H, N, AND C ISOTOPES IN ENSTATITE CHONDRITES AND ACCRETION OF THE EARTH.

M. L. Gray[1], M. K. Weisberg[1,2,3], D. S. Ebel[1,3], C. M. O'D. Alexander[4], D. I. Foustoukos[4], K. T. Howard[1,2,3], [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 Sci., 5241 Broad Branch Road, Washington, District of Columbia, 20015.

Introduction: There are contradictory views on which chondrite groups represent the precursors of Earth. The stable (O, Cr, Ti, Ni) isotope chemistries of enstatite chondrites (ECs) are closest to the Earth [e.g., 1-4], whereas carbonaceous (CCs) and ordinary (OCs) chondrites are ruled out [5]. However, some bulk chemical properties and low δ^{30}Si values of ECs do not match Bulk Silicate Earth (BSE) [6,7] and thus are not easily explained in an EC model for Earth. Studies of volatiles are important because they may provide information on the origin of Earth's oceans, atmosphere, and, potentially, life. Recently, [8] showed that the H and N isotopic compositions of ECs and aubrites are similar to Earth's mantle, which is backed by our new E3 data [9]. To further test these results, we evaluate H, N, and C isotopic compositions of over 120 chondrites [10-12, unpublished] – covering E, C, and O groups – and compare the values to Earth. Our goal is to assess which Solar System material(s) potentially contributed to Earth's accretion.

Results: Interior chips of 2 EL3 and 3 EH3 chondrites, ranging from 0.5g to 0.6g, were powdered and sieved to <106 µm. H, N, and C bulk contents and isotopic compositions of the non-magnetic portion were measured using the techniques in [10]. Aside from one EC (Qingzhen) analyzed, all others are Antarctic or hot desert finds. With regard to potential terrestrial contamination of the samples, some EC phases are unstable in air and have δD values similar to the expected values for water vapor. The H, N, and C isotope values for Earth used in this study are from [8,13,14, respectively]. Based on these isotopes, the chondrite groups that fall within the range of solid Earth are EL3s, some COs, CMs and one OC (Fig. 1). Both EH and EL groups have H and N isotopic compositions similar to Earth's mantle [9]. However, EH3s have lighter C isotopic compositions than EL3 and solid Earth, based on our limited data. As shown by [8] and confirmed by our data, ECs have isotopically lighter N and H compositions than Earth's atmosphere. In contrast, COs and CMs extend to higher δD and δ^{15}N values, overlapping with Earth's oceans.

Discussion: Based on H, N, and C isotopes – and other isotope systems (O, Cr, Ti, Ni) – ELs are the best match for solid Earth. Some issues with an EC precursor for Earth are contradicting bulk chemical properties and their low δ^{30}Si values [7]. However, [15] proposed metal-silicate Si isotope fractionation in a reduced nebular environment, as well as volatilization during accretion as potential processes that influenced the Si isotopic composition of the terrestrial mantle. That being said, it is possible that (1) the materials that accreted to form Earth were exhausted after accretion and are not represented in our meteorite collections, (2) the initial isotopic compositions of the volatile elements were modified during accretion, or (3) Earth accreted from a mixture of materials [e.g., 14]. The ECs' relatively light H and N isotopic compositions cannot account for the oceans and atmosphere, suggesting a contribution from heavier isotope-enriched materials. Several mixing models have been proposed [2,13,14,16]. Our results also favor a mixing scenario (3), with a solid Earth dominated by EL-like material and late contribution from CC-like chondrites, potentially because of instabilities in the outer Solar System [e.g., 17].

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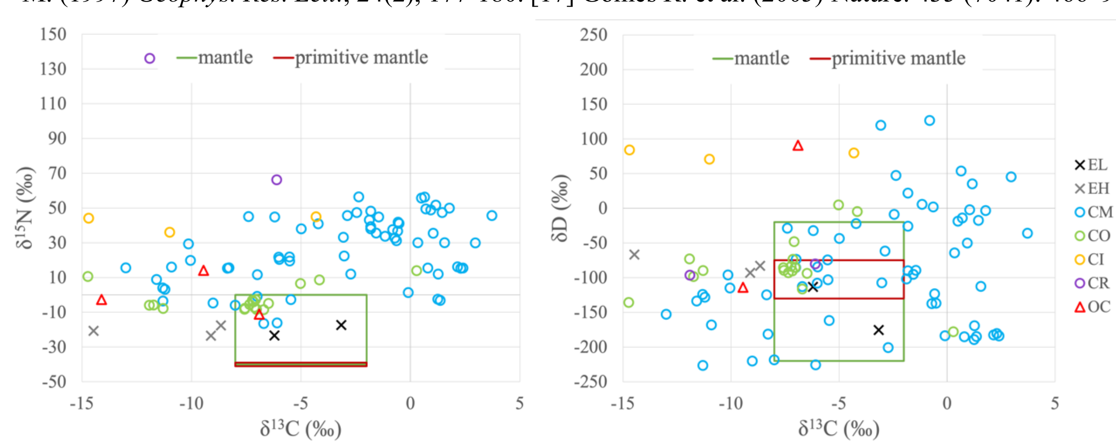

Figure 1. Plots of δ^{13}C vs. δ^{15}N and δD showing ELs, COs, CMs, and one OC have similar stable isotope compositions as Earth's mantle.