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Thermal Expansion of Fluorapatite-Chlorapatite Solid Solutions

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X-ray powder diffraction experiments have been performed on fifteen fluorapatite-chlorapatite solid solutions synthesized and chemically characterized at the GeoForschungsZentrum - Potsdam (Hovis and Harlov, 2010; Schettler, Gottschalk, and Harlov, 2011), as well as two natural near-end-member samples, from room temperature to ∼900 °C at 50 to 75 °C intervals. NIST 640a Si was employed as an internal standard; data from Parrish (1953) were used to determine Si peak positions at elevated temperatures. Unit-cell parameters calculated using the software of Holland and Redfern (1997) result in volume-temperature (V-T) plots that are linear or slightly concave up (V plotted as the vertical axis) over the T range investigated. Relations for the "a" and "c" unit-cell dimensions with T for these hexagonal minerals are nearly linear, but as with V, commonly improved by quadratic fits to the data. Coefficients of thermal expansion for volume (α_V), calculated as ($1/V_{0^\circ C}$) x ($\Delta V/\Delta T$) based on linear V-T relationships, mostly fall within the range 42 $\pm$ 2 x 10^{-6} deg^{-1} and show no obvious dependence on composition. Thermal expansion coefficients for individual unit-cell axes, however, do show clear relationships to composition, α_a increasing from ∼9.5 to ∼13.5 x 10^{-6} deg^{-1} and α_c decreasing from ∼19.5 to ∼13 x 10^{-6} deg^{-1} from the Cl to the F end member. Clearly, a compensating structural relationship accounts for the observed relationships. Such compositional dependence was not seen in the thermal expansion data for F-OH apatite solid solutions (Hovis, Scott, Altomare, Leaman, Morris, and Tomaino, American Mineralogist, in press). This difference can be explained by the similar sizes of F^- and $(OH)^-$ versus the much greater size contrast between F^- and Cl^-. Sincere thanks to the National Science Foundation for support of this work, which has provided numerous research experiences for Lafayette College undergraduates. Thanks also to the Earth Sciences Department, University of Cambridge, for providing X-ray facilities for a portion of these measurements. Finally, thanks to Jeff Post, National Museum of Natural History, and George Harlow, American Museum of Natural History, for providing the natural fluorapatite (NMNH 144954-3, Durango, Mexico) and chlorapatite (AMNH 23101, Kragero, Norway) samples, respectively.