Structural Distortions in Th-rich Fluorapatite

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The apatite crystal structure has been demonstrated to accommodate nearly half of the elements on the periodic table, including many of the harmful byproducts of nuclear fuel generation such as uranium (U) and thorium (Th). Therefore apatite has been proposed as a solid nuclear waste reservoir. This concept is largely predicated on the observation of naturally occurring apatite bearing elevated levels of U and Th. While numerous works suggest apatite can effectively uptake and retain U, Th, and other radionuclides over short timescales, it is still unclear if the apatite structure is stable while hosting high concentrations of these radionuclides over geologically relevant timescales. The current study has analyzed three suites of fluorapatites from the Mont Saint-Hilaire pluton, Quebec, Canada, via wavelength dispersive spectroscopy (WDS) and single crystal X-ray diffraction (SCXRD). WDS analyses revealed high Th contents with values reaching into the multiple weight percent, to date the highest recorded Th contents in natural fluorapatite. SCXRD results displayed a severely disordered structure, indicated by diffraction spots being streaked, displaying satellite spots, and a noted drop in diffraction at high two-theta values. Due to the significant disorder observed in the SCXRD data, and the high Th concentrations observed via WDS analyses, these fluorapatites were interpreted as being partially metamict and annealing experiments were performed in an attempt to heal the damaged structure. The results of these experiments, refinement of the crystal structure, and full results from WDS analyses will be presented.