Planetary Apatites: Critical Problems In Models Of Oh Contents

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Hydroxyl (OH) contents of apatites from lunar basalts are commonly used to estimate the water-budget for portions of the Moon, resulting in a wide range of estimated water contents from ppb to ~1 wt%. But, we call into question the significance of previous estimates, which have not properly considered the complex mineralogy and petrology of apatites.

We demonstrate that mesostasis pockets within lunar basalts represent isolated heterogeneous systems that have evolved independent of each other, each displaying distinct ranges in OH contents. For example, the OH of different apatites in a single thin-section can vary by a factor of 5 and by >10 within one rock. In addition, we note that apatites within these mesostasis pockets typically crystallized from two (2) K-rich and REEP-rich melts, which form during a late-stage, *silicate-liquid immiscibility (SLI)*. These melts are a product of the Fenner-trend fractional crystallization of typical lunar magmas at low fO_2 (e.g., < IW). Apatites which crystallize in equilibrium with these two immiscible melts require an additional set of OH-partition coefficients when back-calculating magmatic water contents. These caculations are further complicated by the fact that there is *an additional OH-bearing phosphate mineral* in lunar rocks: *whitlockite* - $Ca_{18}Mg_2(PO_4)_{12}[PO_3(OH)]_2$ – which contains >100 ppm OH, in addition to anhydrous merrillite - $Ca_{18}Na_2Mg_2(PO_4)_{14}$.

These critical considerations have largely been over-looked in studies to date: 1) OH phases in heterogeneous mesostasis; 2) phosphate phases formed by SLI; and 3) more than one OH-bearing phosphate – i.e., whitlockite & apatite. There is dire need for pertinent investigations. The lack of integration of these factors into any OH-modeling for phosphate minerals casts serious doubt on many published OH contents of lunar parental magmas and subsequently water estimates of the mantle, LMO (lunar magma ocean), and indeed, the whole-Moon.

Importantly, we call into question the validity of the OH-based water-models of Mars, based upon OH-measurements of Martian or other planetary "apatites", without consid-erations of these critical and possibly mitigating factors.