Influencing Factors Study of a Carbonate NMR T2 Cutoff Determination

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Abstract

Nuclear Magnetic Resonance (NMR) well logging provides a list of important Petrophysical properties, such as permeability estimation. Typical T2 cutoff values of sandstones (33ms) and carbonates (90ms) are inadequate for the application of the permeability model to many formations of residual oil saturation by water-based mud filtrate invasion. Laboratory calibration in core plugs is often needed to determine the T2cutoff by centrifuging method. However, there is no apparent criteria for what desaturation pressures or centrifugal speeds to be used for rocks of different types. This study is to assess the uncertainty caused by different experimental parameters, including different oil saturations.

The so-called irreducible water saturation is considered to be reached when the rate of saturation reduction and the effect of remaining saturation on permeability become negligible above certain speeds. Both over and under desaturation could occur, affecting T2cutoff and subsequent correlation coefficient determination. This study utilizes the T2 spatial measurement at multiple speeds to obtain the continuous change of T2 cutoff as a function of desaturation pressure. All correlations from low, medium and high permeability carbonate core samples are compared.

For most core samples, it is found that the regression coefficient of the permeability model increases as the desaturation pressure increases, reaches a maximum, and decreases as the desaturation pressure continue to increase. The optimal pressure depends on both permeability and the pore modality. For samples of medium to high permeability with dominant macro pores, the optimal pressure can be closely linked to the permeability. For samples of low permeability, especially with multiple pore systems, it depends less on the permeability and more on the pore modality. The T2 cutoff can be affected by the oil saturation, which overlaps with the water signal.

In summary, better coefficients for the permeability estimation are obtained by the new experimental calibration procedure using T2 spatial measurement. Optimal desaturation pressure can be estimated from permeability and pore modality instead of by trial and error. The model can be applied to the formation with minimized calibration uncertainty adjusted based on the oil/water saturations.