

Synchrotron U-XAS and U-Pb dating of fluorite: Insights into the role of F in U transport

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A survey of U in fluorite using phosphor imaging revealed that only about 10% of specimens from a wide range of contexts have significant U enrichment. Others have measurable U (low ppm levels) but low U/Pb ratios. Samples from Round Top, a REE (and Be) bearing laccolith in the Trans-Pecos region of Texas, have generations of fluorite with and without elevated U [1]. Similarly, Lenoir et al. [2] found overgrowths of U enriched fluorite on U poor fluorite in an unconformity bounded F-Ba deposit in France. Fluorite from Spor Mountain in Utah has economic enrichment of U and is associated with opal and bertrandite [3]. In the case of the fluorite from Round Top and Spor Mountain, U-Pb ages of the fluorite substantially post-date the time of igneous intrusion, suggesting that later fluids, perhaps not magmatic, produced favorable conditions for U transport and incorporation into fluorite. Synchrotron XAS analyses of samples with elevated U shows its oxidation state to be U(VI) but XANES spectra lack the shoulder feature that is diagnostic of the uranyl ion, $(\text{UO}_2)^{2+}$, the typical geologic form of U(VI). Uranium in fluorite is best modeled by EXAFS to be incorporated into an interstitial site in the crystal lattice as UF_6 coordination, suggesting that U is transported as UF_6 in the fluid. Uranium bearing fluorite is often associated with other critical minerals enriched in elements such as Li, Be, Mo, W, and REE, while fluorite with low U is often from Mississippi Valley-type deposits with base metal (Pb, Zn) enrichment. There are known Eh, pH and water activity controls on the stability of UF_6 and we suggest its presence in fluorite may place constraints on ore forming fluids.

[1] Piccione et al. (2019) *Geosphere*, 10.1130/GES02139.1;
[2] Lenoir et al. (2021) *Geochronology*, 3-199 [3] Lindsey (1998) USGS open-file report 98-524.