Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.14074

Controlling and Modelling the Impact of Bentonite Microbial Communities in Disposal of Radioactive Wastes

MAX N ROSE[1], MATT BAILEY[2], DIRK ENGELBERG[1], KATHERINE MORRIS[1], SAM SHAW[1] AND JONATHAN RICHARD LLOYD[1]

[1]University of Manchester

[2]University of Plymouth

Presenting Author: max.rose@manchester.ac.uk

Disposal in a geological disposal facility (GDF) is the preferred route for the world's growing inventory of nuclear wastes. Bentonite clay is a common component of the engineered barrier system, serving to isolate and stabilise the high heat-generating waste packages in the geosphere [1].

Bentonites naturally contain sulfate-reducing bacteria (SRB), which in the presence of the correct substrates, produce H_2S that is highly corrosive to metals (such as steel waste packages). Sulfate, the electron acceptor, is present in most groundwaters, and the corrosion of steel produces hydrogen, an electron donor [2]. Compacting bentonite on deposition can restrict GDF microbial activity, since swelling pressures upon saturation restrict the available porosity for microbes [3]. Additionally, groundwater chemical conditions [4] may impact bentonite mechanical properties (e.g., the effect of salinity on swelling capacity [5]), and the energetics of bacterial metabolism [6].

This work uses bentonite SRB enrichment cultures to assess parameters that control microbial metabolism, and the relative contribution of microbially influenced corrosion (MIC), versus chemical corrosion of steel (Figure 1). This will provide evidence to underpin lines of argument and models used in the safety assessments for geological disposal. Experiments described include microcosm incubations containing bentonite slurries across a range of salinity, and pressure cell bioreactors to evaluate the above conditions in the context of a compacted bentonite barrier system. Initial results show that in the presence of lactate as an electron donor, slurry systems with bentonite, low-carbon steel and sulfate-containing groundwater provide the essential nutrients for the proliferation of an MIC-inducing community. Experiments have also shown that in such systems, increasing the groundwater NaCl concentration inhibits microbial activity during the 3-month experimental duration.

References:

[1] Stroes-Gascoyne et al. (2010) Appl. Clay Sci. 47:155-162
[2] Bagnoud et al. (2016) Nat Commun 7:12770
[3] Masurat et al. (2010) Appl. Clay Sci. 47:58–64
[4] Metcalfe et al. (2015) www.quintessa-online.com
[5] He et al. (2020) Bull. Eng. Geol. Environ. 79:399-410
[6] Oren (1999) Microbiol. Mol. Biol. Rev. 63(2):334-348
[7] Haynes et al. (2021) Chem. Geol. 581:120353

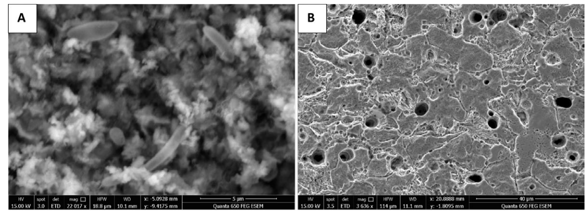

Figure 1: Bacteria colonising steel surfaces (A) and subsequent microbially-influenced corrosion morphological features (B)