

VOLATILE ABUNDANCES AND H ISOTOPE SIGNATURE OF FELDSPATHIC GLASS AND CLINOPYROXENE IN THE SHERGOTTITES ZAGAMI, EETA 79001, SHERGOTTY, AND ALHA 77005; N.Z. Boctor¹, C.M.O'D.Alexander¹, ¹Carnegie Institution of Washington, 5251 Broad Branch Rd., NW, Washington, DC 20015, USA.

Introduction: Volatile elements are of great geochemical importance because they influence a wide range of geological processes. Water and other volatiles play a significant role in partial melting processes in the source regions of magmas and in the eruption and crystallization of primary magmas. [1,2] investigated the volatile abundances and hydrogen isotope signatures of the nominally anhydrous minerals, melt inclusions, and glass in the nakhlites and chassignites (Chassigny and NWA 2737). They concluded that nominally anhydrous minerals in Martian meteorites contain trace amounts of OH and may constitute the main H reservoir in the Martian interior. In this investigation, we extend our study to the shergottites, the most common group of Martian meteorites, and the more severely shocked.

Experimental: The abundances of H₂O, CO₂, F, S, and Cl were measured with a Cameca 6F ion microprobe using the techniques described by [3]. A charge compensated Cs⁺ primary beam was used, and the negatively charged secondary ions were collected. Routine detection limits measured by this method measured on synthetic forsterite were H₂O 2-4 ppm, CO₂ <3 ppm, and F, Cl, and S <1 ppm. Glass standards with appropriate concentrations for all the analyzed volatile elements were used. SIMS operating conditions for H isotopic measurements were 15 kV Cs⁺ primary beam of ~2nA, 5 kV secondary accelerating voltage, a 50 eV energy window, a mass resolution of ~400 and an electron flood gun for charge compensation. Small chips of Martian meteorites EETA 79001, ALHA 77005, Shergotty, and Zagami were mounted in indium metal to avoid any contamination from epoxy and polished by alumina to avoid contamination from carbon-based abrasives.

Results: The volatile abundances and H isotope compositions of feldspathic glass and clinopyroxene are given in Tables 1 and 2. Feldspathic glass in EETA 79001, ALHA 77005, and Zagami show an extraterrestrial H isotopic signature. The δD for clinopyroxene in EETA 77001 and Zagami are low and overlap with the terrestrial range, whereas clinopyroxene in ALHA 77005 shows elevated δD values suggestive of equilibration with a fractionated water reservoir on Mars. We have yet to conduct H isotope measurements on our thick polished section of Shergotty, but our earlier measurement [4] on a polished thin section

found fractionated H isotope signatures. The volatile abundances in the feldspathic glass are generally low and in many analyses, the concentrations of F, S, and Cl are at the detection limits. The high S in Zagami and EETA 79001 glasses are likely due to presence of minute droplets of sulfide disseminated in the glass.

Discussion: The majority of Martian nominally anhydrous minerals, including those from shergottites, have low D/H values. If this signature is a primary magmatic signature and not due to terrestrial contamination, then the D/H ratio of the parent magmas was low. Degassing decreases the δD values of the melt as a result of vapor-melt equilibrium isotope fractionation. Degassing would also account for the depletion of volatiles in Martian nominally anhydrous minerals [1, 2] relative to primitive MORB for instance whose minerals have volatile abundances of (in ppm): H₂O 370-1220, CO₂ 44-244, F 50-155, S 495-1024, and Cl 1-21 [5]. Degassing would also explain the xenon isotope systematics of the known Martian reservoirs [6]. Although Shergotty clinopyroxene shows core to rim zonation of Li and B consistent with degassing [7], other shergottites (e.g., NWA 480 [8]) and some of the nakhlites we examined do not show such chemical zonation. An alternative explanation of the low volatile abundances in Martian nominally anhydrous minerals is depletion of volatiles in the source regions of their parent magmas.

The depletion of volatiles in feldspathic glass is likely due to shock devolatilization and is not related to primary magma degassing. Experiments by [9] show that during shock melting, water is lost from shock melted regions and the water loss is accompanied by enrichment of D in the residues. The elevated D concentration in the Martian glasses is likely due in part to shock loss of H and to exchange with a fractionated Martian reservoir on Mars.

References: [1] N.Z. Boctor et al. (2005) LPSC abstract, 1751. [2] N.Z. Boctor et al. (2006) LPSC abstract, 1412. [3] E. Hauri (2002) Chem. Geol., 183, 115-141. [4] N.Z. Boctor et al. (2003) Geochim. Cosmochim. Acta, 67, 3971-3989. [5] A.E. Saal et al. (2002) Nature 419, 451-455. [6] D.S. Musselwhite and M.J. Drake (2000) Icarus, 148, 160-195. [7] H.Y. McSween et al. (2001) Nature, 409, 487-490. [8] P. Beck (2004) Geochim. Cosmochim. Acta, 68, 2925-2933. [9] J.A. Tyburczy et al. (1990) EPSL 98, 245-261.

Table 1. SIMS analyses of volatiles in feldspathic glass in the shergottites Zagami, EETA 79001, and Shergotty

Sample	H ₂ O ppm	CO ₂ ppm	F ppm	S ppm	Cl ppm
Shergotty	4-35	3-62	<1	<1	<1
Zagami	4-707	3-29	<1-4	<1-53	<1-27
EETA 79001	6-109	4-64	<1-15	<1-20	<1-2

Table 2. SIMS analysis of hydrogen isotopes in feldspathic glass and clinopyroxene in the shergottites Zagami, EETA, 79001, and ALHA 77005

Sample	δD (‰)
EETA 79001	
Feldspathic glass	+10 to +1342
Cpx	-154 to +98
Zagami	
Feldspathic glass	-110 to +908
Cpx	-89 to +45
ALHA 77005	
Cpx	-46 to +753