

Experimental constraints on the partitioning behavior of F, Cl, and OH between apatite and basaltic melt

Francis M. McCubbin, Jessica J. Barnes, Kathleen E. Vander Kaaden, Jeremy W. Boyce, Gokce Ustunisik, and Eric S. Whitson

The mineral apatite is present in a wide range of planetary materials. The presence of volatiles (F, Cl, and OH) within its crystal structure (X-site) have motivated numerous studies to investigate the partitioning behavior of F, Cl, and OH between apatite and silicate melt with the end goal of using apatite to constrain the volatile contents of planetary magmas and mantle sources. A number of recent experimental studies have investigated the apatite-melt partitioning behavior of F, Cl, and OH in magmatic systems. Apatite-melt partitioning of volatiles are best described as exchange equilibria similar to Fe-Mg partitioning between olivine and silicate melt. However, the partitioning behavior is likely to change as a function of temperature, pressure, oxygen fugacity, apatite composition, and melt composition. In the present study, we have conducted experiments to assess the partitioning behavior of F, Cl, and OH between apatite and silicate melt over a pressure range of 0-6 GPa, a temperature range of 950-1500 °C, and a wide range of apatite ternary compositions. All of the experiments were conducted between IW-1 and IW+2 in a basaltic melt composition. The experimental run products were analyzed by a combination of electron probe microanalysis and secondary ion mass spectrometry (NanoSIMS).

Temperature, apatite crystal chemistry, and pressure all play important roles in the partitioning behavior of F, Cl, and OH between apatite and silicate melt. In portions of apatite ternary space that undergo ideal mixing of F, Cl, and OH, exchange coefficients remain constant at constant temperature and pressure. However, exchange coefficients vary at constant T and P in portions of apatite compositional space where F, Cl, and OH do not mix ideally in apatite. The variation in exchange coefficients exhibited by apatite that does not undergo ideal mixing far exceeds the variations induced by changes in T or P. In regions where apatite undergoes ideal mixing of F, Cl, and OH, temperature has a stronger effect than pressure on the partitioning behavior, but both are important. Furthermore, fluorine becomes less compatible in apatite with increasing pressure and temperature. We are still in the process of analyzing our experimental run products, but we plan to quantify the effects of P and T on apatite-melt partitioning of F, Cl, and OH.