Isotopes of H, N, and O in H Chondrite Xenoliths

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Introduction: Brecciated H chondrites host a variety of xenoliths, including unshocked, phyllosilate-rich carbonaceous chondrites (CCs) [1-2]. The brecciated H chondrite Zag (H3-6) is one of two chondrites to host macroscopic (1 - 5mm), xenolithic crystals of halite (NaCl) with aqueous fluid inclusions and organics [3-4]. A ~1cm CC xenolith in Zag (Zag clast) also encloses halite in its matrix, linking the halite and the xenolith to the same parent object. The Zag clast has mineralogy similar to CI chondrites, but it has a unique bulk oxygen isotopic composition among all meteorites ($\Delta^{17}O$ = 1.49 ± 0.04 ‰, $\delta^{18}O$ = 22.38 ± 0.17 ‰) and is therefore derived from a uniquely sampled parent object [5-6]. Organics have high bulk δD and $\delta^{15}N$ values with isotopic "hotspots" similar to organics in CR chondrites and Bells (C2-ung.) [6-7]. Bulk $\delta^{15}N$ is also similar to CRs and Bells [7]. We provide further isotopic characterization of the Zag clast to constrain the formation temperature and origin of its primary and secondary components.

Sample and Methods: We performed secondary ion mass spectrometry (SIMS) with the UH ion microprobe on a ~2x3mm section of the Zag clast. Oxygen isotopes were measured in multi-collection mode for olivine, augite, dolomite (dol) and magnetite (mgt). Hydrogen isotopes were measured at 21 spots in matrix using mono-collection mode with $^{16}O^-$ beam defocused to ~30μm.

Results: Olivine and augite have O compositions that follow the PCM line, similar to CCs. The mean D/H composition of matrix (δD = 357 ± 31 ‰) is in extreme isotopic disequilibrium with organics measured by [6-7], and is similar to bulk CR chondrites and Bells (C2-ung.) measured by [8]. The combined bulk δD (measured by us) and $\delta^{15}N$ [7] signature implies that CRs, Bells, and the parent object of the Zag clast inherited a very similar reservoir of both water ice and organics. Weighted least squares with dol and mgt gives a mass fractionation line with slope = 0.518 ± 0.007 and $\Delta^{17}O$ = 1.46 ‰. We conclude that dol and mgt were mass fractionated from the bulk composition in a closed system. $\delta^{18}O$ values for dol and mgt clustered around +41 ‰ and -6 ‰, respectively. Oxygen isotope geothermometry gives a sub-zero co-crystallization temperature for dol and mgt ~ -15°C, which may explain the isotopic disequilibrium between organics and phyllosilicates.

Xenoliths in brecciated H chondrites provide unique lithologies that are not available as meteorites. We are currently working to characterize several other xenoliths in H chondrites, which will provide a unique library of CC analogs that can be compared to materials returned by asteroid sampling missions.

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