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Petrophysical Characterization Workflow for Shale Reservoirs by Integrating Quad Combo, Spectroscopy, Nuclear Magnetic Resonance, and Dielectric Data

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ABSTRACT

Shale gas and oil reservoirs have rapidly become viable alternative energy resources. To explore and evaluate these reservoirs with only conventional quad combo logs is complicated because of limitations in existing tools. Therefore, it is necessary to address these challenges by integrating conventional quad combo data with high-tech tool data for better petrophysical evaluation of these reservoirs. Shales have complex and varying mineralogies. Additionally, when using a conventional log, the presence of kerogen complicates obtaining an accurate porosity estimation, and conductive mineral-like pyrite, the presence of micropores and nanopores, and intrakerogen porosity complicate hydrocarbon saturation estimation. Because of the complex nature of source rock reservoirs, it is difficult to determine true potential by using conventional workflow. This paper demonstrates a workflow designed to characterize shale reservoirs by integrating quad combo, spectroscopy, nuclear magnetic resonance (NMR), and dielectric data. This integrated workflow helps identify intervals that have potential and will be easy to frac. Water saturation calculation is an important and challenging output for these reservoirs. It has not been possible to calculate water saturation by using resistivity data because this data is affected by the presence of conductive minerals, which are very common in these reservoir types. Additionally, using conventional methods, other parameters, such as Archie’s parameters and formation water resistivity, are required to calculate water saturation. Dielectric logging tools can distinguish water from both kerogen and hydrocarbon. Therefore, dielectric data was integrated with spectroscopy to calculate accurate water saturation and mineralogy for these reservoirs. It was not possible to calculate total porosity directly by using density, density-neutron, or sonic logs in this type of reservoir because of the presence of kerogen. To obtain accurate total porosity, a correction for kerogen volume was applied. Kerogen volume was quantified by integrating density and NMR data. Kerogen volume was converted into total organic carbon, which was then used as an input in the model to calculate accurate total porosity. Sonic anisotropy data was used to calculate elastic properties (Poisson’s ratio and Young’s modulus), fracture initiation and closure pressure, and brittleness for these reservoirs. These outputs help identify zones that can be fractured easily.