ABUNDANCES OF CL, F, H, AND S IN APATITES FROM SNC METEORITES.

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Introduction: Magmatic volatiles influence igneous phase equilibria, eruptive behavior, atmospheric composition, and climate. Several lines of evidence suggest that Mars is rich in halogens and S relative to Earth. However, magmatic volatile abundances and their effects on magmatic processes on Mars are controversial. Here we examine igneous apatites in SNC meteorites as indicators of magmatic volatile abundances.

Methods: We measured Cl, F, H (reported as wt% H_2O), and S in 25 apatites from 3 basaltic shergottites (JaH 479, NWA 856, and NWA 2986), 1 lherzolitic shergottite (NWA 1950), and 1 nakhlite (NWA 998) using Caltech's 7f SIMS. We compared our data to literature data for volatiles in SNC apatites [1-8].

Results: Our measurements of Cl, F, and H in SNC apatites are similar to previous data, but the increased size of the collective data set sheds light on systematic variations. Our 3 basaltic shergottites have 0.33-0.95 wt% H_2O (literature data: 0.18-0.64 wt% [1-2]), those from the lherzolitic shergottite have 0.07-0.27 wt% (the only previously measured apatite from such a sample has 0.43 wt% [3]); and those from the nakhlite have 0.07-0.11 wt%. Data are also available for apatites from Chassigny (0.21 wt% [4]) and ALH 84001 (0.08 wt% [2] and 0.22 wt% [4]). Apatites from basaltic shergottites appear to be on average H_2O-rich relative to apatites from other lithologies. S contents are variable (<0.01-0.82 wt%; previous measurements are <0.01-0.08 wt% [5-8]). As with H_2O, S contents are lower in the nakhlite (<0.01 wt%) and lherzolitic shergottite (0.02-0.04 wt%) than in the basaltic shergottites (0.05-0.82 wt%).

Discussion: The H in apatites from basaltic shergottites spans a range similar to apatites from terrestrial mafic igneous rocks. The higher H and S contents of basaltic shergottites relative to other SNC rock types may indicate higher initial volatile contents or lower extents of degassing prior to apatite crystallization.

Based on our results, apatites in SNCs, particularly basaltic shergottites, are significantly richer in S (by ~2X) than those in mafic terrestrial igneous rocks. S is typically incorporated into apatite as SO_4^{2-}, and thus is expected to be more strongly partitioned into igneous apatite at higher fO_2 (i.e., where sulfate dominates over sulfide in basaltic melts). As expected, terrestrial S-rich apatites are found in lavas that are oxidized (ΔQFM +2 - +6 log units). Estimates of fO_2 in shergottite parent magmas (ΔQFM -4 - +0.5 log units) would indicate that S^{2-} was the primary sulfur species. The high S contents of SNC apatite despite low fO_2 could reflect (1) high total magmatic S contents; (2) apatite crystallized late when fO_2 levels rose above estimates; or (3) some S in SNC apatites is present as sulfide in the halogen site.

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