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Discover bentonites, the heroes of radioactive waste repositories

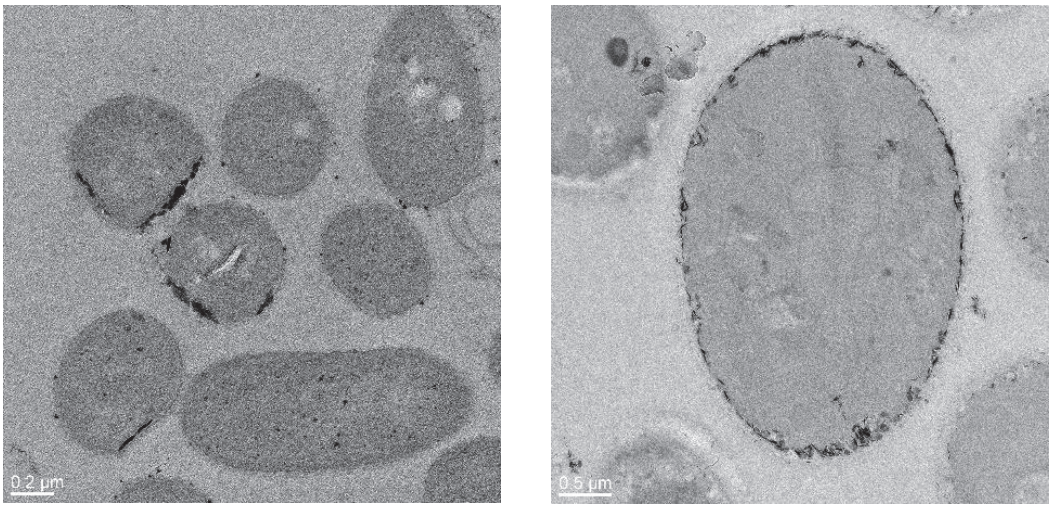
Infosheet 3: Microbial activity at the bentonite barrier in DGRs

As previously mentioned, the use of deep geological repositories (DGRs) has been internationally selected as one of the safest options to dispose of nuclear waste.[1] One option is to encapsulate the highly radioactive waste in metal containers, surround them with a bentonite buffer, and bury them deeply within a stable geological formation.

The bentonite buffer performs important functions to maintain the integrity of the metal canisters. However, the safety of DGRs could be compromised by physicochemical factors (such as pressure, pH, and temperature) and biological activity,[2] due to the microorganisms (microbes) that naturally grow in bentonites, groundwater, and host rocks. Some decades ago, it was demonstrated that microbes could survive and happily live very deep underground.[3] Thus, understanding the microbial functions occurring deep underground will enable greater precision in predicting safety breaches of the DGR.

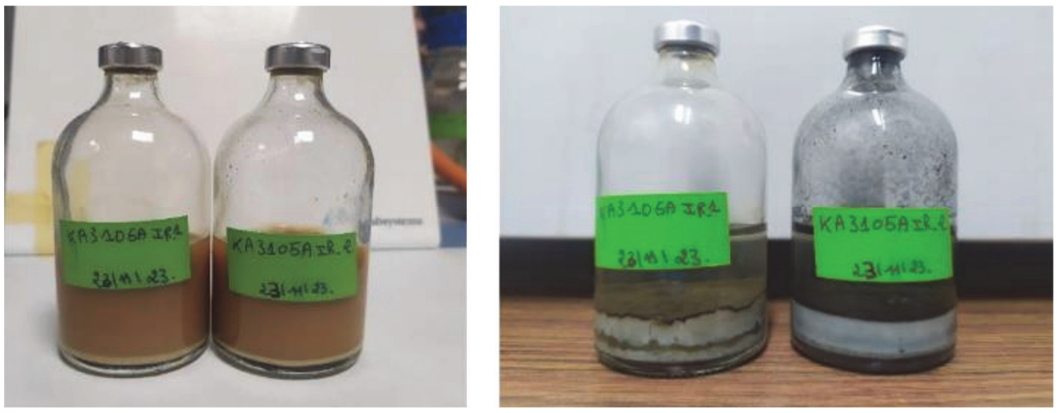
Äspö Hard Rock Laboratory, Sweden, is an underground research tunnel, which gives access to the deep terrestrial biosphere.
Image courtesy of the author

Microorganisms mainly affect the geochemistry of bentonite through **reduction** or dissolution of structural minerals,[4] alteration of mineral surfaces by the production of **siderophores**, and the formation of **biofilms** on clay surfaces.[2] In addition, microbes can negatively affect the container by **microbial corrosion**,[5] and they can control the **speciation** and **mobility** of **radionuclides** through several processes.[6] Previous studies have extensively investigated the microbial diversity in different types of available bentonites.[7,8] Bentonite from Almeria (Spain) was selected as a reference buffer material for the Spanish DGR, and the microbial diversity of the reference bentonites from Almeria has also been studied.[9,10]



Indigenous microbial cells from Almeria's bentonite, which are able to immobilize uranium at their cell walls (black dots). Left side: Stenotrophomonas bentonitica BII-R7 bacterial cells. Right side: Rhodotorula mucilaginosa BII-R8 fungal cells. *Image courtesy of the author*

However, the microbial activity of this bentonite buffer has never been studied under conditions similar to those in a DGR. Although the high compaction of the bentonite buffer may suggest reduced or no microbial activity, the DGR is a multibarrier disposal unit that must be considered as a complex system where all elements (bentonite, groundwater, container, waste, etc.) could have important effects on the long-term isolation of waste.



Microbial batch cultures under repository conditions. Different colours indicate different metabolic processes using iron (brown) or sulphate (black) as energy sources.
Image courtesy of the author

The main research objective of the MicroBent project is to study indigenous microorganisms under in situ repository conditions, to ensure the safety of DGRs of nuclear waste.

Glossary

Reduction: part of a reduction–oxidation (redox) reaction in which atoms have their oxidation state changed.

Siderophore: small, high-affinity iron-chelating (bonding) compounds that are secreted by microorganisms such as bacteria and fungi.

Biofilm: a thin layer that forms on top of some wet surfaces and consists of a community of microorganisms.

Microbial corrosion: when microbes affect the electrochemical environment of the surface upon which they are fixed. Also known as biocorrosion.

Speciation: the distribution of an element amongst different chemical species in a system. It is critical for understanding chemical toxicity, bioavailability, and environmental fate and transport.

Mobility: The ability of a chemical element or pollutant to move through the environment, for example, through a food chain or from a waterbody into the sediment beneath it.

Radionuclide: a radioactive nuclide, radioisotope, or radioactive isotope is a nuclide that has an excess of either neutrons or protons, giving it excess nuclear energy and making it unstable.

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