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Evaluation of Resistivity Index Methods - A North Sea Case Study

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ABSTRACT

Resistivity index (I) was measured on a suite of sandstone plugs cut from preserved cores from North Sea Jurassic and Triassic reservoirs. Duplicate plugs were drilled at each horizon and prepared by soxhlet extraction and oven drying. A set was saturated with brine, desaturated and flooded with crude oil. Ageing for 1000 hours at reservoir temperature followed. Cleaned and aged plugs were available for resistivity index testing.

Resistivity index was determined on cleaned plug sets using an air-brine porous-plate technique, and on the aged plugs using a crude oil-brine continuous injection method. The porous-plate, drainage, I data were determined at both ambient and effective reservoir stress using a four-electrode cell. Air displaced brine during the tests. The continuous injection I data were measured at effective reservoir stress using a two-electrode cell. The samples were initially at irreducible water saturation (S_{wi}), containing brine and crude oil. Brine displaced crude oil in the tests.

Several I-S_w curve shapes were observed in the porous-plate and continuous injection tests. Both linear and "discontinuous" trends were observed in the porous-plate ambient data, whereas linear trends dominated the porous-plate effective reservoir stress data. The discontinuity in the porous-plate data occurs when the continuous brine film ruptures during desaturation, allowing air, the non-wetting phase, to contact the grains. The plugs used for continuous injection were rendered moderately to strongly oil-wet by the ageing process. "Knee" and "sigmoidal" trends dominated the continuous injection data with both "knee" and "sigmoidal" inflexion points occurring at about 34 % S_w. The "knee" and "sigmoid inflexion point" are believed to occur at the point where the injected brine becomes a continuous phase, thus dramatically improving the electrical path. Curve type did not correlate with pore geometry.

The saturation exponent from the porous-plate tests increased with effective reservoir stress when a least-squares fit of the data was used. However, no change was observed when using a two-point method, which uses I at S_{wi}. The value of n determined from the 2-point method does not change appreciably due to measurement method (porous-plate or continuous injection).

The 2-point method of deriving n is recommended for use in estimating initial water saturation in reservoirs of the type studied. This is a pragmatic approach which allows evaluation in non-Archie situations. However, the fluids used in the testing, their distribution, and the S_{wi} reached, must be similar to those found in the reservoir.

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