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Conference Abstract

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

Max Rose[‡], Matt Bailey[§], Chris Boothman[‡], Dirk Engelberg[‡], Katherine Morris[‡], Sam Shaw[‡], Jonathan Richard Lloyd[‡]

‡ The University of Manchester, Manchester, United Kingdom
§ The University of Plymouth, Plymouth, United Kingdom

Corresponding author: Max Rose (max.rose@manchester.ac.uk)

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Abstract

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 (Stroes-Gascoyne et al. 2010).

Bentonites naturally contain sulfate-reducing bacteria (SRB) (Haynes et al. 2021), 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 (Bagnoud et al. 2016). Compacting bentonite on deposition can restrict GDF microbial activity, since swelling pressures upon saturation restrict the available porosity for microbes (Masurat et al. 2010). Additionally, groundwater chemical conditions may impact bentonite mechanical properties (e.g., the effect of salinity on swelling capacity (He et al. 2019), and the energetics of bacterial metabolism (Oren 1999).

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 (Fig. 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 (Fig. 2). Experiments have also shown that in such systems, increasing the groundwater NaCl concentration inhibits microbial activity during the 3-month experimental duration.

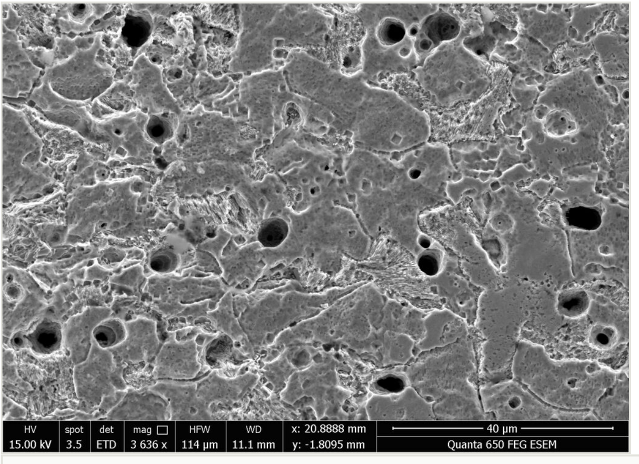

Figure 1. doi

The heavily-pitted surface of a steel coupon incubated for 3-months, in an SRB-active slurry system containing Wyoming MX80 bentonite in sulfate-containing artifical groundwater.

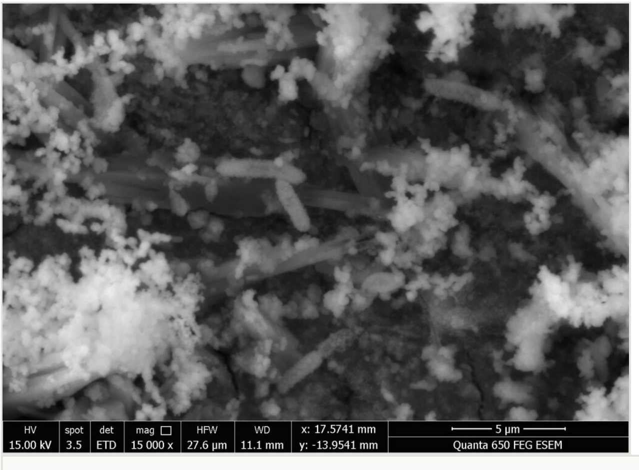

Figure 2. doi

Microbes colonising the surface of a steel coupon after incubation for 3 months with Wyoming MX80 bentonite in sulfate-containing artificial groundwater.

Additionally, SRB have been shown to reduce priority radionuclides, such as selenium (Nancharaiah and Lens 2015). Selenium is a priority radionuclide in high-level waste, and in its highest oxidation states, selenate (Se(VI)) and selenite (Se(IV)), it is highly soluble and therefore mobile in the environment. Early experiments have shown that when an electron donor is present in microcosms containing bentonite and groundwater, bentonite-native SRB may be capable of reducing soluble selenium down to insoluble Se(0), restricting its environmental mobility.

Keywords

Microbial Metabolism, Bentonite, Corrosion, Selenium

Presenting author

Max Rose

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Conflicts of interest

The authors have declared that no competing interests exist.

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