Improved Characterization of Heterogeneous Reservoirs Using Cluster Analysis of Log Data

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Summary

Reserve estimates of gas in place and predictions of reservoir production and recovery depend on robust estimates of reservoir and mechanical properties. These estimates most frequently come from analysis of log data. However, log analysis in unconventional and tight-gas reservoirs is complicated by the fact that these reservoirs are often very heterogeneous, with highly variable matrix properties and low porosities and permeabilities. Consequently, many of the calculations and empirical relationships used to determine reservoir and mechanical properties in conventional reservoirs (e.g. Archie Equation, Wyllie Equation, assumptions of isotropic behavior, or even density-neutron cross-plotting) do not work in tight sands and shales and their use can lead to large errors in the estimates of reserves. This should come as no surprise since Wyllie and Archie, for example, state upfront that their relationships do not apply to these types of rocks, so in order to come up with more robust estimates of reserves, new methodologies need to be developed and employed.

One technique that we have used successfully to predict properties from logs in tight-gas and shale reservoirs is n-dimensional cluster analysis and correlations between cluster-based electrofacies and detailed core analysis. Core-log integration in this manner can be used to derive robust predictive models of reservoir and mechanical properties, based on logs, while pattern-recognition technologies (cluster "tagging") can be used to determine where, in uncored wells, these models can (or cannot) be reliably applied. From the predictive models, it can be determined which units are the most favorable for producing hydrocarbons and which may or may not provide hydraulic fracture containment. Then by using cluster "tagging", these same zones can be identified and modeled in subsequent, uncored wells based on logs alone. With a population of wells evaluated in this way, 3D models can be created to determine the distribution of the best hydrocarbon-bearing zones and the relationship of these zones to potential fracture containment units. These 3D models can also be used to evaluate where uncertainties in reservoir property characterization may exist for more targeted rock work, from which the models can be iteratively improved.