

Apatite-melt partitioning of volatiles in basaltic systems: Implications for determining volatile abundances in planetary bodies from apatite

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Introduction: Apatite $[\text{Ca}_5(\text{PO}_4)_3(\text{F},\text{Cl},\text{OH})]$ is present in a wide range of planetary materials, and due to the presence of volatiles within its crystal structure (X-site), many recent studies have attempted to use apatite to constrain the volatile contents of planetary magmas and mantle sources [i.e., 1]. Experimental studies have investigated the apatite-melt partitioning behavior of F, Cl, and OH in basaltic systems [e.g., 2-3], reporting that apatite-melt partitioning of volatiles is best described as exchange equilibria similar to Fe-Mg partitioning between olivine and silicate melt. However, exchange coefficients may vary as a function of temperature, pressure, melt composition, and/or oxygen fugacity. Furthermore, exchange coefficients may vary in portions of apatite compositional space where F, Cl, and OH do not mix ideally in apatite [3]. In these regions of ternary space, we anticipate that crystal chemistry could influence partitioning behavior. Consequently, we conducted experiments to investigate the effect of apatite crystal chemistry on apatite-melt partitioning of F, Cl, and OH.

Methods: Experiments were conducted in the range of 0-4 GPa and 950-1500 °C using the starting compositions and methods described in [3]. In addition to these methods, we also conducted experiments in a 1-bar furnace and a Walker-style multi-anvil device.

Results: Apatite-melt exchange coefficients vary as a function of all three system parameters investigated (P , T , and apatite composition), but the strongest factor affecting the values of exchange coefficients appear to be related to apatite crystal chemistry.

Discussion: Before apatite is used as a quantitative melt hygrometer in planetary systems, it is imperative that estimates for P and T of crystallization be known. More importantly, apatite compositions in natural samples must be in the region of ideal mixing of the ternary components F, Cl, and OH, which can be gleaned from existing solution calorimetry data as well as crystallographic studies of the apatite structure.

References: [1] McCubbin and Jones (2015) *Elements*, 11, 183-188. [2] Boyce et al. (2014) *Science* 344, 400-402. [3] McCubbin et al. (2015) *American Mineralogist* 100, 1790-1802.