COMPOSITIONAL STUDIES OF THREE LOW-FeO ORDINARY CHONDRITES.
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Introduction: The H, L and LL groups of ordinary chondrites, account for a majority of known chondritic meteorites [1] and are distinguished from each other through differences in bulk chemical and isotopic composition, chondrule size and oxidation state [e.g. 2]. Each of these attributes was primarily established prior to accretion within the solar nebula and/or by incorporation of nebular components in slightly varying amounts. However, some ordinary chondrites (OC) cannot be easily placed within any one of the H, L or LL categories. For example, a small quantity of ordinary chondrites (OC) contain unusually low amounts of FeO in their silicates. These chondrites are sometimes collectively referred to as reduced OC [3,4,5].

Burnwell, LAP 04757 and EET 96031 are three specific examples of these reduced OC. Burnwell shares chondrule sizes and bulk composition with the H chondrites [5], but little else: mean olivine compositions in Burnwell (15.8 mol% Fa) are lower than the range determined by [6] for H chondrites (17.3- 20.2 Fa mol%). Burnwell has a total Fe abundance indistinguishable from the H chondrites so the lower amount of FeO in their silicates is balanced by an increase in Fe_{metal} abundance [5]. The oxygen isotope signature of Burnwell seems unique when compared to those that are well-established for the OC groups (Figure 1). EET 96010 and LAP 04757 share the lower FeO mol% in olivine [7,8]. However, for these latter two chondrites, elemental and isotopic compositional similarities to Burnwell or the H chondrites have not been investigated. Here, we detail our efforts to investigate the compositions in the above three low-FeO chondrites and compare their compositions with other OC.

Samples and Methods: We quantified 46 trace elements by ICPMS using a ThermoElemental X-Series II ICPMS with a technique well established for chondritic meteorites [9]. ICPMS data was collected for Burnwell, LAP 045757, and EET 96031. To build upon our comparison database, we also analyzed the trace element abundances in the two typical H chondrite falls Forest City and Miller (Arkansas).

We also collected synchrotron x-ray microtomography (μCT) data on samples of Burnwell, LAP 04757, and EET 96031 at the GSECARS 13-BM beamline located at the Advanced Photon Source of the Argonne National Laboratory at resolutions of 18.9, 16.8, and 9.8 μm/voxel respectively. To extract compositional and spatial data from our 3D representations, we use BLOB3D [10,11]. Extracted μCT data gives information on Fe_{metal} and FeS abundances.

We analyzed the O isotopic composition of LAP 04757 and EET 96031 to compare with Burnwell and the OC. Oxygen isotopic analyses were performed as in [12] and are compared with prior results [13] below.

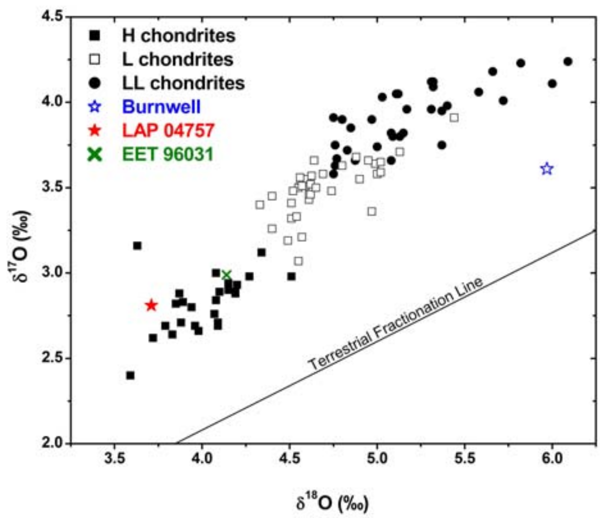

Figure 1. Three isotope plot of oxygen isotopic compositions of Burnwell [5], LAP 04757 and EET 96031 (this work) compared with other ordinary chondrites [13]. The low-FeO ordinary chondrites LAP 04757 and EET 96031 possess isotopic affinities akin to the H chondrites, unlike Burnwell's anomalous composition.

Results and Discussion: Our oxygen isotope, trace element, and μCT results can be summarized as follows:

Oxygen isotopes. Oxygen isotopes in LAP 04757 and EET 96031 fall within those expected for the H chondrites. This is contrasted with the position of Burnwell, which [5] took as evidence for a separate parent body serving as the source for Burnwell. $\Delta^{17}O$ of Burnwell lies at +0.51 ± 0.02‰ [5], whereas our preliminary $\Delta^{17}O$ results for LAP 04757 and EET

96031 show values near +0.8 ‰. From an O isotope perspective LAP 04757 and EET 96031 can be regarded as H chondrites.

Trace elements. Figure 2 shows abundances of lithophiles, siderophiles and moderately volatile elements in Burnwell, LAP 04757, EET 96031 and mildly-shocked (S1-S3) ordinary chondrites analyzed by our methods. Figure 2 shows CI (Orgueil) and Sc normalized abundances to eliminate the effects of volatiles on the comparison. Had any other refractory lithophile been used for comparison, the conclusions would be the same.

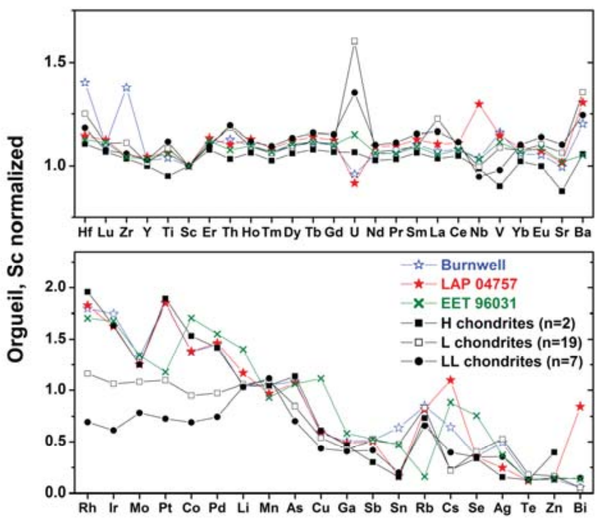

Figure 2. Mean CI and Sc normalized abundances of lithophiles, siderophiles and moderately volatile elements in Burnwell, LAP 04757, EET 96031 compared with averages for H, L and LL chondrites. Elements are organized by increasing putative volatility and similar geochemical character. The three low-FeO chondrites investigated in this study compositionally resemble the H chondrites.

For comparisons we turn to mean CI normalized abundances of lithophiles (n=25, Figure 2 top), siderophiles (n=6, Figure 2 bottom) and 14 moderately volatile elements (Li → Bi, Figure 2 bottom). When considering lithophile data, Burnwell, LAP 04757, EET 96031 and each OC group have essentially the same abundances, as expected for OC [14]. Our data for siderophiles also displays the trends expected: abundances in the L chondrites (1.35±0.10, n=19) show a lower mean and LL chondrites (0.94±0.08, n=7) have even lower mean abundances than the L chondrites. Mean abundances of siderophiles (Rh, Ir, Mo, Pt, Co, Pd) in Burnwell (1.95±0.28), EET 96031 (2.05±0.70) and LAP 04757 (1.96±0.30) have nearly identical abundance as the H chondrites (1.94±0.33, n=2). Moderately volatile abundances are relatively constant throughout the ordinary chondrites, Burnwell, EET 96031 and LAP 04757, which is consistent with the observations of [14]. All other characteristics aside, Burnwell, LAP 04757 and EET 96031 compositionally appear to be H chondrites. To investigate this conclusion in more detail, multivariate statistical analyses are in progress.

Three dimensional petrographic abundances. μCT data was collected on small chips of Burnwell (2165 mg), LAP 04757 (327 mg) and EET 96031 (201 mg). Respectively these were found to contain 9.25, 7.05 and 7.43 vol % Fe_{metal} and 1.59, 2.87 and 6.35 vol % FeS. Compared to H falls [15], which on average contain 7.2 ± 0.7 vol % Fe_{metal} and 4.0 ± 0.3 vol % FeS, LAP 96031 and EET96031 have similar Fe_{metal} abundances. However, EET 96031 has a much higher FeS content while LAP 04757 has a lower FeS content than the H falls. Burnwell has a higher Fe_{metal} content and a lower FeS content than the H falls. We attribute the differences to the small samples analyzed by μCT.

Conclusions: Oxygen isotopes of LAP 04757 and EET 96031 are within the range of values established for H chondrites as are trace element and opaque mineral abundance data. Aside from oxygen isotope data, Burnwell's overall composition seems nearly identical to the H chondrites. The primary difference between these three low-FeO chondrites and the H chondrites is the lower Fa mol% present. Given this, we prefer a common origin asteroidal origin for the low-FeO and H chondrites. Scenarios for this will be discussed.

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