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Improvement of the Conductivity Model in Isolated Porosity Carbonates with Digital Rock Physics Analysis

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ABSTRACT

The quantification of formation properties in carbonate rocks is challenging due to their complex depositional and diagenetic history. Diagenesis often overprints the depositional fabric and can lead to the creation of isolated pores bounded by rims of tight secondary carbonate. In such cases, the fluids in these isolated pores are essentially inaccessible to the electrical currents of the resistivity tool making it difficult to consistently identify saturation. This can lead to erroneous hydrocarbon saturation estimates from wireline logs. This current study illustrates improvement in the conductivity model as well as cementation exponent in isolated porosity carbonates through use of digital rock physics analysis.

Micro X-ray computed tomography (microCT) analysis of the conductivity, resistivity index and formation resistivity factor can provide real constraints for the petrophysical input parameters for hydrocarbon saturation analysis. Ten carbonate core plug samples with isolated porosity were selected for analysis. Tomograms of 38mm diameter core plugs with resolution of approximately 23 µm were incorporated with 3-6 mm sub-plugs with resolution of up to 2 µm to visualize the pore network. Mercury injection capillary pressure data and backscatter scanning electron microscopy images were further used to constrain petrophysical properties such as porosity, permeability, conductivity, formation resistivity factor and cementation exponent.

An improved conductivity model, taking into account electrical properties of the rock with isolated porosity, provided a better match between oil saturation calculations from wireline logs and well tests/production data. Comparison of existing standard log analysis results with modified log-derived saturations from microCT analysis can give a more reliable estimate of hydrocarbon saturation in the reservoir.