Effects of precipitation at the pore-scale on permeability and flow

CATHERINE NOIRIEL[1], CARL STEEFEL[2], LI YANG[2] AND DOMINIQUE BERNARD[3]

[1]Géosciences Environnement Toulouse, Université Paul Sabatier, CNRS, IRD, 14 av. Edouard Belin, F-31400 Toulouse, catherine.noiriel@get.obs-mip.fr

[2]EarthSciencesDivision, Lawrence Berkeley National Laboratory, Berkeley CA94720, cisteefel@lbl.gov, lyang@lbl.gov

[3]CNRS, Université de Bordeaux , Institut de Chimie de la Matière Condensée de Bordeaux, UPR9048, F-33608 Pessac, dominique.bernard@icmcb.cnrs.fr

Precipitation of minerals like calcite in porous media can cause significant reduction in permeability and a reorganization of the flow field in reservoirs by altering the shape, size and connectivity of the pores, the roughness of their surface, and by partial or complete obstruction of flow in pore throats. Developing a full understanding of the feedbacks between geochemical reactions and flow and transport characteristics at the reservoir scale requires an investigation of the precipitation mechanisms at the pore-scale. We present a combined experimental and modelling study to evaluate the impact of mineral precipitation on flow and permeability reduction [1]. X-ray microtomography images of two columns packed with glass beads and calcite spar crystals or aragonite 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. For similar magnitude reductions in porosity, the decrease in permeability was highest within the sample that experienced the greatest increase in pore roughness. 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.

[1] Noiriel C., Steefel C.I., Yang L., and Bernard D. (2015) Effects of pore-scale heterogeneous precipitation on permeability and flow. Advances in Water Resources, in press, DOI: 10.1016/j.advwatres.2015.11.013