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Tracer Partitioning in Two-Phase Flow at Bravo Dome CO_2 Reservoir

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The concentration distributions of geochemical tracers in a subsurface reservoir can be used as an indication of the reservoir flow paths and constituent fluid origin. In this case, we are motivated by the origin of marked geochemical gradients in the Bravo Dome natural CO_2 reservoir in northeastern New Mexico. This reservoir contains 99% CO_2 with various trace noble gas components and overlies the formation brine in a sloping aquifer. It is thought that magmatic CO_2 entered the reservoir, and displaced the brine. This displacement created gradients in the concentrations of the noble gases. Two models to explain noble gas partitioning in two-phase flow are presented here. The first model assumes that the noble gases act as tracers and uses a first order non-linear partial differential equation to compute the volume fraction of each phase along the displacement path. A one-way coupled partial differential equation determines the tracer concentration, which has no effect on the overall flow or phase saturations. The second model treats each noble gas as a regular component resulting in a three-component, two-phase system. As the noble gas injection concentration goes to zero, we see the three-component system behave like the one-way coupled system of the first model. Both the analytical and numerical solutions are presented for these models. For the process of a gas displacing a liquid, we see that a noble gas tracer with greater preference for the gas phase, such as Helium, will move more quickly along the flowpath than a heavier tracer that will more easily enter the liquid phase, such as Argon. When we include partial miscibility of both the major and trace components, these differences in speed are shown in a bank of the tracer at the saturation front. In the three component model, the noble gas bank has finite width and concentration. In the limit where the noble gas is treated as a tracer, the width of the bank is zero and the concentration increases linearly with time.

Keywords: Reservoir Simulation, Multiphase Flow, Noble Gas, CO_2