H_2O ABUNDANCES OF AN EH6 CHONDRITE AND POTENTIAL IMPLICATIONS FOR EARTH.

M. L. Gray[1], M. K. Weisberg[1,2,3], C. M. O'D. Alexander[4], J. Wang[4], D. S. Ebel[1,3], [1]Dept. Earth and Environmental Sci., CUNY Graduate Center, New York, NY 10016. (mgray1@gradcenter.cuny.edu) [2]Dept. Physical Sci., Kingsborough College CUNY, Brooklyn, NY 11235. [3]Dept. Earth and Planetary Sci., American Museum of Natural History, New York, NY 10024. [4]Earth and Planets Laboratory, Carnegie Institution for Science, 5241 Broad Branch Road, Washington, District of Columbia, 20015.

Introduction: A major issue in Planetary Science is the development of terrestrial planet habitability, and essential to this is understanding the distribution of volatile elements in the early Solar System. There are uncertainties about which meteorite group or groups, if any, are analogs of the major building blocks that formed the Earth and contributed to its volatile inventory. The stable isotope compositions of enstatite (EC) chondrites are closest to Earth [e.g., 1-4], but ECs have been considered too dry to have provided Earth with its oceans, compared to the more hydrous carbonaceous (CC) and ordinary chondrites [5]. However, [6] analyzed the H contents of a number of ECs and concluded that they can contain sufficient H to explain Earth's inventory. A difficulty in measuring the H content of meteorites is the potential of terrestrial weathering. Ensuring that one only measures the indigenous H content is particularly acute for ECs, as they contain phases that readily react with atmospheric moisture [7]. To further test the H contents of ECs, and to gain a better understanding of the carriers of their volatiles, we will be analyzing the volatile contents in individual mineral grains in ECs. Here we present our initial results on H in the EH6 chondrite Northwest Africa (NWA) 7976. We chose this as an initial test of blanks because it is heavily weathered.

Methods: We prepared a polished chip of NWA 7976 and analyzed it by electron microprobe to obtain element maps and mineral compositions. We performed NanoSIMS analysis to obtain the H contents of enstatite, reported here as equivalent H_2O contents, in a total of 33 grains.

Results: NWA 7976 is texturally and compositionally equilibrated and contains only a single relict chondrule [8]. It was assigned weathering grade W4 [9] and contains small to large weathering veins throughout. It has a roughly granoblastic texture, dominated by anhedral to subhedral equant crystals of enstatite and plagioclase with minor diopside. Enstatite shows undulose extinction in cross-polarized light, suggesting a shock stage S2 resulting from relatively low shock pressures of 5-10 GPa [10]. The enstatite composition is $En_{98.0\pm0.20}Wo_{1.43\pm0.05}$ (N=18) and the fairly homogenous plagioclase composition is $Ab_{80.8\pm0.69}An_{15.0\pm0.56}$ (N=18), as reported previously [9]. The H_2O contents of the enstatite grains we analyzed have a range of 27 to 51 ppm, with an average of 39±7 pmm (N=33). Previously, we determined the bulk H content of five E3s, which showed a range of 753 to 3213 ppm (N=5) [3].

Discussion: Our results for the H_2O contents of enstatite are significantly lower than our previously determined bulk values for E3 whole rock powders [3], and the H_2O values reported by [6]. [6] measured bulk EC H_2O contents between 800 ppm (EL6) and 5400 ppm (EH3), in interior chips from a range of EL6 to EH3 chondrites. The pyroxenes in E3s make up on average 62.8 vol. % [5]. This raises the question of what other phases could be the carriers of H in ECs, in addition to fractures and grain boundaries, since reported bulk H values are significantly higher than we would estimate from our measurements. Organics are the second largest carrier of H in CCs, but in type 6 chondrites, it is likely that the organics have been destroyed [11]. Additionally, thermal metamorphism in the EH parent body would have resulted in dehydration of the higher petrologic types [6], such as NWA 7976.

Weathering. Measured values for H could be the result of terrestrial weathering, and reflect weathering at the surface, water absorbed from the atmosphere, or reaction with atmospheric moisture. E3s, being finer-grained and more porous, may be more susceptible to absorbing water than higher petrologic types [6].

Conclusion: Our measurements of H_2O abundances in enstatite in the EH6 NWA 7976 are significantly lower than our previous bulk measurements for EH3s, and for bulk and mineral values reported by [6]. Since enstatite is a major constituent of ECs, remaining H carriers must contain abundant water to account for the reported bulk H contents and for ECs to have significantly contributed to Earth's volatile budget. Alternatively, Earth's water was accreted from a mixture of materials, such as a combination of different chondrite groups (EL, CM, CO [4]) [6,12-14], and/or cometary materials [15]. For future work, to get a better understanding of all the H carriers in ECs, additional individual phases will be analyzed and their relative mass fractions determined.

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