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Volatile abundances of coexisting merrillite and apatite in the martian meteorite Shergotty: Implications for merrillite in hydrous magmas

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ABSTRACT

Whitlockite and merrillite are two Ca-phosphate minerals found in terrestrial and planetary igneous rocks, sometimes coexisting with apatite. Whitlockite has essential structural hydrogen, and merrillite is devoid of hydrogen. Whitlockite components have yet to be discovered in samples of extraterrestrial merrillite, despite evidence for whitlockite-merrillite solid solution in terrestrial systems. The observation of merrillite in meteoritic and lunar samples has led many to conclude that the magmas from which the merrillite formed were "very dry." However, the Shergotty martian meteorite has been reported to contain both apatite and merrillite, and recently the apatite has been shown to contain substantial OH abundances, up to the equivalent of 8600 ppm H_2O. In the present study, we determined the abundances of F, Cl, H_2O, and S in merrillite from Shergotty using secondary ion mass spectrometry (SIMS). We determined that the merrillite in Shergotty was properly identified (i.e., no discernible whitlockite component), and it coexists with OH-rich apatite. The absence of a whitlockite component in Shergotty merrillite and other planetary merrillites may be a consequence of the limited thermal stability of H in whitlockite (stable only at T <1050 °C), which would prohibit merrillite-whitlockite solid-solution at high temperatures. Consequently, the presence of merrillite should not be used as evidence of dry magmatism without a corresponding estimate of the T of crystallization. In fact, if a whitlockite component in extraterrestrial merrillite is discovered, it may indicate formation by or equilibration with hydrothermal or aqueous fluids.

Keywords: Water on Mars, martian meteorite, SIMS, whitlockite, phosphates