Fluid-Rock Processes Driving Isolation of Crustal Fluids in Crystalline Basement Systems

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The US DOE Office of Nuclear Energy Spent Fuel and Waste Science and Technology Campaign launched a Deep Borehole Field Test (DBFT [1]). The DBFT will have no radioactive waste; rather its purpose is to evaluate feasibility of the deep borehole disposal concept for such [2]. The approach is to drill a Characterization Borehole (CB; 8.5" diameter), followed by an optional, larger, Field Test Borehole (FTB; 17" diameter). Both boreholes are to be a depth of ~5,000 m (16,400 feet) with the lowest 3,000 m in stable crystalline basement rock. The focus of CB work is to measure and/or sample the geologic, mechanical, hydrologic, and geochemical aspects in the basement rocks to assess how robustly isolated, or just how leaky, the system is [3].

To estimate mineral alteration and fluid composition at depth (~150°C, 50 MPa, & above), we investigate fluid-rock coupled reaction processes using reaction path and reactive transport (PFLOTRAN) methods. Initial analyses on granitic rocks constrain salts contributed from fluid inclusions, and evaluate primary mineral alteration that can (a) fix H_2O in minerals, (b) raise Ca/Na ratios in brine, and (c) shift isotopic signatures of fluids. Assessment of mineral reaction rates against diffusion-limited to advective flow regimes can define minimum depth and time frame over which altering metastable phases could generate rock-dominated fluid compositions. Identifying the most efficient H_2O-sink phases can guide petrologic observations on DBFT CB core samples. Delineating such alteration reactions (and rates) that may drive a net H_2O flux into the crystalline basement (resulting in at most diffusion-limited transport of constituents out of the basement system) will provide specific alteration regimes to constrain with experiments. *Sandia National Laboratories is a multi-mission laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND2017-3312 A.*

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