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Microbial metabolic potential in a natural clay analogue for deep geological radioactive waste repositories

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In most countries, high-level nuclear waste will be stored in deep geological repositories (DGRs). To ensure safety for up to 1 million years, DGRs are designed to maintain stable mechanical, chemical and hydrological conditions in which microbial activity is limited. Predicting the persistence, viability, and activity of a microbial community over such extended periods is challenging and can only be extrapolated from relatively short-term laboratory or field-based experiments. As such, a natural analog site, an alteration clay zone of (most likely) Precambrian age (hundreds of millions of years old) [1] associated with magnetite-(hematite)-apatite deposits in Kiruna (Sweden) was selected to study microbial survival and potential activity in future DGRs. Using air-cooled conventional single-barrel core drilling, free of drilling fluid (in order to minimize core loss and contamination), we collected rock samples from mine galleries at 1,137-1,194 m below the surface. First, the presence of modern and/or past microorganisms in the clay was confirmed by the extraction of nucleic acids using protocols tailored for ancient materials containing highly fragmented DNA. Second, the presence of viable and active bacteria was evidenced using a cultivation-based approach resulting in substrate consumption by heterotrophic Fe(III)-reducing and denitrifying communities obtained from rock particles incubated in a medium with ^{13}C-bicarbonate and ^{15}N-ammonium. The bacterial activity was further investigated using a combination of SEM (scanning electron microscopy) and NanoSIMS (nanoscale secondary ion mass spectrometry) aiming to trace the incorporation of labeled substrates into biomass. Our findings show the existence of metabolically active microorganisms (however slow the *in-situ* metabolism may be) in deep old Kiruna clay deposits and indicate the microbial potential to survive in future DGRs even at the timescale of expected operation.

References :

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