PALLASITE, MESOSIDERITE, AND HED Δ^{17}O SIGNATURES: THE DETAILS. K. Ziegler[1] and E. D. Young[1,2], [1]Department of Earth and Space Sciences, University of California Los Angeles (UCLA), Los Angeles, CA 90095 (kziegler@ess.ucla.edu), [2]Institute of Geophysics and Planetary Physics, UCLA, Los Angeles, CA 90095 (eyoung@ess.ucla.edu).

Introduction: We revisit the question of the relationship between individual differentiated meteorite groups based on their Δ^{17}O values. Previous studies have shown contradicting results for main group pallasites (MG), mesosiderites, and the howardite-eucrite-diogenite suite (HEDs). One study finds these groups to be indistinguishable in Δ^{17}O [1], while another [2] found that the pallasites are different from the two other groups. Here we show that the pallasites exhibit a range in Δ^{17}O values, blurring the distinction between them and the other groups. Within the MG pallasite group, we notice an as yet unobserved internal Δ^{17}O variability that can explain the disagreement between the previous studies; we believe that differences in sampling methods are responsible. Our results necessitate re-thinking of the meaning of Δ^{17}O as a tool for assigning meteorite groups to parent bodies.

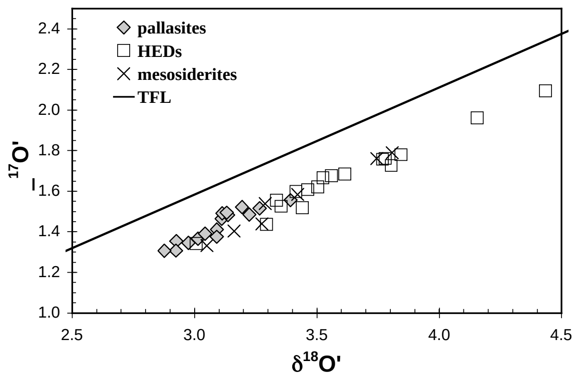

Figure 1. Oxygen isotope composition (δ^{17}O' vs. δ^{18}O') of differentiated meteorite groups (TFL = terrestrial fractionation line).

Results: High-precision infrared laser-heating fluorination (IR-LF) with an analytical precision of ~0.02 ‰ is essential for the differentiation of close or overlapping Δ^{17}O ranges. We obtained IR-LF oxygen isotope data for 15 HEDs, 7 MG pallasites, 7 mesosiderites, and 7 e-chondrites. Meteorites were not homogenized prior to sampling of the ~ 1 mg aliquot used for analysis. Therefore, any naturally occurring inhomogeneity within a meteorite will be revealed by our sampling method. Multiple aliquots were analyzed from most meteorites, and are treated like separate samples in our presentation of the data. Well-known 'outliers' (HEDs Ibitira, Pasamonte; e-chondrites Indarch, Abee) have been confirmed in our study, and are excluded from figures and averages. The average Δ^{17}O values of the groups are: mesosiderites = –0.241 ±0.036 1σ ‰; pallasites = –0.204 ±0.031 ‰; and HEDs = –0.238 ±0.031 ‰ (Fig. 1).

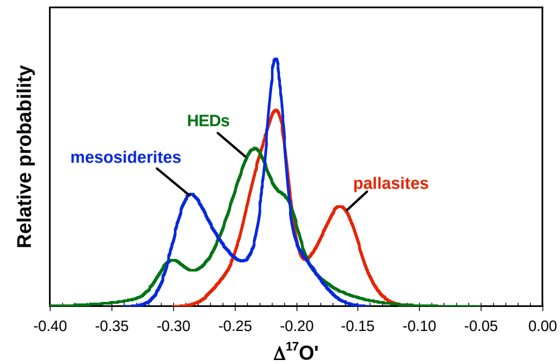

Figure 2. Relative probability of Δ^{17}O values for MG pallasites, HEDs, and mesosiderites.

Discussion: *Differentiated Meteorites.* Our results disagree somewhat from a study of the same three differentiated meteorite groups ([2], see below) in that our pallasite average Δ^{17}O value (-0.204 ±0.031 ‰) is more negative by 0.025 ‰ and, therefore, closer to our HED (-0.238 ±0.031 ‰) and mesosiderite (-0.241 ±0.036 ‰) average values and statistically indistinguishable at the 1σ level. The three groups cannot be resolved from each other based on averages of our data. Relative probability plots (Fig. 2) show multiple populations within the three groups. This suggests Δ^{17}O variability within the pallasites and mesosiderites.

Comparisons with Rocks of Known Provenance. The total Δ^{17}O spread exhibited by the differentiated meteorites (~ 0.20 ‰) is similar to that of other groups of rocks and meteorites from known parent bodies (Fig. 3). Figures 3 and 4 show that Earth and e-chondrites are also indistinguishable from one another in their average Δ^{17}O values (and in total spread ~ 0.18 ‰), but that the e-chondrites have signs of multiple populations in the probability density plot, analogous to the situation for the differentiated meteorites considered here. Rocks from Mars [4] have a narrower spread in Δ^{17}O values of ~ 0.14 ‰ and show no hint of multiple populations. The data for Earth and e-chondrites show that groups of rocks from different parent bodies may be identical in average Δ^{17}O but exhibit differences in the details of their distributions (e.g., unimodal *vs*. bimodal distributions; Fig. 4).

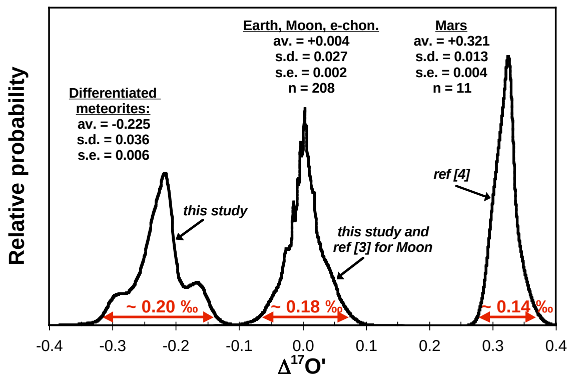

Figure 3. Relative probability of high-precision IR-LF $\Delta^{17}O$ values for differentiated meteorites (see Fig. 2); Earth, Moon [3], and e-chondrites; and Mars [4].

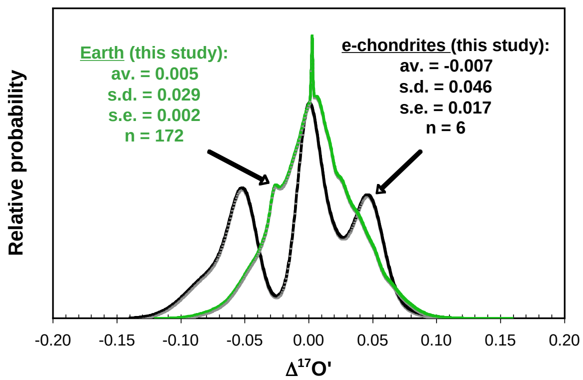

Figure 4. Relative probability of high-precision IR-LF $\Delta^{17}O$ values for Earth and e-chondrites.

Pallasites. We detect a bimodal distribution in pallasite olivine $\Delta^{17}O$ values (Fig. 2). Our more positive $\Delta^{17}O$ grouping coincides within analytical precision with the average pallasite $\Delta^{17}O$ value of –0.179 ‰ obtained in another study [2]. We attribute our larger total pallasite spread and its bimodality to the fact that we did not homogenize large olivine samples but instead used whole olivine grains for our analyses. Not only does this bimodality occur within the pallasite group as a whole, but also within individual meteorites: multiple aliquots of Brenham, Giroux, and Quijingue vary by up to 0.06 ‰ (> 2 times analytical uncertainties). Average $\Delta^{17}O$ values from homogenized samples [2] compare as follows with average values from the non-homogenized samples in this study: Giroux-homogenized = -0.194 ‰, Giroux-non-homogenized = -0.193 ‰ (avg. of –0.225, –0.190, –0.164 ‰); Brenham-homogenized = –0.187 ‰, Brenham-non-homogenized = –0.211 ‰ (avg. of –0.178, –0.235, –0.221 ‰).

The oxygen isotope spread and bimodality might allude to a correlation between $\Delta^{17}O$ inhomogeneity and chemical inhomogeneity [5, 6] among the MG pallasites, which in itself might suggest either different evolutionary processes or different provenance for pallasite meteorites. Reported chemical MG pallasite subgroups [5] correlate, imperfectly, with some of our $\Delta^{17}O$ values. Two of the pallasites with more positive values (Brenham, Pavlodar) are categorized as "anomalous metal" MG pallasite [5]. Pavlodar is also thought to be distinct in origin from other MG pallasites [5]. Another of our more positive pallasites (Giroux) is classified as a normal MG pallasite but is one of only two that plot within the IIIAB field on an Ir-Au diagram [5]. The chemical variability, coupled with our observed isotopic heterogeneity supports the suggestion that more than one genetic process and/or environment are responsible for pallasite formation. Therefore, similar to the coincidence of $\Delta^{17}O$ values among rocks derived from more than one parent body (e.g., Earth/Moon/e-chondrites), the $\Delta^{17}O$ variability within the MG pallasite group might in fact be the expression of a near-agreement in $\Delta^{17}O$ values among materials of different origins. A comparative study aimed at correlating chemical and oxygen isotope compositions in pallasites is in progress.

Conclusions: (1) Average $\Delta^{17}O$ values of the differentiated meteorite groups HEDs, mesosiderites, and MG pallasites are indistinguishable within uncertainties; (2) a bimodal $\Delta^{17}O$ structure within the MG pallasites is apparent when sampling does not include homogenization and distinguishes this group from the mesosiderites and HEDs; (3) MG pallasites have an inherent, as yet unexplored, oxygen isotopic heterogeneity requiring further investigation; (4) studies of populations of mineral grains from individual meteorite groups reveal differences in oxygen isotope systematics not seen in averages alone.

References: [1] Ziegler K. *et al.* (2006) *LPSC XXXVII*, Abstract #1894. [2] Greenwood R.C. *et al.* (2006) *Science, 313*, 1763-1765. [3] Wiechert U. H. *et al.* (2004) *Earth and Planetary Science Letters, 221*, 373-382. [4] Franchi I. A. *et al.* (1999) *Meteoritical & Planetary Science, 34*, 657-661. [5] Wasson J. T. and Choi B.-G. (2003) *Geochimica et Cosmochimica, 67*, 3079-3096. [6] Mittlefehldt D. W. and Rumble III D. *Meteoritics & Planet. Sci., 41*, A123.