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Isotopic and Chemical Composition of Fluids in a Granodiorite Pluton: Implications for Fluid Stability over Geologic Time.

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The isotopic and chemical compositions of fluids found at depth in crystalline shield environments can be used to understand solute sources and evolutionary processes, such as water/rock interaction and mixing. Chlorine and strontium isotope signatures in crystalline shield fluids have been routinely used to track processes such as fluid mixing and mineral precipitation/dissolution reactions. Bromine and calcium isotope systems are less explored in the study of crystalline shield fluids but have the potential to better elucidate fluid origins and evolution. A multi-isotope approach, employing all four isotope systems, can help to determine the evolution and stability of crystalline shield fluids, which is important for the siting of deep geological repositories (DGR) for nuclear waste.

This study examines fracture-water, porewaters and fluid inclusion/grain boundary salts in a 2.7-billion-year-old granodiorite pluton for the purpose of site characterization for a DGR. Fluids were extracted through out-diffusion and crush and leach experiments on intact core from the granodiorite pluton. The resultant fluids were analyzed for concentrations of major ions as well as the isotopic values of $\delta^{37}Cl$, $\delta^{81}Br$, $\delta^{44}Ca$, and $^{87}Sr/^{86}Sr$ using various techniques including Thermal Ionization Mass Spectrometry and Continuous Flow Gas Chromatography Isotope Ratio Mass Spectrometry.

Differences in the chemical makeup of the different fluid types within the granodiorite pluton and their isotopic values suggest a potential influence of ancient magmatic/metamorphic water on the porewaters. Elevated Br/Cl ratios, as well as $\delta^{37}Cl$ and $\delta^{81}Br$ values, measured in porewaters of the granodiorite may be related to Br-rich fluid inclusions leftover from crystallization of the pluton. Porewaters of the granodiorite pluton appear to be intermediate between the fracture waters and the crush and leach waters, suggesting contributions from both. Correlations between $\delta^{44}Ca$ and $^{87}Sr/^{86}Sr$ in the porewaters and crush and leach fluids suggest a possible radioactive decay relationship between the two systems that is largely unaffected by subsequent processes that cause mass-dependent fractionation. A lack of fractionation in the $\delta^{44}Ca$ system supports interpretations of long-term fluid stability in the highly unaltered granodiorite pluton.