causal oil-source rock correlation definitively ties an individual source rock sample to an individual crude oil using genetically-based, internally consistent parameter matches. Given the importance of these correlations as risk reduction tools in exploration of both frontier and mature sedimentary basins, it is surprising how few rigorous oil-rock correlations can be found in the open literature (Waples and Curiale, 1999), and how many published correlations are indefensible. Indeed, although petroleum geochemists can cite several "accepted" oil-source rock pairs, the invoked chemically and geologically consistent correlative relationship is subjective to an extent that would be unacceptable in other areas of organic geochemistry. My objectives here are to outline the reasons for the inherent subjectivity of oil-source correlations, and to recommend conceptual and practical approaches for improving them as an approach toward reducing exploration risk.

An oil-source rock correlation is a causal relationship established between the two components which is consistent with all known chemical, geochemical and geological information -- a definition originally established implicitly by Hunt et al. (1954). Specifically: (a) the relationship must be *causal* -- the oil must arise (at least in part), from the specified source rock; (b) chemical data used in the correlation must be *comparable* – the elemental, molecular and isotopic data derived from the source rock must be of the same type as that derived from the oil; and (c) all available geological data must be *supportive* -- clear geological evidence must exist which *allows* the proposed source rock to have sourced the oil. The presence of all three points is required before declaring a correlation to be successful.

The three points of this definition will be satisfied if we address one analytical and three geological aspects of the problem. Natural extraction of crude oil from its source rock – i.e., "expulsion" – differs mechanically and temporally from laboratory extraction, leading to a correlation problem referred to here as "extraction differences", and representing the single greatest analytical uncertainty in correlation efforts. Geologically, three aspects confound oil-source correlations: occurrence of multiple source units; lateral and vertical variation in source unit(s) organic matter; and lateral and vertical variation in reservoir unit(s) organic matter. Since the seminal work on multiple source units by Seifert et al. (1979), numerous authors have demonstrated the pervasive occurrence of multiple source input, and new examples will be presented here. Lateral and vertical source variability has also been demonstrated extensively, with cm-scale variations shown to be commonplace. Lateral and temporal changes in conduit and reservoir organic matter, accompanied by compositional differences due to migration-induced phase changes, are extensive in many petroleum systems. Several examples of these natural geological variations will be presented, including multiple sourcing in Alaska and China, intra-source unit organic differences in Brazil, Thailand and West Africa (e.g., $\delta^{13}C_{OM}$ ranges > 10 o/oo), and migration-induced compositional differences in the USA and elsewhere (e.g., substantial differences in molecular ratios previously thought to be source-defined). Emphasis is placed on the difficulty, and importance, of identifying the original source signature from the composition of the crude oil, in the face of post-source compositional changes caused by these multiple geological influences.

Five recommendations are forwarded as part of a unified approach to deal with oil-source rock correlation concerns, and examples of applying these actions are presented. (1) Select representative samples using statistically defensible methods. (2) Establish the inherent compositional variability – laterally and temporally – in each prospective source unit. (3) Assess the extent of migration-induced changes in oil composition. (4) Support each correlation with migration histories derived from 4d models. (5) Iterate correlation results with new data gathered from ongoing exploration efforts. These recommendations are designed (a) to allow correlation success to be measured more objectively, (b) to establish risking parameters for direct use in basin assessment, and (c) to provide baseline criteria for use in reviewing oil-source rock correlations prior to publication.

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