Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.8014

Water in the Crust: Implications for the Evolution of Mars

JESSICA J BARNES[1], FRANCIS MCCUBBIN[2], ALISON SANTOS[3], JAMES M. D. DAY[4], JEREMY BOYCE[5], SUSANNE SCHWENZER[6], ULRICH OTT[7], IAN FRANCHI[8], MAHESH ANAND[6] AND CARL AGEE[9]

[1]University of Arizona
[2]NASA Johnson Space Center
[3]NASA Glenn Research Center
[4]Scripps Institution of Oceanography
[5]NASA
[6]The Open University
[7]Max Planck Institute for Chemistry
[8]Open University
[9]University of New Mexico

Presenting Author: jjbarnes@lpl.arizona.edu

The abundance and distribution of water within Mars through time plays a fundamental role in constraining its geological evolution and habitability. The isotopic composition of Martian hydrogen provides insights into the interplay between different water reservoirs on Mars. However, D/H ratios of Martian rocks and of the Martian atmosphere span a wide range of values. This has complicated identification of distinct water reservoirs in and on Mars within the confines of existing models that assume an isotopically homogenous mantle.

Here we present H_2O-D/H data collected by nanoscale secondary ion mass spectrometry from apatite in two Martian meteorites: Allan Hills (ALH) 84001 and lithic clasts in Northwest Africa (NWA) 7034. Both samples record the history of fluids in the Martian crust. Apatite grains within these samples display a similar spread in D/H ratios over a wide range of water contents. Our results are consistent with D/H values reported for the Martian crust within the time span of 0.7 to 472 million years ago (Ma) [1] and analyses of Hesperian (~3 Ga) clays by the Sample Analysis at Mars (SAM) instrument on board the Mars Science Laboratory rover (D/H ratio of $(4.67 \pm 0.31) \times 10^{-4}$)[2]. Combined these data indicate that the Martian crust has been characterized by a constant D/H ratio over the last 3.9 billion years.

The crust represents a reservoir with a D/H ratio that is intermediate between at least two isotopically distinct primordial water reservoirs within the Martian mantle, sampled by partial melts from geochemically depleted and enriched mantle sources. From mixing calculations, we find that a subset of depleted Martian basalts is consistent with isotopically light hydrogen (low D/H) in their mantle source, whereas enriched shergottites sampled a mantle source containing heavy hydrogen (high D/H). Our findings indicate that the Martian mantle is chemically heterogeneous with multiple water reservoirs, indicating poor mixing within the mantle after accretion, differentiation, and its subsequent thermochemical evolution [3].

[1] Usui, et al (2015), *Earth Planet. Sci. Lett.* 410, 140–151.

[2] Mahaffy, et al (2014), *Science* 347, 412–414.

[3] Barnes, J (2020), *Nature Geoscience*, 13(4), 260-264.