Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.5462

Determination of sulfur speciation in apatites from Martian meteorites (shergottites) using µ-XANES

PROTEEK CHOWDHURY[1], MARYJO BROUNCE[2], JEREMY BOYCE[3] AND FRANCIS MCCUBBIN[4]

[1]University of California, Riverside
[2]University of California Riverside
[3]NASA
[4]NASA Johnson Space Center

Presenting Author: proteekc@ucr.edu

Apatite is a ubiquitous accessory mineral in planetary materials, including in Martian meteorites. Sulfur in terrestrial apatites is mostly S^{6+} as they are formed in relatively oxidized environments [1]. Recently, S^{2-}-only bearing apatites have been documented in lunar and terrestrial [1] environments and in experiments [2], the later also reporting simultaneous incorporation of both S^{6+} and S^{2-} at intermediate oxygen fugacities (fO_2). Thus, it has been suggested that proportions of S^{6+}/S^{2-} in apatite, together with major element compositions, T and P, may record the fO_2 of formation of these apatites [1,2]. Martian rocks, by the virtue of recording intermediate fO_2 between the Moon and Earth [4], may contain S^{2-}-only or both S^{6+} and S^{2-} bearing apatites.

Martian shergottites Shergotty and QUE 94201 record fO_2 of ~IW+1.9-IW+2.8 and ~IW-1.5-IW-1.0, respectively [3], where we expect silicate liquids and the apatites crystallizing from those liquids to contain S primarily as S^{2-}. To test this hypothesis, we present S-XANES measurements of apatite grains and other associated phases.

Shergotty apatites only show peaks of structural S^{2-} in apatites (2470 and 2477 eV) with $S^{6+}/\sum S=0$. The presence of S^{2-}-only apatites in Shergotty is consistent with other mineralogical records of fO_2 in this meteorite and suggest that the oxidation state of sulfur records and preserves the fO_2 during igneous crystallization of apatite. QUE 94201 apatites, however, show peaks of both S^{2-} and S^{6+} (2481.7 eV), varying in $S^{6+}/\sum S$ from 0-100%. This meteorite is known to have gone through substantial sulfate-rich alteration and oxidation both on the fusion crust and in the interior upon arrival to Earth's surface [4]. The oxidized nature of apatites, when considered together with the low fO_2 recorded by the meteorite and reduced nature of apatites from minimally altered Shergotty and lunar rocks suggest that these measurements and/or the apatite grains themselves are subject to contamination by secondary oxidative alteration events on Earth and/or Mars.

[1] Brounce M. et al. (2019) *Am. Min., 104,* 307-312. [2] Konecke B.A. et al. (2019) *Geochim. Cosmochim. Acta, 265*, 242-258. [3] Wadhwa M. (2001) *Science, 291,* 1528-1530. [4] Ross et al. (2010) *LPSC 2010*.