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Interactions between microbes and low-pH cement in low-carbon source groundwater (relevant to radioactive waste geodisposal)

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Higher-activity nuclear waste in the UK (and other countries with significant nuclear activities) will be disposed of in a Geological Disposal Facility (GDF). The GDF is a multibarrier system, and cement is used as an engineered barrier and construction material. Over time, the GDF will be exposed to groundwater infiltration, and the carbon source carried with the groundwater may trigger microbial activity within aged concrete. Microbes can have positive (e.g., fracture healing) or negative (e.g., generation of acidic conditions) effects on the cementitious materials. In this project, to stimulate aged GDF conditions, low-pH cement samples (pH ~9) were incubated under anaerobic conditions with low-carbon artificial groundwater and an inoculum rich in alkaliphilic microbes. A parallel positive control experiment with a higher amount of organic carbon (lactate) was conducted for comparison. In both systems, nitrate was used as an electron acceptor. After six months of incubation, various techniques (pH, ICP, IC, SEM-EDS, XCT, 16S rRNA gene sequencing) were used to evaluate the biogeochemical evolution of the systems, and any microbial impacts on the cement structure. Analyses indicated that cement degradation did not occur, but cement healing through microbial biomineralization was noted and was more pronounced in the high-carbon (lactate) system. 16S rRNA gene sequencing further confirmed the enrichment of bacteria including Bacilli in a high-carbon source system, which are well known to promote microbially induced carbonate precipitation (MICP). This research seeks to enhance our understanding of how long-term microbial activity could impact on the integrity of cementitious materials within a GDF saturated with low-carbon groundwaters.