Effect of Mineralogy on Imbibitions Relative Permeability Behavior in Gharif Formation

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Abstract

Capillary pressure (Pc) and relative permeability (kr) are important parameters in reservoir engineering calculations and numerical simulation of reservoir performance because they have a major effect on multiphase flow process in porous media. The former gives reliable information on the evaluation of reservoir fluid distribution, while the latter is essential in predicting the production performance, residual fluid saturations, fractional flow, and ultimate recovery. In practice, laboratory measurements of relative permeability and capillary pressure are performed on representative core samples collected from petroleum-production wells. However, this approach has several limitations including high cost of well coring, insufficient core samples to cover the entire reservoir, long experimental times, difficulties in interpreting the experimental data as a result of capillary end effects and displacement rate sensitivity. Consequently, empirical correlations are often used to estimate relative permeability using data extracted from Laboratory experiments.

Generally, depositional environments have a major effect on pore architecture, clay contents and rock mineralogy which make them some of the factors that are responsible for relative permeability variation from one formation to another. As a consequence, several correlations for estimating relative permeability were developed for different rock types (sandstone and carbonate) with different wettability.

A comprehensive investigation was carried out in this study to explore the similarities and differences in mineralogy and grain size within Gharif formation with the objective of studying the geological effects on experimental kr behavior. 98 kr and Pc experimental collected data were quality checked using a specific criterion for different experiments; steady state and single speed centrifuge for kr and multi-speed centrifuge for Pc resulting in 34 qualified kr and Pc curves. The qualified 21 kr curves were corrected for capillary end effects using MoReS simulator. Then, principal component analysis (PCA) was conducted using XLSTAT 2012 software to map out the geological factors responsible for kr variations within different fields in Gharif (clay content, grain size, and mineralogy). As a result, authigenic quartz and illite were found to be more dominant in Gharif north while feldspar in Gharif south. Six groups, UG-North, UG-south, MG-north, MG-south, LG-north and LG-south, of data were identified. Based on this, experimental kr were grouped in order to study the kr behaviour in context of mineralogy effects. Generally, three types of clay (illite, chlorite and kaolinite) in Gharif had almost the same effect in terms of decreasing end point water relative permeability and increasing irreducible water saturation. There was not enough kr data available to draw conclusions with confidence for each of the six groups, leading to development of kr reference model for Gharif. The robustness of this model has been challenged by the shortage of qualified data. However, 9 out of 22 corrected experimental kr curves fit the base case of the developed model which in turn eliminates the concerns about its reliability.