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High temperature laboratory experiments on Wyoming and Czech bentonites from the full-scale HotBENT experiment

MARLENA J ROCK[1], AMBER ZANDANEL[1], FLORIE CAPORUSCIO[1] AND KIRSTEN SAUER[2]

[1]Los Alamos National Laboratory
[2]NA

Presenting Author: mrock@lanl.gov

The full-scale HotBENT experiment aims to investigate higher temperature repository concepts. One objective of the HotBENT experiment includes studying the effects of high temperatures (i.e., high thermal loading) (> 150 °C) at and in the vicinity of the heater surface to evaluate the performance of bentonite and/or bentonite-mixtures as buffer materials at realistic in-situ conditions. Bentonite materials are important components of geological repositories for spent nuclear fuel and waste, and the interface between the bentonite buffer and the canister has a large chemical gradient and will likely be reactive at repository conditions. Our laboratory experiments aim to examine the effects of temperature on the mineralogy and geochemistry of the bentonites in a system representing the conditions of a crystalline-hosted repository.

Hydrothermal experiments were conducted at 200 °C and 150 bar for a period of eight weeks. Experimental components included Wyoming bentonite (FE) ± Czech bentonite (BCV), low carbon steel (LCS), and a synthetic Grismel granodiorite groundwater at water rock ratio of six. Two bentonite compositions were investigated: (1) FE bentonite which is an unprocessed Na-type bentonite leftover from the FE experiment and (2) BCV bentonite an unprocessed iron-rich bentonite. Reaction fluids were extracted weekly during the experiment and assessed for changes in pH and major cations/anions. Post-experiment characterization included SEM-EDS, XRF, clay XRD and qXRD analyses of the solid reaction products.

The results from these three experiments document the potential mineralogical and geochemical changes in the FE and BCV bentonite at 200 °C in water saturated conditions. The observations from heating the bentonites are the slight reduction in montmorillonite swelling, formation of carbonate phases in experiments that contained BCV, and the lack of formation of silicate minerals such as zeolites. The LCS coupons included in the experiments provided a substrate for Fe-rich mineral precipitation. Fe-oxides and phyllosilicates were observed in the experiment with FE only. Fe-rich carbonates were observed on the reacted steel surface in addition to oxides and Fe-saponite in experiments with BCV.