Engineering Particle Movement and Fluid Flow in Reservoirs

Ayusman Sen

Department of Chemistry

The Pennsylvania State University

University Park, PA 16802

Email: asen@psu.edu

We will discuss particle movement and fluid flow in reservoirs in response to in-situ ion gradients. The particles (bots) can be deployed in a reservoir through injection in the form of aqueous suspensions. They move actively by utilizing ion gradients arising from differential salinity found in the reservoir. The observed active chemotaxis is caused by the diffusiophoretic force on the particles combined with osmotic flow. The particles are able to navigate around obstacles in seeking the source of the ion gradient. Further, their small dimensions allow them to migrate through narrow channels, including those found in rock samples. The observed active chemotaxis of particles can be modeled on the basis on standard diffusiophoretic mechanism. Diffusiophoretic pumping is particularly efficient for movement of both particles and fluids through micro and nanochannels. Because of capillary forces, other flow mechanisms such as pressure driven flows do not work well in these narrow channels.

A second aspect of ion-gradient induced particle and fluid motion involves movement in response to the dissolution of minerals from rock surfaces. This results in the formation of ion gradients that originate at the rock surface. The resultant gradients can lead to active fluid flow and particle movement along the mineral surface. Because of its extensive occurrence in geologic formations, calcium carbonate was used as the model system. We find that ion dissolution from calcium carbonate can cause active fluid flow and particle movement in the surrounding aqueous medium.