Monitoring groundwater evolution in bentonite buffer systems using the corrosion of NdFeB magnets

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The short-and long-term passive and remote monitoring of the bentonite-based Engineered Barrier System (EBS) typical of a number of geological concepts for the disposal of high-level nuclear waste is central to demonstration of safety. As part of a major EPSRC-NDA sponsored research consortium focused on the monitoring of EBS (SAFE Barriers) we are investigating the capability of selected permanent magnets (in particular commercial N42 grade NdFeB alloy) to detect the evolution of groundwater chemistry within the EBS through the variation of their magnetic signals with time as a consequence of their reaction and corrosion.

NdFeB alloys were put in sealed and saturated environments within Na-bentonite matrix and not and reacted with distilled, alkaline and saline waters for 5 months at 70°C.

Corrosion effects were greater for magnets embedded in bentonite and reacted with saline waters, with complete disaggregation of the alloy (and realignment of the magnetic particles) and preferential corrosion of the intergranular phase; the main magnetic phase underwent hydrogenation, reflected in a big shift of PXRD reflections towards lower angles and in an increasing Curie temperature.

Other samples showed hydrogenation of the main magnetic phase but far less intense exfoliation processes and hence no realignment of the magnetic particles. The corrosion started aerobically, with precipitation of Fe oxyhydroxides at the water/clay interface and then proceeded anaerobically with neoformation of mixed-layers of Fe-smectite and Na-montmorillonite at the magnet/clay interface.

Magnets reacted in aqueous media showed surface passivation and little hydrogenation only with Ca(II) in solution in alkaline solutions. In the most corroded samples, presence of hydrogen gas was detected, and the amounts of Nd(III), Fe (III, II) and other metallic cations in solution were negligible for all the samples.

These experiments confirmed the capability of commercial grade NdFeb permanent magnets to detect different water compositions through the variations of their magnetic properties.