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Microbially induced carbonate precipitation, fracture sealing?

Grainne El Mountassir, Heather Moir, and Rebecca J. Lunn
Department of Civil Engineering, University of Strathclyde, Glasgow, United Kingdom (grainne.mccloskey@strath.ac.uk)

Predicting and controlling spatial and temporal variations in fracture flow properties is of considerable importance to the nuclear waste disposal, carbon capture and storage, and hydrocarbon industries. Fractures and faults can result in a small number of poorly mixed pathways dominating fluid flow from depth to the surface. Fracture hydraulic properties are governed by the interactions between the evolving stress field and the continuous precipitation and dissolution of minerals transported via subsurface fluids. Fractures can be subject to multiple mineralization episodes, between which they may seal completely before being subject to further shear failure.

We investigate experimentally the spatial and temporal evolution of carbonate precipitation in fractures. We use microbially mediated reactions to reproduce precipitation events similar to those that may be found in fractured rocks. A series of laboratory experiments was carried out using transparent idealised fracture networks to investigate how repeated carbonate precipitation events result in spatial and temporal evolution of the fracture aperture distribution. Time varying flow paths and mineral precipitation were imaged by alternating coloured dyes within the flow field. Experiments show that the type of precipitate formed, fine grained-relatively evenly distributed, versus larger isolated mineral growths, is dependent on the concentrations of bacteria, urea and calcium and the injection procedure used. All experiments show a gradual decrease in average fracture aperture accompanied by a progressive focussing of fluid pathways within the fracture plane onto an increasingly small number of discrete channels. This gradual channelling of fluid flow within fractures has implications for both fluid flow modelling and for prediction of contaminant dispersion, and hence dilution, along flow paths. The results from these experiments provide new insights into the role of mineralization in controlling the hydraulic properties of fracture networks. They will also form the basis for design of an engineered carbonate precipitation methodology to seal narrow aperture fractures located at depth.