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Multiphase flow of carbon dioxide and brine in dual porosity carbonates

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The storage of carbon dioxide in subsurface formations presents a challenge in terms of multiphase flow characterisation. Project planning requires an understanding of multiphase flow characteristics such as the relationship between relative permeability and saturation. At present there are only a limited number of relative permeability relations for carbon dioxide-brine fluid systems, most of which are measured on sandstone rocks.

In this study coreflood experiments are performed to investigate the relative permeability of carbon dioxide and brine in two dual porosity carbonate systems. Carbon dioxide is injected into the brine saturated rocks in a primary drainage process. The rock fluid system is pre-equilibrated to avoid chemical reactions and physical mass transfer between phases. The pressure drop across the samples, the amount of brine displaced and the saturation distribution within the rocks are measured. The experiments are repeated on the same rocks for the decane-brine fluid system.

The experimental data is interpreted by simulating the experiments with a continuum scale Darcy solver. Selected functional representations of relative permeability are investigated, the parameters of which are chosen such that a least squares objective function is minimised (i.e. the difference between experimental observations and simulated response).

The match between simulation and measurement is dependent upon the form of the functional representations. The best agreement is achieved with the Corey [Brooks and Corey, 1964] or modified Corey [Masalmeh et al., 2007] functions which best represent the relative permeability of brine at low brine saturations. The relative permeability of carbon dioxide is shown to be lower than the relative permeability of decane over the saturation ranges investigated. The relative permeability of the brine phase is comparable for the two fluid systems. These observations are consistent with the rocks being water-wet. During the experiment only a portion of the full saturation range is investigated, corresponding to carbon dioxide entering the macro pores of the dual porosity systems. Within this pore space the relative permeability behaviour is comparable to that measured in Berea sandstone.

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