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On the origin of fluorine-poor apatite in chondrite parent bodies

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Abstract

We conducted a petrologic study of apatite within one LL chondrite, six R chondrites, and six CK chondrites. These data were combined with previously published apatite data from a broader range of chondrite meteorites to determine that chondrites host either chlorapatite or hydroxylapatite with ≤33 mol% F in the apatite X-site (unless affected by partial melting by impacts, which can cause F-enrichment of residual apatite). These data indicate that either fluorapatite was not a primary condensate from the solar nebula or that it did not survive lower temperature nebular processes and/or parent body processes. Bulk-rock Cl and F data from chondrites were used to determine that the solar system has a Cl/F ratio of 10.5 ± 1.0 (3σ). The Cl/F ratios of apatite from chondrites are broadly reflective of the solar system Cl/F value, indicating that apatite in chondrites is fluorine poor because the solar system has about an order of magnitude more Cl than F. The Cl/F ratio of the solar system was combined with known apatite-melt partitioning relationships for F and Cl to predict the range of apatite compositions that would form from a melt with a chondritic Cl/F ratio. This range of apatite compositions allowed for the development of a crude model to use apatite X-site compositions from achondrites (and chondrite melt rocks) to determine whether they derive from a volatile-depleted and/or differentiated source, albeit with important caveats that are detailed in the manuscript. This study further highlights the utility of apatite as a mineralogical tool to understand the origin of volatiles (including H_2O) and the diversity of their associated geological processes throughout the history of our solar system, including at its nascent stage.

Keywords: CK chondrite, R chondrite, phosphate, volatiles, chlorine, fluorine, water; Experimental Halogens in Honor of Jim Webster