

GLOBAL PRESENCE OF SUBSURFACE GLACIER ON MARS EVIDENCED BY THE CORRELATION BETWEEN WATER CONTENTS AND HYDROGEN ISOTOPIC RATIOS OF MARTIAN METEORITES.

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Introduction: At present Mars is prevailed by frigid and dry climate. It is widely accepted that there was flowing water on the surface of Mars probably 3.7 Ga ago [1], based on the topography and the presence of phyllosilicates, sulfates and carbonates. The vanishing of surface water was partly attributed to sputtering escape of H₂O by the solar wind due to cessation of the internal dynamo action of Mars 4 Ga ago [2]. The escaping of water from Mars resulted in enhancing of D/H ratios in the remained water, which could be recorded in Martian meteorites [3]. Another fraction of water could be preserved as subsurface glacier [4] and mixed with carbon dioxide ice in the polar ice sheets. The subsurface glacier would be melted when basalt erupted, and the event could be recorded in the basalt via rock-water reaction. This scenario was revealed by high resolution topography [5] and evidenced by our previous study of the tholeiitic basalt GRV 020090 [6], which recorded the highest D-enrichment of Martian meteorites with $\delta D = 6034 \pm 72 \text{‰}$ (2σ). We extended the measurements to more Martian meteorites, and the results argue for the global presence of subsurface glacier on Mars.

Sample and Experiments: Beside GRV 020090, other 5 shergottites NWA 8657, NWA 6162, Y 002192, Y 980459 and Tissint, have been studied in this work. The petrography and mineral chemistry of these Martian basalts were studied with an FE-SEM, an EPMA and laser Raman spectroscopy. Silicate melt inclusions in olivine, pyroxene and a few in chromite, apatite, maskelynite and shock melt glass were selected for analysis of water contents and H isotopes, which were carried out with NanoSIMS 50L. The NanoSIMS analyses were calibrated for the matrix effects, using the standards of apatite and basaltic glass.

Results and Discussions: The analyses of melt inclusions in all 6 Martian basalts GRV 020090, Tissint, NWA 6162, NWA 8657, Y 002192 and Y 980459 plot on the same two-endmember mixing line, with one reservoir representative of the δD -normal Martian mantle and the other for Martian underground water that was produced by melting of subsurface glacier due to eruption of basalt magma. The Martian underground water reservoir shows a rather narrow range of δD values (5200-6000 ‰). These observations argue for the global presence of subsurface glacier, and suggest that the transformation from flowing water on the surface to the subsurface glacier took place very fast. The δD values of the Martian subsurface glacier should have been fixed since the red planet became frigid. Beside those plotted on the two-endmember mixing line, some analyses of the melt inclusions in Y 002192 contain lower water contents with higher δD values, probably due to moderately degassing loss of water accompanying isotope exchange with the D-enriched molten subsurface glacier. The global presence of the D-enriched molten subsurface glacier was confirmed by the measurements on shock-induced melt veins and pockets in these meteorites, which plots on the same mixing line defined by the melt inclusions. In Y 980459, it was also noticed that the shock-induced glasses contain more water with higher δD values than the melt inclusions in the same meteorite, suggestive of addition of water mainly by impact. During impact events, water vapor could be released and mixed with the silicate melt.

Acknowledgments: NWA 6162 was supplied by El Goresy. This work was supported by Natural Science Foundation of China (41430105, 41573057) and Key Research Program of Frontier Sciences, CAS (QYZDJ-SSW-DQC001).

References: [1] Ehlmann B. L., et al. 2011. *Nature* 479: 53-60. [2] Acuña M. H., et al. 1999. *Science* 284: 790. [3] Watson L. L., et al. 1994. *Science* 265: 86-90. [4] Holt J. W., et al. 2008. *Science* 322: 1235-1238. [5] Neukum G., et al. 2004. *Nature* 432: 971-979. [6] Hu S., et al. 2014. *Geochimica et Cosmochimica Acta* 140: 321-333.