American Mineralogist, Volume 96, pages 1650–1653, 2011

LETTER

Differential degassing of H_2O, Cl, F, and S: Potential effects on lunar apatite

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ABSTRACT

Recent SIMS analysis of water, F, and Cl in lunar apatite suggests significantly higher volatile abundances in lunar magmas than previously considered. However, apatite is commonly a late-crystallizing mineral and its volatile content may reflect late-stage open-system processes that have perturbed the magmatic volatile content and obscured direct information regarding the volatile contents of the parental magmas and magmatic source region. Degassing during magma ascent has the potential to perturb not only the absolute but also the relative magmatic volatile abundances. A set of evacuated silica tube degassing experiments were conducted that simulate ascent of high-Al basalt 14053 with 0.5 wt% Cl, 0.5 wt% F, 0.3 wt% S, and 2.2 wt% (and 2.5 wt%) water (in addition to dissolved C-O-H species) from 100 km to within ~20 m of the surface followed by degassing (at an f_{O_2} of ~QIF). Extensive degassing occurred within 6 h during which 99–100% of the initial water, 89–84% of the initial Cl, 60–61% of the initial F, and 94–92% of the initial S was lost. During degassing, the relative volatile contents showed a strong decrease in water content and an increase in F:Cl ratio. In reflection of the changes in melt volatile contents, apatites crystallizing from the degassed melt would have much lower OH contents and higher F:Cl ratio than apatites crystallized from the non-degassed melt. These results confirm the possibility of significant underestimation of primary magma volatile contents, especially water and Cl, through use of apatite volatile contents and the assumption of simple increases in volatile abundance during magma differentiation.

Keywords: Experimental degassing, lunar magmas, magmatic volatiles, apatite