The Sensitivity of Water Saturation Calculation and Modelling to the Uncertainties of the Petrophysical Inputs

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Water saturation (Sw) spatial distribution within a hydrocarbon-bearing zone is a critical factor influencing reservoir management and directly impacts business-critical processes including reservoir economics, production performance and facilities capacity handling. However, derivation of the saturation parameter itself is subject to a large degree of uncertainty in terms of both its calculation and also its distribution within the inter-well spaces. Describing and quantifying the Sw uncertainties prevalent in all reservoir models is an important element of understanding and mitigating risks inherent in reservoir management.

This work documents a case study from a producing carbonate reservoir in Abu Dhabi, UAE. A reservoir model was constructed for hydrocarbon-in-place calculations and the analysis of simulation based reservoir production performance for forward development planning.

The saturation data was interrogated at two scales:

1. 1D analysis of the calculation of Sw itself from petrophysical, core analysis and SCAL inputs
2. 3D analysis of the spatial population of the reservoir model with Sw data

In 1D, the input petrophysical parameters derived from log and SCAL data such as porosity, cementation factor, saturation exponent, formation water resistivity, true formation resistivity and capillary pressure data are subject to different uncertainties related to data acquisition and analysis (such as different tools, techniques and contractors) and/or interpretation (e.g. porosity calculation and core analysis data interpretation).

In 3D, the static distribution of initial Sw is sensitive to structural variations relative to hydrocarbon contacts, distribution of reservoir rocktype (saturation region) to which the saturation formula may be tied, the careful selection of data unaffected by production related fluid displacements and also resolution effects related to the dimensions of the cellular framework itself.

For the reservoir featured, detailing the sensitivity of the Sw calculation and its subsequent distribution proved crucial in providing a numerical description of the uncertainties, yielding direct input for risk management and contingency planning processes.