

A Universal Equation to Calculate Shale Volume for Shaly-Sands and Carbonate Reservoirs

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Abstract

It is common to use the standard gamma ray log (SGR) or the total contribution from all three elements - uranium (U), potassium (K), thorium (Th) - as an indicator of shale content. The linear IGR shaliness indicator model over-estimates the shale volume. The nonlinear models have been developed for specific geographic areas or formation ages. All non-linear relationships are more optimistic in that they produce a shale volume value lower than that from the linear equation. On the other hand, the presence of highly-radioactive black organic material in carbonate or unconventional reservoirs "gas/oil shale", overestimates the shale volume. In all cases, an accurate determination of shale volume impacts in the calculation of formation porosity and water saturation and therefore affects the original oil in place (OOIP) and reserves.

The question from engineers and geoscientists: which is the best model to be used? We have found that the sigmoidal function can be used for any kind of reservoir: shaly-sands or carbonates with highly radioactive black organic material or presence of radioactive material in factures. We have tested our new equation for carbonate reservoirs in Venezuela and Mexico; shaly-sands reservoirs in Colombia, Venezuela including deepwaters in the Gulf of Mexico. In all cases, the calculated V_{shale} volumes have been validated with the X-ray diffraction data or the elemental capture spectroscopy (ECS) logs that quantify the actual clay volume (V_{sh}) and achieve correlation coefficients, r^2 , greater than 0.92.