

Using TRIFS to explain increased uptake of Eu^{3+} and Cm^{3+} into biologically produced apatite

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The long term geochemical modeling of nuclear waste in the environment requires a molecular understanding of the interaction between radioactive materials and mineral phases. Of particular importance is the adsorption and incorporation of trivalent actinides such as plutonium, americium and curium. In this study time-resolved laser fluorescence spectroscopy was used to probe europium and curium which have been incorporated into biologically produced apatite. Apatite produced by *Serratia* bacteria has been shown to have an increased uptake of various cations. Time resolved laser fluorescence spectroscopy was used to identify and characterize the nature of $\text{Eu}^{3+}/\text{Cm}^{3+}$ sorption and incorporation within the mineral phase. Using site-selective excitation different interactions can be isolated. The lifetime and emission spectra were analyzed at each site that was identified. The number of hydrating waters was determined by the lifetime measurement and used to distinguish species that are sorbed to the surface from those incorporated into the bulk. Emission spectra were measured to determine the symmetry of the site being occupied by the sorbed or incorporated trivalent cation and determine the substitution for non-equivalent calcium positions. By these measurements it was determined that Eu^{3+} and Cm^{3+} are incorporating into the amorphous grain boundaries of the apatite polycrystalline material. Biologically produced apatite has smaller crystalline grains resulting in a greater amount of amorphous grain boundary within a particle as compared to synthetic or natural apatite. This greater amount of amorphous grain boundary results in an increased uptake of Eu^{3+} and Cm^{3+} and is therefore a more effective barrier to radionuclide migration.

Nitrogen isotopes and geochronology of the Musselwhite Au mine, Canada

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The Musselwhite Au mine, a large orogenic lode gold deposit hosted in amphibolite grade metamorphic rocks, is located in the ~2.98 Ga North Caribou Lake greenstone belt of the North Caribou Terrane, Superior Province, Canada. The mine has produced ~3.1 million ounces of gold and has a total reserve and measured plus indicated resource base of 2.31 million ounces as of December 31, 2010. Gold mineralization within the host iron formation is largely confined to subvertical shear zones along the steeply dipping limbs of isoclinal folds and tends to swell where these limbs transition into the crests or keels of antiformal and synformal structures.

Nitrogen isotopes in biotite from Musselwhite Mine are characterized by a $\delta^{15}\text{N}$ range from -1.3 to 11.1 per mil whereas oxygen and hydrogen isotopes of biotites from the mine range from +7.1 to +10.1 per mil for $\delta^{18}\text{O}$ and -55 to -100 per mil for δD . Biotite samples from granites and metasedimentary rocks adjacent to the deposit have a $\delta^{15}\text{N}$ range of -6.9 to +6.1 per mil.

Uranium-lead ages on zircons and monazites from intrusive rocks surrounding the mine range in age from 2875 Ma to 2670 Ma, whereas Ar-Ar ages range from 2658 to 2440 Ma. An Sm-Nd age of 2690 ± 9 Ma for garnets that host gold mineralization is bracketed by peraluminous S-type granites with ages of 2668.3 ± 1.6 Ma and 2715.8 ± 1.6 Ma.

The $\delta^{15}\text{N}$, $\delta^{18}\text{O}$ and δD stable isotopic data for biotite from the mine suggests that both metamorphic and magmatic fluids played a role in the formation of the deposit. Sm-Nd ages of garnets that are coeval with mineralization suggest that the orogenic gold mineralization at the Musselwhite mine was broadly synchronous with the ~2700 Ma orogeny caused by the collision of the Oxford-Stull domain with the North Caribou Terrane ~75 km northeast of the mine. The presence of coeval S-type granites suggest that these may have played a greater role in the formation of orogenic gold deposits than has been previously recognised.