Application of Rock Geochemistry and Advanced Surface Logging Techniques to Predict Rock Heterogeneity and Fluid Distribution in Unconventional Reservoirs

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ABSTRACT

Assessment of rock heterogeneity and fluid distribution along the lateral unconventional reservoirs has a significant impact on the quality of completion and production. Geochemical data acquired from drilled cuttings allows prediction of rock heterogeneity while fluid composition data from real-time mud gas measurements establishes fluid distribution in the reservoir.

The recent surge in production in Oklahoma have stimulated economically feasible production in Mississippian Meramec limestone and Devonian Woodford shale formations. In the following case study, lateral wells were logged in the two formations acquiring rock composition from drilled cuttings and real-time mud gas data.

The mineralogy and elemental composition of the drilled cuttings were analyzed using X-Ray Diffraction and X-Ray Fluorescence. The analysis provided the full lithofacies of geological formations including information on the sedimentary deposition and diagenetic events. This case study presents a correlation between lithofacies and the petroleum system, based on the association of organic matter and the source rocks.

The organic matter is preserved in unique geochemical conditions that are linked to depositional environments, lithofacies and trace elements like Mo, U, Ni, V, Zr, Fe, S, etc. The lithofacies are integrated with fluid facies derived by fluoroscopy and real-time mud gas data by gas chromatography. Fluid characterization can be enhanced using real-time mass spectrometry and continuous measurement of stable carbon isotope. Fluid geochemistry is important in the evaluation of reservoir for hydrocarbons in-place, distribution, thermal maturity stage, and quality.

Meramec and Woodford formations exhibit different rock composition. These reservoirs exhibit some degree of lateral compartmentalization and discontinuity. The resulting mineral heterogeneities can be the result of the sedimentary depositional sequence followed by local diagenetic changes. Integration of petrophysical and geomechanical information provides further insight into diagenetic events and reservoir properties such as permeability/cementing and porosity. Fluid heterogeneities recorded in Meramec and Woodford formations may be attributed to natural fractures, permeability barriers or reservoirs charging models.

Reliable information of rock quality, heterogeneity, depositional environment and fluid distribution along the lateral serves as a critical factor for engineered fracking design and completion optimization.