
Extended Abstract—Shale Resource Systems for Oil and Gas

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ABSTRACT

Shale resource systems have had a dramatic impact on the supply of oil and especially gas in North America, in fact, making United States energy independent in natural gas reserves. These shale resource systems are typically organic-rich mudstones that serve as both source and reservoir rock or source petroleum found in juxtaposed organic-lean facies. Success in producing gas and oil from these typically ultra-low-permeability (in nanodarcys) and low-porosity (<15%) reservoirs has resulted in a worldwide exploration effort to locate and produce these resource systems.

Shale-gas resource systems considerably vary from system to system, yet do share some commonalities with the best systems, which are, to date, marine shales with good to excellent total organic carbon (TOC) values, gas window thermal maturity, brittle rock fabric, and low porosity and permeability. A general classification scheme for these systems includes gas type, organic richness, thermal maturity, and juxtaposition of nonsource facies. Such a classification scheme is very basic, having four shale-gas resource types: biogenic gas systems, organic-rich mudstone systems at a low thermal maturity, organic-rich mudstone systems at a high thermal maturity, and hybrid systems that contain juxtaposed source and nonsource intervals.

Generally, three types of porosity exist in these systems: matrix porosity, organic porosity derived from decomposition of organic matter, and fracture porosity. However, fracture porosity has not proven to be an important storage mechanism in thermogenic shale-gas resource systems.

To predict accurately the resource potential, determination of original hydrogen and organic carbon contents is necessary. This has been a cumbersome task that is simplified by the use of a nomograph (Figure 1) and a frequency distribution (P50) hydrogen index of 475 mg hydrocarbon/g TOC for type II marine shale source rocks in the absence of immature source rocks or data sets.

A basic classification scheme for shale-oil resource systems includes fractured mudstone, tight mudstone, and hybrid mudstone systems, which are different from most thermogenic shale-gas resource systems because open fractures are typically not a key component of shale-gas systems. Hybrid systems typically

include mudstones with abundant amounts of interbedded or juxtaposed closely associated organic lean carbonates or other lithofacies.

Potentially producible oil zones can readily be recognized using basic geochemical data. Such recognition relies heavily on the oil crossover effect, such that when the oil saturation index (OSI) exceeds 100 mg hydrocarbon/g TOC, potentially producible petroleum is present. This is shown to be true for fractured Monterey, Cody, and Bazhenov shales; tight Antelope, Monterey, Mowry, Cane Creek, Tuscaloosa, and Barnett shales; and hybrid Eagle Ford Shale and Bakken Formation reservoirs (Figure 2).

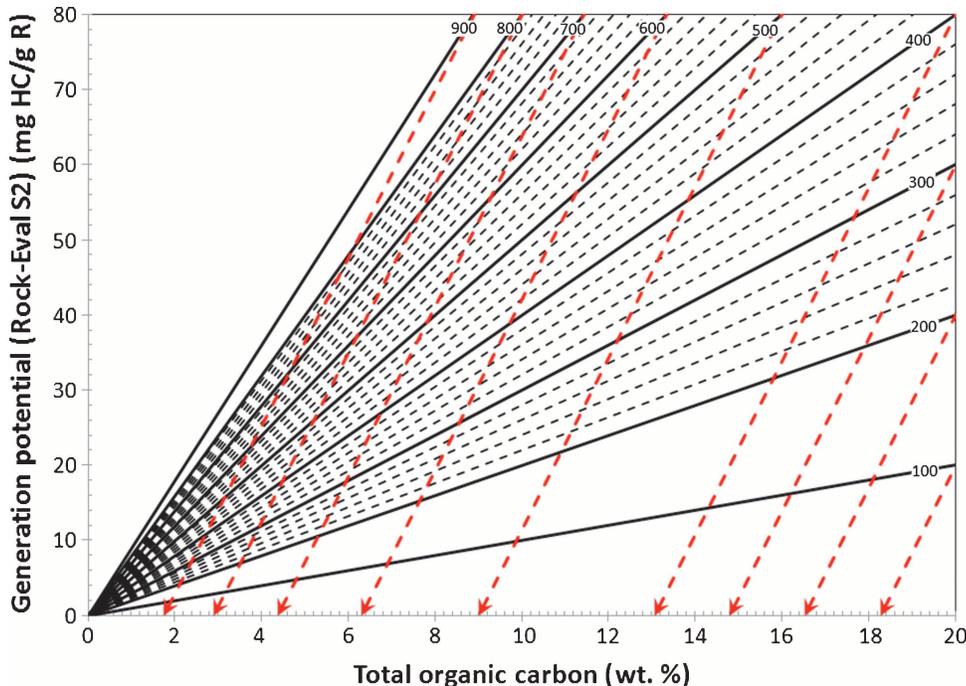


FIGURE 1. Iso-original hydrogen indices and isodecomposition lines. Solid and dashed black lines are isohydrogen index lines, whereas red dashed lines are decomposition lines. Original total organic carbon (TOC) values can be derived by taking adjusted present-day TOC values and projecting along a line parallel to any iso-decomposition line to original hydrogen index (HI). A perpendicular drop line gives the original TOC. S2 = Rock-Eval measured oil contents.

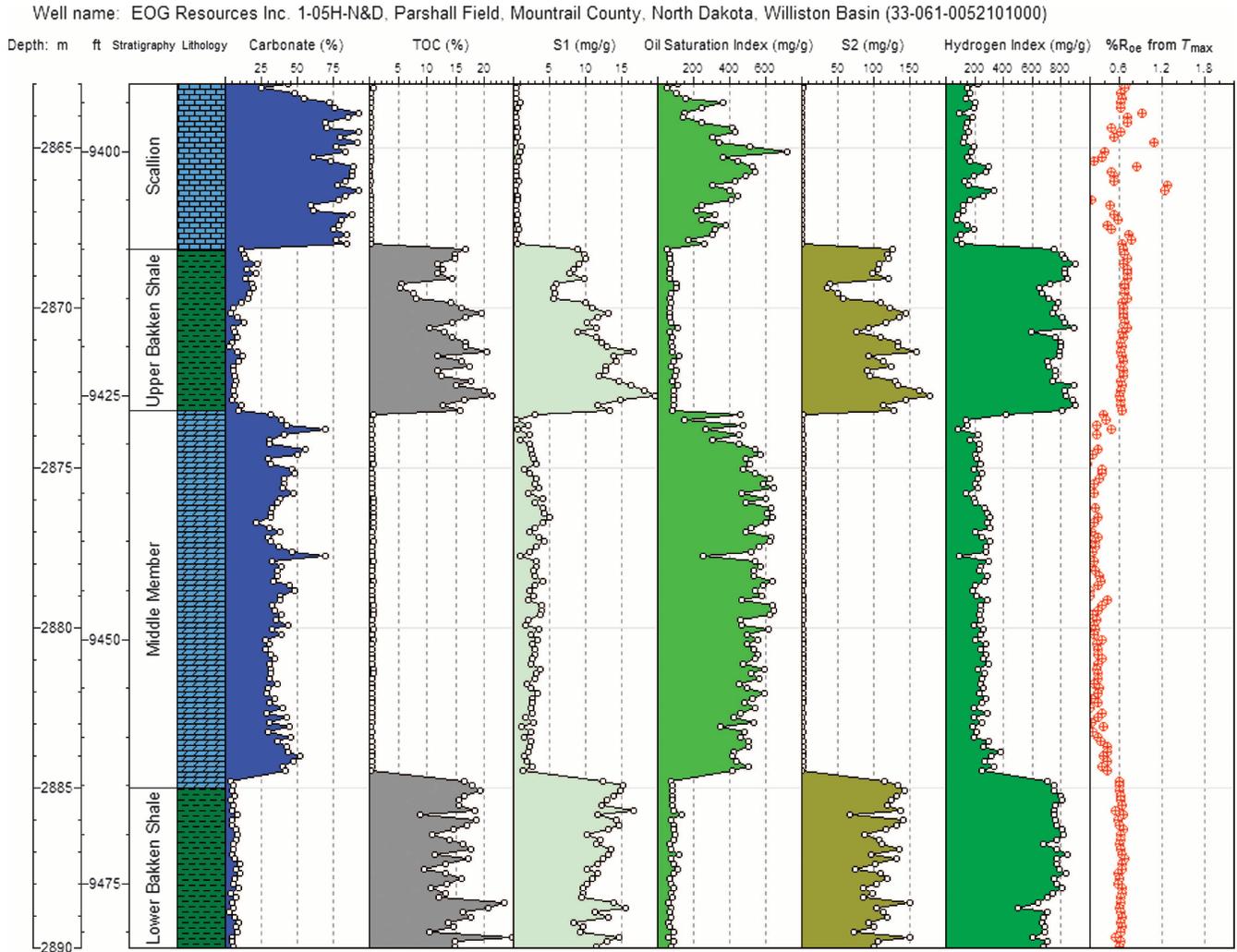


FIGURE 2. EOG Resources Inc. 1-05H-N&D geochemical log showing the geochemical results for the Scallion and Bakken formations. This log illustrates the oil crossover effect (S1/total organic carbon [TOC]) for the carbonate-rich Scallion and Middle Member. The upper and lower Bakken Shales are organic rich and carbonate lean but have high oil contents for the level of thermal maturity (~0.60% R_{oe}). The high oil contents in the Bakken shales are offset by the high retention of oil. S1 = Rock-Eval measured oil contents. S2 = Rock-Eval measured kerogen yields.

