AAPG Datapages/Search and Discovery Article #90242 © 2015 AAPG Education Directorate, Geoscience Technology Workshop, Revitalizing Reservoirs-Rocky Mountains, MidContinent, Canada, International Focus, Golden, Colorado, August 11-12, 2015

Fracture Intensity, Relative Permeability, and Distinction Between Brittle vs Ductile for Unconventional Reservoirs Using Standard Triple/Quad Combo Logging Suites: Examples from the Bakken and Niobrara

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Abstract

Fracture Intensity

Calculations involve examining ratio of change of curve magnitude with depth. If the change is considered to be too rapid to be explained from likely primary geologic variation, a fracture is inferred. Trends to high porosity are interpreted as open fractures, and to low porosity closed (cemented) fractures. Indication of fractures from a single curve is discounted. However, if multiple curves show the same pattern, especially over a continuous depth range, a fracture swarm is suggested.

Relative Permeability

Examination of porosity/water saturation cross plots (Buckles Plot) can be interpreted to identify levels at irreducible water saturation. Intervals where water saturation is greater than irreducible can be identified. By comparing actual water saturation with theoretical irreducible water saturation, relative permeability curves to both wetting and non-wetting phases can be determined using equations developed by Corey (1954). The Corey relations are based on extensive analysis of measured capillary pressure and relative permeability data.

Brittle vs Ductile

Using Rock Physics petrophysical modeling, it is possible to generate pseudo acoustic data (both compressional and shear) from other logs. The pseudo logs require knowledge of matrix and clay acoustic properties by petrophysical zone. These can be determined by matching pseudo data with measured acoustic data. Once these matrix and clay properties have been established, the pseudo data can be used reliably in wells where no acoustic measurements have been made. Also, the pseudo data can be used to verify accuracy of measured data, and to fill in intervals when, for example, shear data is missing.

Using compressional and shear acoustic data together with density log data, a full suite of mechanical properties can be calculated. Brittle/ductile distinction is accomplished by comparing Poisson’s Ratio with Young’s Modulus. Brittle intervals have high values of Young’s Modulus and low values of Poisson’s Ratio. Ductile rocks are the reverse.

A continuous profile of brittle vs ductile can be used to aid in deciding intervals to complete, and to estimate barriers to fracture growth.