Contribution ID: **749** Type: **Oral 20 Minutes**

Permeability Reduction Caused by Multiple Treatments of Biomineral Precipitation in Homogeneous Porous Media: Experimental Study and Pore Scale Modelling

Wednesday, 16 May 2018 16:16 (15 minutes)

Several biochemical processes have been investigated to modify engineering properties of soil. Biomineral precipitation can increase strength and stiffness, and reduce porosity and permeability. Enzymatically induced calcium carbonate precipitation (EICP) is a biochemical process in which urea is hydrolyzed into ammonium and inorganic carbon, which promotes carbonate mineral precipitation. Different morphologies and patterns of carbonate mineral precipitation, such as particle surface coating, pore filling, and soil particle contact bonding have been observed in the previous studies, in which the mineral structure and distribution has been evaluated after the completion of the treatment using SEM (Scanning Electron Microscope) imaging and XRD (X-ray Diffractometer) structural analysis. As the hydro-mechanical properties of soils can be significantly affected by the distribution of precipitated mineral in the pore space it is important to investigate these properties at pore scale. In this research, an EICP reaction medium is injected into a microfluidic channel to observe the entire process of carbonate mineral precipitation through several cycles of EICP treatment in the porous medium. Mineral phase changes and concomitant porosity and permeability reduction throughout the system are evaluated by image processing. A two-dimensional simulation model involving urea hydrolysis and mineral precipitation is developed, and the results are analyzed in comparison to the experimental results.

References

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Session Classification: Parallel 8-A

Track Classification: MS 4.05: Biochemical mineral precipitation for subsurface applications