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Log-Derived J Functions for Calculating Saturations, Estimating Permeability, and Identifying Reservoir Compartments

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ABSTRACT
A new method is presented for using log-derived J functions to calculate saturations, estimate permeability, and identify compartments in reservoir models comprising a multitude of zones, fault blocks, PVT relationships, and rock types. By honoring well-established principles of capillarity, the method provides a physically reasonable way to capture reservoir heterogeneities in porosity, permeability, and saturations as evidenced in well logs and imbed them in 3D geological and flow simulation models.

The past decade has seen vast improvements in the 3D reservoir modeling of facies and porosity. However, far less attention has been given to the 3D modeling of saturation and permeability. At first this may seem surprising. After all, saturations and permeability are essential to answering the key reservoir production questions of "how much?" and "how fast?" However, unlike facies distributions, which are largely within the domain of geologists, saturation modeling requires contributions from geologists, geophysicists, engineers, and petrophysicists. Saturation modeling must account for stratigraphic variability, structural complexity, aquifer flow, variable fluid properties, core measurements, and well log measurements. Getting it right means forging bridges across the interdisciplinary abyss.

Interpretation of log-derived J functions is inherently an interdisciplinary process. It begins with considering clusters of wells simultaneously, rather than one-by-one, within a structural and stratigraphic context. A natural outcome of the search for J functions is the identification of free water elevations, which signal the presence of reservoir compartments. This search is facilitated by additional information such as reservoir zone, fault block, and lithofacies, which are normally contained in 3D geological models. Because the method uses log data, the resulting J functions are representative of reservoir heterogeneity and apply to reservoir conditions. Additional benefits of this approach are that inconsistent interpretations can be easily identified for correction. Of particular note is our methodology for improving estimates of Archie's cementation and saturation exponents.

Estimations of permeabilities and irreducible saturations can be improved by bringing log measurements of porosity and water saturation data into conformance with a limited number of J functions. These J functions are used to identify a newly defined rock attribute called J Facies, which may span multiple equilibrium regions and are suitable for geostatistical indicator simulations.

Several examples of this new methodology are shown. In one example, the calculated oil-water contact grids exhibit more than 30 meters of relief within equilibrium regions, thus demonstrating the importance of the method for planning wells. This methodology is now patented. It has been applied to numerous fields worldwide. In Canada, it has been used on East Coast light oil reservoirs and heavy oil reservoirs in Alberta, even one in which the oil resides below the water phase.