Fluid Behaviour in Porous Materials Studied by NMR

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Fluid-accessible volumes and reactive interfaces in geological systems must be quantified to improve our understanding of geosystems at conditions relevant for CO_2 sequestration. We describe techniques for Nuclear Magnetic Resonance (NMR) and Magnetic Resonance Imaging (MRI) of rocks using water as a freely diffusible tracer, and demonstrate applications to the measurement of wetting and diffusion of water and key dissolved species. In this study, chemical composition and physical characteristics of connected pores, and its NMR response were measured for samples of nanoporous silica and Indiana limestone (2 and 70 mD). The volume and geometry of fluid accessible pores in limestone were mapped in 2D and 3D using MRI, and their correlations with relaxation time were studied using T_2-relaxometry to classify fluid molecules as surface-bound, capillary, or bulk-like in porous media. Various isotopically labeled ionic species (^{1}H, ^{13}C, and ^{23}Na) can be traced to measure their wetting and diffusion behaviors. Effective diffusion coefficients of the molecule of interest were obtained with the use of mathematical models as a function of fluid salinity and ionic sizes of fluids. Based on this preliminary analysis, the results show that the integrated relaxation time of the fluid depends on the surface area to volume ratio of pores and permeability of the sample rock core. In the diffusion study, an increase of NaCl concentration reduces the effective diffusion coefficients within Indiana Limestone (D_e of 1M NaCl < 0.5M NaCl < 0.1M NaCl solution). We observed little difference between different permeability carbonate rocks in terms of effective diffusion behavior. The implications for fluid behavior can be upscaled temporally and spatially by using modeling approach to predict fluid dynamics at the fluid-rock interface of the more complicated natural system with the presence of multi-component fluid and injected CO_2.