Petrophysical Modeling of Unconventional Reservoirs Using Standard Triple/Quad Combo Logging Suites: Examples from the Bakken and Niobrara

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Abstract

Unconventional reservoirs are composed of several types of porosity/hydrocarbon components – standard effective porosity, clay porosity, total organic carbon (TOC), and micro porosity associated with shales. Adsorbed hydrocarbons reside in the TOC component and "free" hydrocarbons in the effective porosity and shale micro porosity. An accurate definition of all these components is essential in defining the reservoir hydrocarbon resource volume.

TOC has a density response close to porosity and indeterminate neutron response. The log responses are probably related to the degree of thermal maturity.

Previous publications (Holmes, et al. AAPG 2011 and 2012) were earlier attempts to define these porosity components. This publication is a significant refinement, whereby TOC and clay log responses are determined using an iterative technique. An initial estimate of TOC properties (density vs. neutron) is subtracted from raw logs to derive a "TOC-free" log response. Then clay log responses are defined by subtracting matrix, effective porosity, and silt contributions. The resulting density/neutron cross plot is then compared with known clay mineral responses to determine if estimates of the various component log responses are reasonable. If not, these responses are adjusted and the procedure is repeated. A final check of the methodology is to calculate a reconstructed porosity, which is the sum of effective porosity, clay porosity, and shale micro porosity, and see if it agrees with total porosity determined from the "TOC-free" reservoir model.
Examples are presented from the Bakken (Montana) and Niobrara (Colorado).