Tight Oil Geochemistry

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Summary

Petroleum geochemistry provides basic and highly detailed data on components and processes in a petroleum system, whether in a conventional or unconventional system. In either case understanding the source rock petroleum generation potential and related petroleum quality at a given thermal maturity are critical factors in such an assessment.

Basic understanding of the source rock in terms of original and present-day quantity and quality enable prediction of the total petroleum generation potential as well as the amount and quality of oil retained and expelled. Basic data include measured amounts of organic carbon, relative hydrogen content, and thermal maturity. Many of the best producing tight oil plays are volatile oil to condensate-wet gas in phase. The use of forward and reverse models utilizing restored oil (S1) and kerogen (S2) allows cross checking the generation potential of the source rock as well as obtaining a pseudo-oil saturation value. The latter requires a gas chromatographic fingerprint of solvent extracted oil or an end member oil sample. These data are complemented by collection of mud gas samples for gas composition and carbon isotopes (C_1-C_3) as well as wet cuttings in isojars. A few samples of the drilling mud should also be collected, and a list of mud additives is very helpful. Some organic additives in water-based muds can result in very poor-quality results if not identified. A common shale additive is Soltex®, which is a sulfonated asphalt that bonds to the rock surface albeit weakly.

The relationship between thermal maturity and petroleum phase is not necessarily straightforward. Variations in kerogen type and processes that alter reservoired petroleum may result in errors in prediction. Processes that can alter petroleum include biodegradation (more relevant to conventional reservoirs), gas exsolution and secondary charge. More detailed data provide information on the determination of oil quality and phase of petroleum at given determined levels of thermal maturity. Variations in organic matter including mixed kerogen types as well as petroleum alteration processes can be assessed by such data as oil and extract gas chromatography, pyrolysis gas chromatography, carbon isotopes, biomarkers, and diamondoids analyses.

Common citations of oil versus gas window are insufficient for sound assessment of producibility from tight oil systems. Typical oil versus gas windows must be further refined into engineering scenarios where more mature oil systems tend to flow best. There are dependencies such as system and kerogen type that must be accounted for as well as the usual criteria for successful stimulation and flow of petroleum. A hybrid system with marine carbonate sourcing may be quite different from an organic-rich marine shale system. The timing and related maturity of petroleum formation and transition to light oil, volatile oil, or condensate must be considered. The most difficult issue is often the determination of the thermal maturity with a source rock deposited and preserved in a deep marine setting where little indigenous vitrinite is present. Bitumen reflectance is variable and is

dependent on the correlation equation. A new technique utilizes quantitative aromatic hydrocarbons. Such technique may be used on either rocks or oils. As a quantitative technique it is highly reproducible. Correlation is best achieved by comparison of values to production, which may be established with available samples across a basin. This may also be combined with diamondoid data to ascertain the presence of secondary charge of gas condensate.

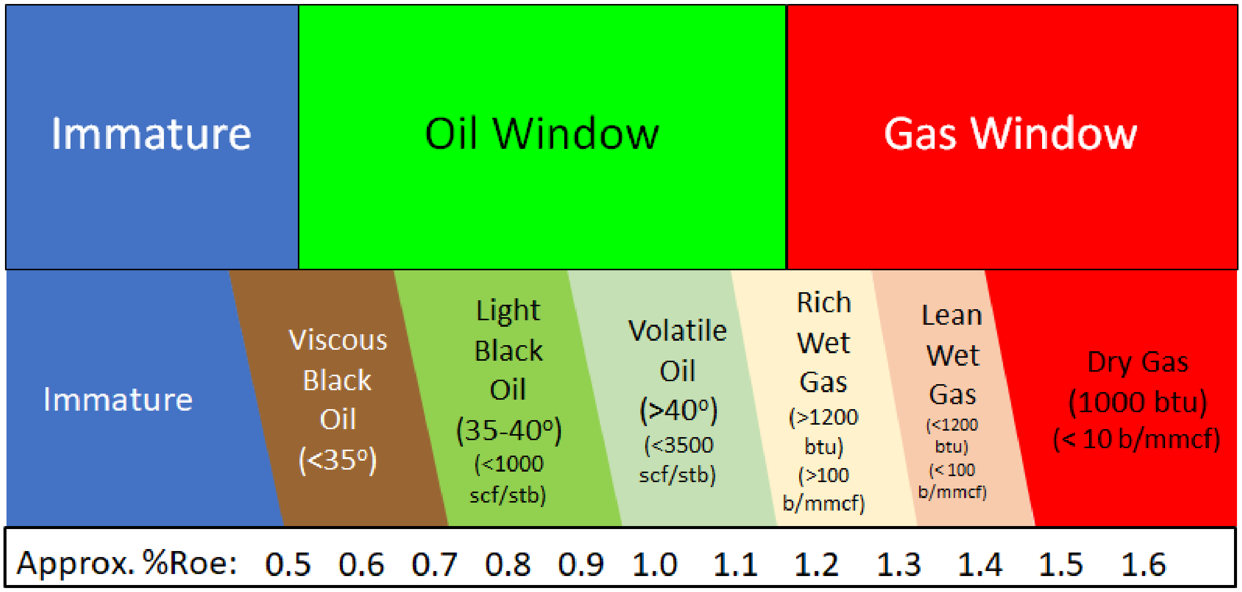

Figure 1. The best oil production is in discrete API gravity and GOR windows exclusive of other reservoir rock properties such as organic richness, brittleness, etc. System type depends on whether system is organic-rich tight rock or a hybrid system.

Allocation of production requires careful and ongoing collection of oil samples and solvent extraction of reservoir rocks. This allows assessment of how much oil is being produced from a given horizon that may change after initial stimulation of a well. Barriers may not be consistent rather being baffles that heal through time resulting in changes in which zone(s) are contributing to production.

High quality data are key to good interpretation; such high-quality data are available from most geochemical laboratories when samples are appropriately collected, preserved, and described.