Abstract

The effects of calcite precipitation on flow were evaluated in porous media with a combined experimental and modeling study. X-ray microtomography images of two columns packed with glass beads and calcite (spar crystals) or aragonite (Bahamas ooids) injected with a supersaturated solution (log Ω = 1.42) were processed in order to calculate rates of calcite precipitation with a spatial resolution of 4.46 µm. Identification and localization of the newly precipitated crystals on the 3D images was performed and results used to calculate the crystal growth rates and velocities. Precipitation was also evaluated in terms of column-scale growth rate, crystal shape, surface area and pore roughness changes. While growth is epitaxial on calcite spar, calcite rhombohedra and clusters of polyhedrons form on glass beads and aragonite ooids, respectively. Near the column inlets, calcite precipitation occurred preferentially on the carbonate grains compared to glass beads, with almost 100% of calcite spar surface area covered by new crystals versus 92% and 11% for the surface area of aragonite and glass beads, respectively. The evolution of the pore geometry was very different between the two samples, leading in turn to distinct changes in pore roughness. The impact of mineral precipitation on pore-scale flow and permeability was evaluated using a pore-scale Stokes solver that accounted for the changes in pore geometry. For similar magnitude reductions in porosity, the decrease in permeability was highest within the sample that experienced the greatest increase in pore roughness. In addition, several model porous media were generated to show the impact of different crystal growth patterns and pore roughness changes on flow and permeability-porosity relationship. Under constant flow rate boundary conditions, precipitation resulted in an increase in both the average and maximum velocities. Increases in pore roughness lead to a more heterogeneous flow field, principally through the effect on the fastest and slowest velocities.