OXYGEN ISOTOPE COMPOSITIONS OF MAIN GROUP PALLASITES. K. Ziegler[1,2], E. D. Young[1,2]. [1]Institute of Geophysics and Planetary Physics, University of California Los Angeles (UCLA), Los Angeles, CA 90095, USA. [2]Department of Earth and Space Sciences, UCLA, Los Angeles, CA 90095, USA (kziegler@ess.ucla.edu, eyoung@ess.ucla.edu).

Introduction: We are using high-precision measurements of both $^{17}O/^{16}O$ and $^{18}O/^{16}O$ in silicate meteorites to examine small oxygen isotopic deviations from the terrestrial mass fractionation line (TFL), $\Delta^{17}O$ that may serve as fingerprints for parent bodies in meteorites.

In the past few years there has been a debate about the extent to which $\Delta^{17}O$ can be used to distinguish main group pallasites (MG) on the one hand from the howardite-eucrite-diogenite (HED) suite and mesosiderites on the other. While various laboratories agree that HEDs and mesosiderites are indistinguishable with $\Delta^{17}O$ values of −0.23 ± 0.01‰ [1-4], only the Open University (OU) laboratory finds pallasites (−0.187 ± 0.018‰) distinguishable from HEDs and mesosiderites [3, 4].

Our previous work [1, 2] indicated that the three groups are indistinguishable within uncertainties (pallasites -0.204 ± 0.031, HEDs -0.238 ± 0.031, mesosiderites -0.241 ± 0.036‰). We also found a larger range of $\Delta^{17}O$ values in pallasites (Fig. 1) [2]. A wide spread in pallasite $\Delta^{17}O$ values compared to [3] and [4] was also obtained by Rumble, (unpublished data; Carnegie Washington Institute (CIW)), though his average is more positive than for the other groups (Figs. 3, 4). Furthermore, we detected a bimodal distribution not only in MG pallasite $\Delta^{17}O$ values (Fig. 1), but also within individual meteorites [2]. This bimodality could not be confirmed by [4]. We attributed 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.

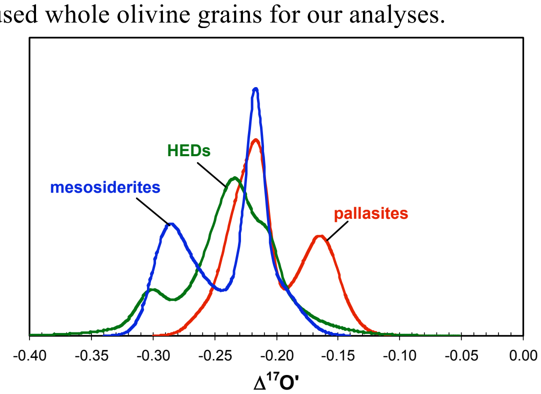

Figure 1. Relative probability of $\Delta^{17}O$ values for MG pallasites, HEDs, and mesosiderites measured at UCLA [2].

Objective: At issue is whether or not pallasites have $\Delta^{17}O$ values that are uniform and distinctive from those of HEDs and mesosiderites. The issue is an important one because if pallasites are not reliably resolvable from these other differentiated meteorite groups, then it raises the possibility that $\Delta^{17}O$ values might not be unique to each and every differentiated parent body. The results will establish the degree to which $\Delta^{17}O$ values can be used as truly unique fingerprints among these major groups of differentiated meteorites.

Samples and Analyses: In order to test the degree of homogeneity or heterogeneity within pallasites, we analyzed individual olivine grains picked from a single large olivine aggregate from the MG pallasite Esquel (Fig. 2). The $\Delta^{17}O$ values for ten of these samples were analyzed (aliquots B, D, F, H, J, K, N, O, P, R; Fig. 2). We used a 20W CO_2 infrared laser heating-assisted fluorination system [5] to extract the molecular oxygen from cleaned, 1-2 mg-sized olivine samples, and analyzed their isotopic compositions on a ThermoFinnigan gas source mass spectrometer (Delta Plus™). Analytical precision for $\Delta^{17}O$ is 0.02‰.

Figure 2. Microphotograph of a broken up olivine aggregate from Esquel (IN1658). Image width ~1.5 cm.

Results: We obtain a much tighter clustering of $\Delta^{17}O$ values for a single olivine sample from one pallasite than for the meteorite group as a whole (Fig. 3). The 10 individual grains from one silicate aggregate from Esquel have an average $\Delta^{17}O$ value of -0.156 ± 0.008‰ (c.f. average of all other pallasites -0.204 ± 0.031‰). Thus, Esquel falls into the oxygen isotopically less negative group of our bimodal $\Delta^{17}O$ distribution for pallasites (Fig. 1); it has the least negative $\Delta^{17}O$ value of all pallasites analyzed in our laboratory.

Figure 3 shows that our Esquel data have both a tighter cluster and more positive $\Delta^{17}O$ values than our previous pallasite data. They are more similar to the CIW data in their $\Delta^{17}O$ value and range than to the OU data. Including the Esquel data in the UCLA pallasite relative probability plot adds a higher probability (sharp peak) at the average Esquel Δ^{17}O value (see Fig. 4).

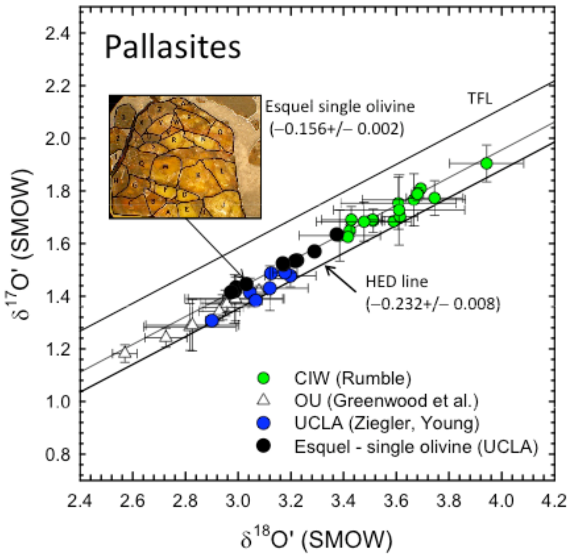

Figure 3. Oxygen three-isotope plot showing data from a variety of pallasites from three laboratories. Our multiple samples of a single olivine aggregate from Esquel yield more homogeneous Δ^{17}O values than the MG pallasites as a group. Numbers are Δ^{17}O values for the indicated samples. Greenwood data are [3], UCLA data are [2], CIW data are unpublished, Esquel data are this study.

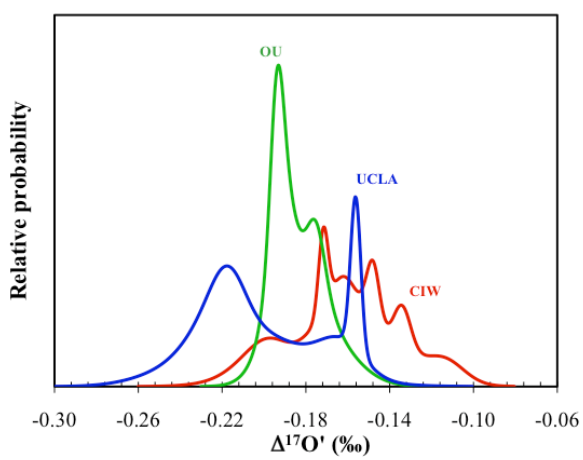

Figure 4. Relative probability of Δ^{17}O values for MG pallasites (averaged per meteorite) measured at UCLA (8 pallasites) [2, and the Esquel data from this study] OU (12 pallasites) [3], and CIW (16 pallasites) [unpublished]. Different β-factors (mass-dependent slope) were used by the different studies: UCLA 0.528, OU 0.5242, CIW 0.526.

Discussion: The very narrow range of 0.02‰ of the ten individual Δ^{17}O analyses measured in a single Esquel olivine aggregate is remarkable, and attests to oxygen isotopic homogeneity within one silicate aggregate. The Δ^{17}O bimodalities observed in two other meteorites (Brenham: −0.178, −0.235, −0.221; Giroux: −0.225, −0.190, −0.164‰) [2], therefore, are most likely due to a Δ^{17}O inhomogeneity between aggregates or between different parts of the same meteorite. It is noted that the UCLA Brenham aliquot was analyzed by OU for calibration purposes; the OU value is −0.201‰, in reasonable agreement with the UCLA value. The OU value for Esquel (not the UCLA aliquot) is −0.185‰ (c.f. UCLA value −0.156‰).

Conclusions: While these new Esquel results do not necessarily provide more insights into whether the MG pallasites can be distinguished from HEDs and mesosiderites on the basis of their Δ^{17}O values, nor into the discussion of whether or not MG pallasites are oxygen isotopically homogeneous, they do add support to both our own previous data [2] and also the OU data [3]. In the first case, these new results make our observed pallasite Δ^{17}O bimodality more pronounced (Fig. 4). In the second case, although very weakly, they do shift our average pallasite Δ^{17}O value from -0.204 ± 0.031‰ without Esquel to −0.199 ± 0.029‰ including Esquel, therefore very slightly further away from our HED and mesosiderite Δ^{17}O average values, and a little more in support of the data of [3]. With more future pallasite oxygen isotope data, these issues will hopefully be better resolved.

At this time, however, based on our bimodal and large-spread pallasite data, we cannot maintain with certainty that MG pallasites can be distinguished on the basis of Δ^{17}O analyses and at the 0.02‰ level of precision. As described in [2], the oxygen isotope spread and bimodality might allude to a correlation between Δ^{17}O and chemical inhomogeneity among MG pallasites [6, 7], supporting the suggestion that more than one genetic process and/or environment are responsible for pallasite formation. It appears that MG pallasites have an inherent, as yet not fully explored oxygen isotopic heterogeneity. The new Esquel data from one aggregate of pallasite olivine is a first step in understanding this issue.

References: [1] Ziegler K. *et al.* (2006) *LPSC XXXVII*, Abstract #1894. [2] Ziegler K. and Young E.D. (2007) *LPSC XXXVIII*, Abstract #2021. [3] Greenwood R.C. *et al.* (2006) *Science, 313*, 1763-1765. [4] Greenwood R.C. *et al.* (2008) *LPSC XXXIX*, Abstract #2445. [5] Sharp Z.D. (1990) *Geochimica et Cosmochimica Acta,* 54, 1353-1357. [6] Wasson J. T. and Choi B.-G. (2003) *Geochimica et Cosmochimica Acta, 67*, 3079-3096. [7] Mittlefehldt D. W. and Rumble III D. *Meteoritics & Planet. Sci., 41,* A123.