ENHANCED ASSESSMENT OF FLUID SATURATION IN THE WOLFCAMP FORMATION OF THE PERMIAN BASIN

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Abstract:

Conventional resistivity models often overestimate water saturation in organic-rich mudrocks and require extensive calibration efforts. Conventional resistivity-porosity-saturation models assume brine in the formation as the only conductive component contributing to resistivity measurements. Enhanced resistivity models for shaly-sand analysis include clay concentration and clay-bound water as contributors to electrical conductivity. These shaly-sand models, however, consider the existing clay in the rock as dispersed, laminated, or structural, which does not reliably describe the distribution of clay network in organic-rich mudrocks. They also do not incorporate other conductive minerals and organic matter, which can significantly impact the resistivity measurements and lead to uncertainty in water saturation assessment. We recently introduced a method that quantitatively assimilates the type and spatial distribution of all conductive components to improve reserves evaluation in organic rich mudrocks using electrical resistivity measurements. This paper aims to verify the reliability of the introduced method for the assessment of water/hydrocarbon saturation in the Wolfcamp formation of the Permian Basin.

Our recently introduced resistivity model uses pore combination modeling to incorporate conductive (clay, pyrite, kerogen, brine) and non-conductive (grains, hydrocarbon) components in estimating effective resistivity. The inputs to the model are volumetric concentrations of minerals, the conductivity of rock components, and porosity obtained from laboratory measurements or interpretation of well logs. Geometric model parameters are also critical inputs to the model. To simultaneously estimate the geometric model parameters and water saturation, we develop two inversion algorithms (a) to estimate the geometric model parameters as inputs to the new resistivity model and (b) to estimate the water saturation. Rock type, pore structure, and spatial distribution of rock components affect geometric model parameters. Therefore, dividing the formation into reliable petrophysical zones is an essential step in this method. The geometric model parameters are determined for each rock type by minimizing the difference between the measured resistivity and the resistivity, estimated from Pore Combination Modeling.

We applied the new rock physics model to two wells drilled in the Permian Basin. The depth interval of interest was located in the Wolfcamp formation. The rock-class-based inversion showed variation in geometric model parameters, which improved the assessment of water saturation. Results demonstrated that the new method improved water saturation estimates by 32.1% and 36.2% compared to Waxman-Smits and Archie's models, respectively, in the Wolfcamp formation. The most considerable improvement was observed in the Middle and Lower Wolfcamp formation, where the average clay concentration was relatively higher than the other zones. Results demonstrated that the proposed method was shown to improve the estimates of hydrocarbon reserves in the Permian Basin by 33%. The hydrocarbon reserves were underestimated by an average of 70000 bbl/acre when water saturation was quantified using Archie's model in the Permian Basin. It should be highlighted that the new method did not require any calibration effort to obtain model parameters for estimating water saturation. This method minimizes the need for extensive calibration efforts for the assessment of hydrocarbon/water saturation in organic-rich mudrocks. By minimizing the need for extensive calibration work, we can reduce the number of core samples acquired. This is the unique contribution of this rock-physics-based workflow

Bio:

Sabyasachi Dash is a PhD student in the Department of Petroleum and Geosystems Engineering at The University of Texas at Austin. He holds a Master's degree in Geophysical Technology from Indian Institute of Technology, Roorkee. Sabyasachi has six years of experience as an Exploration Geophysicist working for Cairn India Ltd in fluvial rift systems and thrust belt area. Sabyasachi is currently a graduate research assistant at The University of Texas at Austin under the supervision of Dr. Zoya Heidari. His research interests include formation evaluation, multi-scale petrophysics, rock physics and mathematical modeling.