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Detection of structurally bound hydroxyl in fluorapatite from Apollo Mare basalt 15058,128 using TOF-SIMS

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Abstract

Fluorapatite grains from Apollo 15 Mare basalt 15058,128 were analyzed by Raman spectroscopy, Raman spectral imaging, time-of-flight secondary ion mass spectrometry (TOF-SIMS), field emission scanning electron microscopy (FE-SEM), and electron probe microanalysis (EPMA) in an attempt to detect structurally bound OH^- in the fluorapatite. Although OH^- could not be definitively detected by Raman spectroscopy because of REE-induced photoluminescence, hydroxyl was detected in the fluorapatite by TOF-SIMS. The TOF-SIMS technique is qualitative but capable of detecting the presence of hydroxyl even at trace levels. Electron microprobe data indicate that on average, F and Cl (F+Cl) fill the monovalent anion site in these fluorapatite grains within the uncertainties of the analyses (about 0.07 ± 0.01 atoms per formula unit). However, some individual spot analyses have F+Cl deficiencies greater than analytical uncertainties that could represent structural OH^-. On the basis of EPMA data, the fluorapatite grain with the largest F+Cl deficiency constrains the upper limit of the OH^- content to be no more than 4600 ± 2000 ppm by weight (the equivalent of ~2400 ± 1100 ppm water). The TOF-SIMS detection of OH^- in fluorapatite from Apollo sample 15058,128 represents the first direct confirmation of structurally bound hydroxyl in a lunar magmatic mineral. This result provides justification for attributing at least some of the missing structural component in the monovalent anion site of other lunar fluorapatite grains to the presence of OH^-. Moreover, this finding supports the presence of dissolved water in lunar magmas and the presence of at least some water within the lunar interior.

Keywords: Water on Moon, TOF-SIMS, apatite, mare basalt, lunar water, EPMA, Raman spectroscopy, Apollo sample