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Volatile abundances and H isotope signatures of melt inclusions and nominally anhydrous minerals in SNC Martian meteorites

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Water and other volatiles play a significant role in partial melting processes. Water degassing at shallow depths is the main source of energy for volcanic eruptions. Nominally anhydrous minerals also contain trace or minor amounts of OH and constitute the main H reservoir in the Earth's mantle and perhaps the Martian interior. Water in nominally anhydrous minerals has a profound effect on the rates of high-pressure phase transitions in planetary interiors. We measured the abundance of H_2O, CO_2, F, S, and Cl and the H isotope composition of the nominally anhydrous minerals and melt inclusions in the shergottites, nakhlites, and chassignites (SNC meteorites) using standard SIMS techniques. The volatile abundances in the olivine and pyroxene in the nakhlites which show no pervasive alteration or shock melting are lower than those of typical terrestrial basalts, mantle xenolithes, and megacrysts. The δD values for olivine are low and overlap with the terrestrial range (-350 to +100‰). The clinopyroxene shows a wide range of δD, the largest being Governador Valadares (+200 to 1250‰). The olivines in chassignite have water abundances that are similar to those of terrestrial mantle olivine (140 to 280 ppm) and low δD values (-67 to +86‰). In the shergottites, water abundance in cpx varies from one meteorite to another and ranging from 7 to 66 ppm for ALH 77005, and 454 to 714 ppm in Zagami. Water abundances in cpx of the analyzed shergottites are lower than those in cpx from terrestrial mantle derived pyroxenes, which range between 130 and 970 ppm .These are also lower than the most primitive MORB (370 to 1220 ppm). Olivine in ALHA 77005 has water abundance of 14 to 205 ppm. The most hydrous naturally occurring mantle-derived olivine contains 240 ppm. Water abundance in the melt inclusions in

ALH 77005 ranges from 74 and 163 ppm, and δD for melt inclusions lies between +28 to +375‰. The δD for the host olivine ranges between –47 to 746‰ with most of the olivine showing an extraterrestrial H signature. Most inclusions in the nakhlites, chassignites, and shergottites have low water abundances and, by Martian meteorite standards, modest D enrichment. If the compositions of the nominally anhydrous minerals are primary, then the δD value of the parent magma is low. H isotopes provide clues to why the water contents of the melt inclusions are low. Degassing reduces the δD of the magma due to vapor-liquid equilibrium isotopic fractionation. The low volatile abundance in nominally anhydrous minerals relative to terrestrial analogs suggests that either their parent melts degassed or volatiles were depleted in the source regions of magma generation. Devolatilization by impact would also lead to loss of volatiles, especially if partial melting occurs. Vesiculation of the feldspathic glass in ALHA 77005 and EETA 79001 suggest that volatile loss has occurred. In the majority of meteorites we studied, there is no significant correlation between δD and H_2O.contents Given the low water contents, devolatilization by impact and terrestrial contamination may be complicating the interpretation of the H isotope data.