Reestimate the intermediate water reservoir on Mars recorded by martian meteorite Yamato 980459

Sen Hu[1], Akira Yamaguchi[2], Yue Zhang[3], Huicun He[1], Jialong Hao[1], Wei Yang[1], and Yangting Lin[1]
[1]*Institute of Geology and Geophysics, Chinese Academy of Sciences*
[2]*National Institute of Polar Research*
[3]*Nanjing University*

Mars is one of the most intriguing planets in the solar system because of the presence of water and its consequences in the early times. Widespread phyllosilicates on the ancient terrains and evaporate deposits on the young ones indicate that Mars' paleoclimate has experienced a wet to arid transform (Ehlmann et al., 2011). The igneous rocks ejected from Mars, martian meteorites, would have experienced water-rock interactions on Mars as evidenced by the secondary hydrous alteration minerals in nakhlites chassignites, and some shergottites (Bridges et al., 2001). Therefore, martian meteorites could be able to record the hydrogen isotope of the surface water reservoir because of the water cycle on Mars (Jakosky, 2021). Most shergottites display notable D-enriched signature similar to the value of present martian atmosphere measured by Curiosity (Mahaffy et al., 2013; Wang and Hu, 2020). However, Yamato (Y) 980459 displays an intermediate D-enriched nature which probably represents a new water reservoir or potential D-poor water hydrothermal activities on Mars (Usui et al., 2012, 2015). In this study, we remeasured the H_2O, F, and Cl abundance and H and Cl isotope systematics of melt inclusion glasses and impact glasses from Y 980459 in order to unravel the details of hydrothermal events that happened on Mars.

A polished thin section of Y 980459 (41-5) was used in this study. The petrography details were obtained with FE-SEM at the NIPR. Y 980459 is an olivine-phyric shergottite. It is mainly comprised of pyroxene, goundmass, and olivine phenocrysts with minor opaque minerals. About 20 melt inclusions with diameter less than 10-50 μm were identified in olivine phenocrysts. A shock induced melt pocket was observed in Y 980459, displaying smooth surface and quenched textures. The volatile element abundances and H and Cl isotopes of melt inclusion glasses and impact glasses from Y 980459 were measured at the IGGCAS using NanoSIMS 50L.

The water contents and hydrogen isotopes of Y 980459 melt inclusion glasses varied from 16 to 135 ppm ppm and 3335 to 6618 ‰, respectively. Y 980459 impact glasses have higher water abundance (27-4699 ppm) and comparable δD values (2826-5442 ‰) compared with melt inclusion glasses. Both melt inclusion glasses and impact glasses have similar δD values to present martian atmosphere (Mahaffy et al., 2013). Water abundances and δD values of Y 980459 melt inclusion glasses and impact glasses are logarithmically correlated along two-endmember mixing trend similar to the features recorded in other shergottites (Wang and Hu, 2020), indicating that previously reported δD values were underestimated and the intermediate water reservoir on Mars could not exist. Y 980459 melt inclusion glasses have comparable Cl abundances (39-332 ppm) and higher F (12-15 ppm) and δ^{37}Cl (-0.2 to 5.8 ‰) than that of impact glasses (Cl: 37-305 ppm, F: 2-17 ppm, δ^{37}Cl: most < -1 ‰). In the aspect of Cl isotope, melt inclusion glasses may have exchanged with crustal Cl reservoir while impact glasses are likely printine to the mantle reservoir (Sharp et al., 2016; Williams et al., 2016). The similar δD values and decouple of Cl isotope between melt inclusion glasses and impact glasses could be the result of at least two hydrothermal events that happened on Mars, one is magmatic based (Hu et al., 2014) and the other one is created by asteroid impact (Chen et al., 2015; Hu et al., 2020).

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