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Early anaerobic corrosion of potential canister material in compacted bentonite

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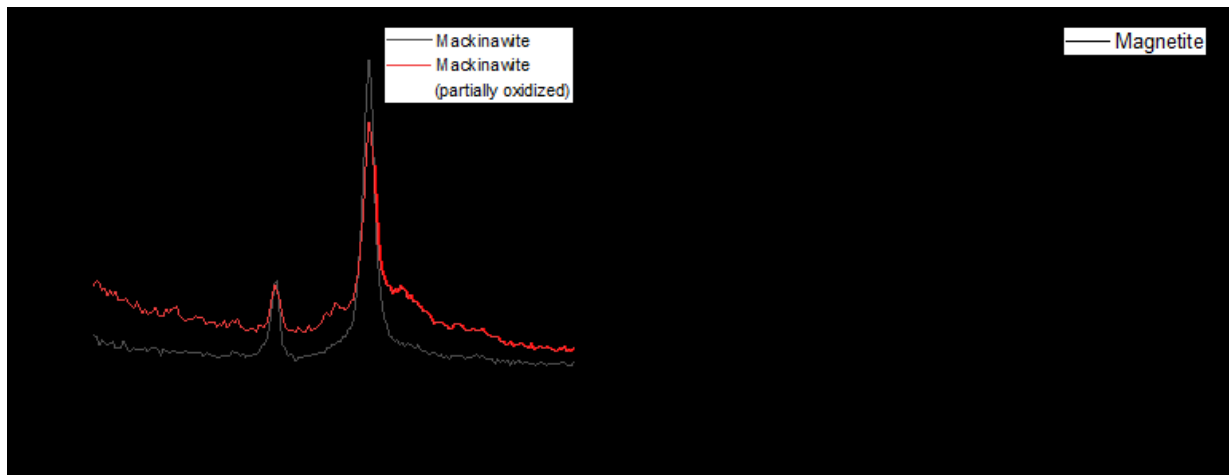
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In the multi-barrier system for deep geological repositories of high-level nuclear waste, the stability of potential canister and geotechnical barrier materials are essential for long-term safety. Over time, the canister near-field is expected to become saturated with groundwater, leading to a shift in the geochemical environment from oxic – warm – unsaturated to anoxic – cool – saturated conditions. At the current status of the German site selection act, the geochemical environment as well as the electrolyte in contact with the canister and surrounding buffer material are not defined yet. However, a change in geochemical conditions over longer time is expected and it will affect the long-term behavior of the canister and buffer materials. Corrosion of the canister materials may occur, potentially altering the properties of both the canister and the buffer material.

Here we present a study on the effect of corrosion of potential canister materials on alteration of compacted Wyoming bentonite in a synthetic ground water with composition close to electrolyte compositions within crystalline host rocks. The salt concentrations of the synthetic water were calculated based on given ionic compositions of Bucher and Stober [1]. All metal coupons (cast iron type EN-GJS-400-15 and oxygen-free phosphorous copper) were ground with 600, 800 and 1200-grit SiC papers and subsequently cleaned with acetone to guarantee a defined surface state before start of exposure experiments. Metallographic pre-characterization of the coupons was performed by light optical (LOM) and scanning electron microscopy (SEM). Exposure experiments were undertaken for 1 and 3 months in compacted bentonite in tailor made corrosion cells under anoxic conditions. Granulated bentonite was uniaxially compacted to a dry density of 1.50 g/cm³. To ensure anaerobic conditions, the corrosion cells were assembled and dismantled within an Ar-filled glovebox. After the exposure experiments subsequent analysis of the physico-chemical changes at the metal/bentonite interface was performed by (μ)-X-ray diffraction (XRD), μ-X-ray-fluorescence (μXRF) analysis, SEM, LOM and Raman spectroscopy.

After exposure of cast iron (type: EN-GJS-400-15) for one month at 60 °C in compacted bentonite, changes were observed on the metal coupon and at the interface in the bentonite. The shown Raman spectra indicate the formation of mackinawite (FeS) and magnetite (Fe₃O₄) on the metal coupon. The same results were observed with complementary SEM-EDX analysis. Additionally, metal/bentonite interfaces after exposure for 4.5 and 7.1 years in the MaCoTe experiment at Grimsel Test Site were studied by μXRF, XRD and SEM for comparison. The impact of the observed bentonite alteration for the long-term safety will be discussed.



[1] Bucher, K., Stober, I. (2000). *The Composition of Groundwater in the Continental Crystalline Crust*. In: Stober, I., Bucher, K. (eds) *Hydrogeology of Crystalline Rocks*. Water Science and Technology Library, vol 34. Springer, Dordrecht.