Validation of Simulated Relative Permeability Estimates in Very Low Permeability Rocks

Nick Drenzek, *Ryan* Antler, *Shawn* Zhang, *James* Howard

Abstract. Simulation of various petrophysical properties based on high-resolution images of reservoir rocks nominally requires validation with selected laboratory measurements. In the case of very low-permeability, low porosity unconventional reservoirs, the cost and time required for these validation experiments is significant. A workflow was developed that highlights the minimum in measured static and dynamic properties required to evaluate 2- and 3-phase relative permeability simulations in shale samples. A fossiliferous organic-rich shale noted by its complex fabric of large carbonate fragments floating in a fine-grain matrix of clay minerals and organic matter was used in this study. A low-resolution (~20 microns/voxel) microCT scan of the 2.5 cm diameter core plug was captured before and after measurement in a steady-state flow set up. Inspection of these images revealed faint longitudinal cracks that likely affected flow properties. Steady-state permeability to water (SSKw) measured at an effective stress of ~2500 psi was 50 nD. Subsequent gas flow and pressure decay permeability results acquired on the dried sample under significantly less effective stress were up to three orders of magnitude greater. Low-field NMR and mercury injection capillary pressure measurements indicated a bimodal distribution of pores and throats, while the NMR results show very low residual oil saturations after the SSKw test. The mercury drainage curve validated the pore geometry captured from the images. The relative permeability endpoints were defined by the SSKw and SSKo permeability and the NMR-based saturations. A 3D image volume acquired from FIB-SEM was used for the simulation of relative permeability and other basic petrophysical properties of the matrix-rich portion of the shale. These results were upscaled to a high-resolution microCT volume (~ 1 micron/voxel) that included regions of solid grains. These results were then applied to the low-resolution microCT volume, where the role of the cracks in the core plug were tested, and in some cases removed numerically.