Innovative Fluid Identification Method by Integrating Array Dielectric Measurements, Nuclear Magnetic Resonance and Spectroscopy Data: One Case Study in the Low Contrast Complex Oil Reservoir, Bohai Bay, China

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ABSTRACT

Shahejie formation of the Bohai Bay, is characterized by complex lithology with various minerals, low formation water salinity, high pore structure heterogeneity and flooding, which complicates the logging responses, especially the low contrast of resistivity. Traditional methods can hardly to quantify the complex minerals and evaluate the petrophysical parameters accurately, moreover the fluid types are difficult to identify with the similar logging responses. In this study, the reservoir heterogeneity was investigated using spectroscopy data and nuclear magnetic resonance data, and then oil saturation was inverted using array dielectric data. By comparing the free fluid porosity from NMR with the oil-filled porosity from array dielectric measurements, a special reservoir evaluation and fluid identification method was established. The dielectric properties of water are very different from that of oil, and other formation components, making dielectric measurements particularly useful for saturation evaluation independent of resistivity. However, zones with the same water-filled porosity may produce different fluids due to heterogeneity in pore structure. Nuclear magnetic resonance data, spectroscopy data and borehole images can be used to analyze the properties related to reservoir heterogeneity, such as mineralogy, free fluid porosity, pore-size distribution and irreducible water-filled porosity. By comparing the oil-filled porosity from array dielectric measurements with the free fluid porosity from NMR, the relative ratio of oil in the free fluid porosity can be calculated, which has been proved to be the driving factor of fluids types. This method can help to identify oil zones with high irreducible water saturation and water zones with residual oil saturation, which is not possible from resistivity measurements alone. This method has been applied in five wells, and all the sampling results agree well with our interpretation, which has demonstrated the effectiveness of the proposed method. Producible fluid identification has been improved by 30% using the new method. Identifying producible fluid from resistivity alone has been a challenge in these kind of complex reservoirs. The combination of dielectric and nuclear magnetic resonance data overcame this difficulty by incorporating resistivity-independent saturation with reservoir heterogeneity information in an innovative way.