Understanding Unconventional Resource Potential by Conventional Petroleum Systems Assessment

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The Permian Basin has a long standing history of oil and gas production and has attained yet another renaissance due to unconventional shale resource systems for gas and, currently, for oil and natural gas liquids. Although these are unconventional systems, understanding conventional petroleum systems enables a description of potential unconventional resource systems by inferences derived from the geochemistry of conventionally produced oils. While only limited information on Permian Basin petroleum systems have been made public, most source rocks have been identified by those working the basin, although some potential source intervals, and certainly variability in source rocks, have not been studied or reported extensively.

Inferences from geochemical oil analyses suggests at least six different source rocks with organofacies variations. These conventionally produced dead oil samples have been typed using high resolution gas chromatography, carbon isotopes, biomarkers, and sulfur contents. The following source and lithofacies inferences can be made from these results:

Inferred source rock and lithofacies
1. Permian (Leonardian) Bone Springs
   a. marly shale
   b. carbonate
2. Permian (Guadalupian) shale
3. Permian Wolfcamp
   a. shale
   b. carbonate
4. Pennsylvanian shale source
5. Mississippian Barnett Shale source
6. U. Devonian-Mississippian Woodford Shale source
7. Ordovician
   a. G. *prisca*
   b. non-G. *prisca*

One key point from these inferred lithofacies is that carbonate and marly shale sourced oils will have variable hydrocarbon generation kinetics with carbonates generating at lower thermal stress than shales, but having lower API gravity due to higher amounts of resins and asphaltenes also with higher concentrations of sulfur-bearing compounds that can impact fluid handling and economics.

Establishing the effective source rock for various conventional reservoirs requires correlation of source rock extracts to oils. Effective source rocks are targets for unconventional resource development depending on various factors such as thickness and depth to the interval. Analytical work confirms various source rock intervals and their characterstics as well as identifying additional sources that have not been documented. For example, prospective source rocks in the basin such as the Bell and Cherry Canyon formations.

Understanding the potential production of unconventional oil from tight reservoirs requires a detailed understanding of the system much as unconventional shale gas, but with different parameters. One basic parameter that demonstrates the presence of potentially producible oil is the oil crossover effect or oil saturation index (OSI) (Jarvie, 2011). In addition, while quartz content is very important in shale gas plays as it reflects increased brittleness, in shale oil resource plays carbonate contents become equally important.

A shale resource system can be described as an unconventional resource by using the terms typical and atypical for description of a reservoir rock. As such shales are not typical reservoir rocks although they have served as such for some time. An unconventional or atypical system could be predominantly a quartz-clay system such as the Barnett Shale oil play where a clay/quartz-rich system is the productive horizon or a hybrid shale resource system where an organic-rich source rock may contribute to production but primary production is from juxtaposed (overlying, interbedded, or underlying) organic-lean horizons, typically carbonates, that are tight but productive with stimulation.

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