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Pore space sealing using microbially mediated calcite precipitation: a lab to field scale study

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Microbially driven calcite precipitation (via ureolysis) has shown great potential in a wide range of applications, including solid-phase capture, concrete crack remediation, soil stabilisation and carbon sequestration. Here, this process is investigated as a means of reducing the primary porosity and/or secondary fracture porosity of host rocks surrounding nuclear waste repositories in order to control or prevent radionuclide transport. To determine a suitable field injection approach, a series of bench scale experiments were undertaken in the laboratory. First, batch experiments focussed on the kinetics of calcite precipitation as a function of bacterial mass, urea and Ca²⁺ concentration and anaerobic vs aerobic conditions. Results showed that the ureolytic bacteria performed equally well under both oxygen poor and oxygen rich conditions. In the next stage, flow-through experiments in various media (sand columns, rock cores) were carried out to examine the homogeneity and extent of the pore space fill along the column / core as a function of injection strategies. It emerged that a staged injection strategy, where we alternate between bacterial and reactant injection, yields the most homogeneous calcite fill, reducing overall porosity by up to 45 %. Ultimately, this approach was tested at the field scale, led by University of Birmingham, to seal a fractured rock (dacite) at ~28 m depth, in a quarry in Leicestershire, UK. Within few injection cycles, the single fracture was substantially plugged by calcite, yielding a significant transmissivity decrease over several meters.

References

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