

NEW CONSTRAINTS ON THE RELATIVE ABUNDANCES OF WATER, F, AND CL IN PARENTAL MAGMAS OF KREEP-BEARING LITHOLOGIES – TAKING DEGASSING INTO ACCOUNT. H. Nekvasil¹ ¹Department of Geosciences, Stony Brook University, Stony Brook, NY 11794-2100 Han-na.Nekvasil@sunysb.edu

Introduction: Two basic questions have arisen from the recent discovery of significant OH in lunar apatites [1-3]: How much water does this imply for lunar magmatic source regions, and, what is the abundance of water relative to that of other major volatiles with significant melt solubility, such as F, Cl, and S? As a first step towards answering these questions, [1] converted the volatile contents measured in apatite from three KREEP-bearing lithologies to the volatile contents of the instantaneous co-existing melts and, assuming an incompatible increase in water, Cl, and F during crystallization of volatile-free minerals, approximated both the parental magma and source region volatile contents. However, if magma degassing took place during apatite growth and the composition of the fluid lost differed in relative abundance of volatiles from that of the magma, the absolute abundance of volatiles can be greatly underestimated and the relative abundances of volatiles changed drastically from that calculated in this manner.

In order to assess the possibility that the apatites themselves preserved information on degassing, [4], [5] conducted a mass balance analysis of the apatite analyzed by [1]. They concluded that the apatites from all three lithologies showed evidence of a degassing history that involved first loss of a water- and Cl-rich bulk fluid (Fluid I in Fig 1) followed by a more water-poor, Cl-rich bulk fluid (Fluid II in Fig 1). Using partition coefficients for F, Cl and OH between melt and apatite of [1],[6],[7] they computed the compositions of the instantaneous melts coexisting with each apatite analysis (colored hexagons in Fig. 1) and mapped out melt evolution paths during degassing (heavy colored solid arrows in Fig. 1). Their results indicated that both the absolute and relative abundances of these volatiles in the melts changed during degassing.

Such analysis was continued to determine if information regarding the relative abundance of water, F, and Cl in fluid and melt *prior to open system degassing* could be extracted in order to provide first insights into the relative volatile abundances of parental magmas of KREEP-bearing lunar lithologies.

Fluid evolution: Computed fluid compositions for the two-stage degassing process recorded in the analysis of apatites from 14053,16 and 15404,51 (open colored circles) form two linear arrays that emerge from the calculated bulk fluid composition of NWA 2977 (thin colored arrows, Fig. 1) at a molar ratio of 86:7:7 (H₂O:F:Cl). It is proposed that this common ratio

represents the composition of fluid just before open-system processes commence and loss of fluid causes divergence of residual magma compositions.

Melt evolution: The calculated melt compositions show a path in H₂O-F-Cl space that reflects the two-stage degassing process recorded in the apatites. Although the path for each lithology is unique, the melt paths emerge from a common point - the initial melt volatile ratio computed for NWA 2977 (as shown by the heavy dashed colored lines of Fig. 1). This suggests that these different lithologies and melt evolutionary paths shared the same initial water:F:Cl ratio. It is proposed that the emergence point at the molar ratio of 82:10:8 (H₂O:F:Cl) represents the point at which simple incompatible increase due to crystallization ended and fluid exsolution and open-system degassing began. Thus, this ratio would be that of the parental magma of these KREEP-bearing lithologies since the ratio does not change upon crystallization of volatile-free minerals (or only changes to a small extent upon crystallization of minor amounts of apatite).

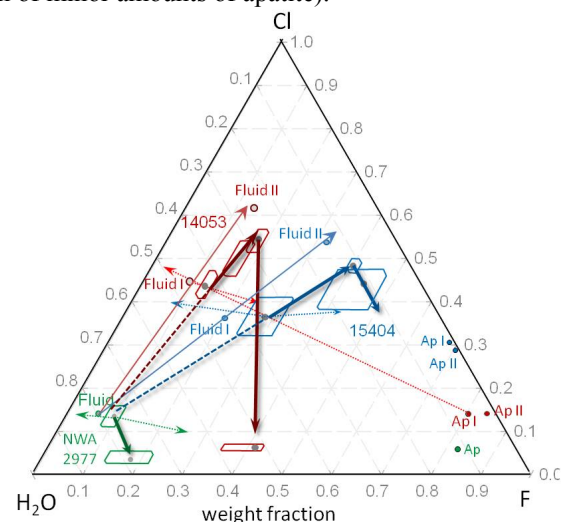


Figure 1. Melt and fluid evolution paths in F-Cl-H₂O space based on apatite analysis of [1] for 14053, 16 (red), 15404, 51 (blue), NWA 2977 (green). Arrows and symbols as described in text.

References: [1] McCubbin F.M. et al. (2010) *PNAS* 107, 11223. [2] Boyce J.W. et al. (2010) *Nature*, 466, 466-469. [3] Greenwood J.P. et al. (2011) *Nature Geoscience*, 4, 79-82. [4] Nekvasil H. et al. (2010) Fall *AGU*, P41A05. [5] Nekvasil H. et al. (2011) *LPSC XLII*, 2240. [6] Boyce J.W. and Hervig R. L. (2009) *Contr. Mineral. Petrol* 157, 135-145. [7] Mathez, E.A. and Webster, J.D. (2005) *GCA* 69, 1275-1286.