Adding phosphate as a ‘uranium getter’ in hydrothermal bentonite experiments

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Isolation of radioactive waste in deep geologic repositories relies on both engineered and natural barriers, typically consisting of a waste canister, bentonite buffer, and host rock. In natural hydrothermal systems, phosphate minerals are observed to incorporate heavy elements, such as uranium and rare earth elements. Therefore, this study explores the mineralogical and geochemical effect of adding apatite to hydrothermal experiments with Wyoming Bentonite (clay buffer) ± Opalinus Clay (host rock).

The hydrothermal experiments were performed using Dickson reaction cells at temperatures and pressure of up to 300°C and 150 bar, respectively, for six weeks. Fragments/ powder of fluorapatite ($Ca_5(PO_4)_3F$) from Mexico was added to Wyoming Bentonite ± Opalinus Clay and saturated with a Na-Cl type brine solution. Reaction products will be characterized for aqueous geochemical, mineralogical, and bulk chemical changes.

Although our experiments are in progress, complementary hydrothermal experiments suggest uptake of uranium in phosphate systems [1]. Further, our previous research on bentonite stability indicates that pyrite grains in the bentonite break down to create H_2S gas, which in turn may convert apatite to woodhouseite [$CaAl_2(PO_4)(SO_4)(OH)_6$]. Results of this research will pave the way for research on phosphate-based engineered barrier material to act as a uranium capture mineral (autunite) in response to mineral alteration during hydrothermal interactions with bentonite barriers.

[1] Gabitov et al. 2020. Immobilization of uranium by phosphate and carbonate crystallization as an improvement of engineering barriers. EGU General Assembly 2020.