HYDROGEN ISOTOPE STUDIES OF FELDSPATHIC AND MAFIC GLASSES IN MARTIAN METEORITES ALH 84001 AND EETA 79001; N.Z. Boctor[1], J. Wang[2], C.M.O'D Alexander[2], E. Hauri[2], C.M. Bertka[1], and Y. Fei[1], [1]Geophysical Laboratory, Carnegie Institution of Washington, 5241 Broad Branch Rd., NW, Washington, DC 20015; USA, [2]Department of Terrestrial Magnetism, Carnegie Institution of Washington, 5241 Broad Branch Rd., NW, Washington, DC 20015, USA.

Introduction: A recent investigation of the hydrogen isotopic composition of water extracted by stepwise heating of SNC meteorites [1] suggests that the water originated from two sources: a terrestrial contaminant released at low temperature and an extraterrestrial component released at high temperature. The whole rock δD value of the high temperature hydrogen in ALH 84001 (+800‰) is higher than the δD values reported by [2, 3] for the water-bearing phases whitlockite (+166‰ to +477‰) and carbonate (+175‰ to +313‰). Calculations by [1] show that more than 6 wt.% of a phosphate containing 0.4 wt.% water is required to account for the water released from ALH 84001 above 350° C. The modal abundance of whitlockite in ALH 84001 is <1.0% and its water content (800 to 1600 ppm) [3] is too low to account for the high temperature water component in the whole rock. The same argument holds for the carbonate which form ~ 1.0% of ALH 84001 and which has a water content lower than whitlockite (400 to 700 ppm) [3]. It is therefore logical to assume that there is another water-bearing phase in ALH 84001 with a high δD value, a higher modal abundance, or a higher water content than whitlockite and carbonate in order to account for the high δD value in the whole rock and its high temperature water budget. A likely phase is feldspathic glass which is known to have the capacity to incorporate water into its structure.

In this investigation, we determined the hydrogen isotopic composition of the feldspathic glass in ALH 84001 and the much younger shergottite EETA 79001. The hydrogen isotopic signature of the mafic glass in EETA 79001 lithology C [4, 5] was also determined. Earlier investigations of the hydrogen isotopic compositions of amphibole and apatite in shergottites [6] suggest that they interacted with crustal fluids that equilibrated with present day Martian atmosphere. If the glass in the much older ALH 84001 has interacted with crustal fluids on Mars, it may provide clues about an earlier and perhaps less fractionated Martian atmosphere 4.5 b.y. ago.

Results: The ion probe analyses were performed with a 12.5kV Cs^+ primary beam of 2nA, 5kV secondary accelerating voltage and an electron flood gun for charge compensation. The analyzed areas ranged from 5 to 25 μm. The water contents of the feldspathic and mafic glasses were determined from the measured $H/^{30}Si$ calibrated against $H/^{30}Si$ of rhyolite standards containing 0.297 to 0.992 wt.% water and an amphibole standard (2.03 wt.% water). The results are given in Table 1.

The δD of feldspathic glass in ALH 84001 ranges between +1748 ± 107‰ and 969 ± 13‰. The water contents range between 0.081 and 0.183 wt.%. An exceptionally high water value of 0.732 wt.% in one analyzed area is likely to be due to a contribution from phyllosilicate inclusions [7]. The feldspathic glasses in EETA 79001 have higher δD values relative to ALH 84001 (+2757 ± 38‰ to +1727 ± 59‰) and lower water contents of 0.008 to 0.012 wt.%. The mafic glasses in

Table 1. Ion Probe Analyses of Hydrogen Isotopes of Glasses in ALH 84001 and EETA 79001

Sample	δD%	wt.% water
ALH 84001 Feldspathic glass	+1748 ± 107	0.081
	+1628 ± 136	0.109
	+1460 ± 24	0.088
	+1175 ± 11	0.183
	+1152 ± 16	0.104
	+969 ± 13	0.732
	+1755 ± 36	-
	+1459 ± 35	-
	+1357 ± 13	-
	+1215 ± 15	-
	+1073 ± 18	-
EETA 79001 Feldspathic glass	+2757 ± 38	0.008
	+2087 ± 44	0.006
	+1727 ± 59	0.012
Mafic glass	+2901 ± 23	0.012
	+2607 ± 27	0.028
	+2023 ± 34	0.035

EETA 79001 also show high δD values (+2901 ± 23‰ to +2023 ± 34‰) and low water contents (0.012 to 0.035 wt.%). Though the data are limited, there appears to be a negative correlation between the δD values and the water content. A single grain of whitlockite in EETA 79001 has a δD of 147 ± 17 and a water content based on the measured $H/^{16}O$ of 0.116 wt.%.

Discussion: The hydrogen isotope data on the feldspathic and mafic glasses confirm the presence of an indigenous extraterrestrial hydrogen component in ALH 84001 and EETA 79001. The hydrogen isotope data can be interpreted by one of two hypotheses: (A) feldspathic and mafic glasses reacted with a crustal water reservoir that equilibrated with the Martian atmosphere. The whitlockite and the carbonates did not fully equilibrate with the reservoir or were much more susceptible to terrestrial contamination than the glasses. (B) Impact induced hydrogen loss from the feldspathic or mafic glasses is responsible for, or contributed to, the enrichment of D in the glasses. In such case, the whitlockite and carbonate preserved their primary hydrogen isotopic signature, or this signature was acquired by interaction of whitlockite and carbonate with a more primitive atmosphere much less fractionated than present day Martian atmosphere. If hydrogen loss during impact metamorphism is responsible for the D enrichments in the glasses, then the low δD values of carbonates argue against their formation by impact as suggested by [8].

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