OXYGEN ISOTOPE VARIATIONS IN MAIN GROUP PALLASITES AND HEDs.
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Introduction: Pallasites are stony-iron meteorites mainly composed of cm-sized olivine crystals disseminated in a network of Fe-Ni metal. Based on the oxygen isotope signatures of pallasite olivines and silicates from IIIAB iron meteorites [1] it has been suggested that main group pallasites may represent the core-mantle boundary and IIIAB irons may represent the core of the Howardite-Eucrite-Diogenite (HED) parent body 4 Vesta [1]. The HED suite of achondrites have a close resemblance to terrestrial igneous rocks, and are thought to originate from the shallow to deep regions of the asteroid 4 Vesta on the basis of spectral analyses [2] and data from the DAWN mission [3]. The triple oxygen isotope analyses of the major minerals (plagioclase and pyroxene) in HEDs is consistent with an igneous origin for these meteorites [1]. Eventually, after the original work of [1] it was generally accepted that pallasites and HEDs belong to the same parent body. Recently, there has been interest in distinguishing differentiated meteorites including main group pallasites (MG), HEDs and mesosiderites on the basis of $\Delta^{17}O$ [4-8]. We have contributed to this effort by studying the offset ($\Delta^{17}O$) of oxygen isotopes from the terrestrial fractionation line (TFL) to distinguish differentiated meteorites including MG pallasites and HEDs. The resolution of $\Delta^{17}O$ among these meteorites is of utmost importance to understand the genetic processes that happened on the parent bodies.

Methodology: High-precision triple oxygen isotope compositions of acid-leached olivine grains of 10 MG pallasites (Brahin, Esquel, Fukang, Giroux, Seymchan, Brenham, Huckitta, Imilac Springwater and Sterley) and 3 HEDs (two Eucrites: Stannern, Juvinas and one Diogenite: Tatahouine) were determined following the methods described in [9] by using a dual-inlet system on Delta V plus IRMS. Typical sample size used for analyses was about 1 mg. 8 individual runs of UWG-2 provided an external precision (1σ) of ±0.04‰ in $\delta^{17}O$ and ±0.08‰ in $\delta^{18}O$ values. Leached olivine grains of all the pallasites were also mounted in epoxy and carefully polished followed by microprobe analyses at the University of Alberta.

Results and Discussion: Our high-precision oxygen isotope data show different $\Delta^{17}O$ values for the MG pallasites and HEDs (Figure 1) which is consistent with the interpretation of [8] that they do not originate from the same parent body. It is evident (Figure 2) that HEDs are lighter in terms of $\delta^{17}O$ oxygen isotopes than the pallasites and make a half slope line below the TFL. However, our data unexpectedly unequivocally resolves the MG pallasites into two subgroups i.e., high-$\Delta^{17}O$- and low-$\Delta^{17}O$-bearing pallasites. This is in contrast to data reported by [8]. The values for both subgroups are averaged at -0.172 ± 0.007 (2σ) and -0.213 ± 0.011 (2σ) respectively. Each group clearly defines a linear array with a half slope on a three oxygen plot (Figure 2) below the TFL. The high-$\Delta^{17}O$ values are exhibited by Brenham, Huckitta, Imilac, Springwater and Sterley and on the other hand, low-$\Delta^{17}O$ values are exhibited by Brahin, Esquel, Fukang, Giroux and Seymchan. Figure 3 shows the separation of the two different populations of MG pallasites from the HEDs based on $\Delta^{17}O$ vs. $\delta^{18}O$ values. This bimodality is further supported by mineral geochemical variations [10] in the olivine and metal parts of the two proposed subgroups. The low-$\Delta^{17}O$-bearing MG pallasites typically are more olivine-rich (olivine/metal=~2.9) than the high-$\Delta^{17}O$-bearing MG pallasites (olivine/metal=~2.0) [10]. Our new mineral geochemical data on these pallasites exhibit (Figure 4) two distinct groups based on Fo-contents.

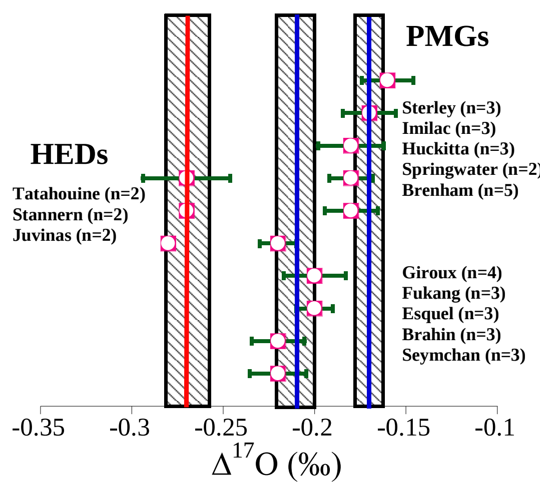

Figure 1. $\Delta^{17}O$ values of main group pallasite olivines and HED's bulk materials. All solid lines represent group averages. The shaded areas show 2-sigma error of the group. All error bars are 1-sigma. N stands for the number of individual runs.

The low-$\Delta^{17}O$-bearing pallasites have typically a higher and more restricted Fo-content with the exception of Fukang, while the high-Δ^{17}O-bearing pallasites display a lower and wider range in Fo-content. Additional support for bimodality in the MG pallasites comes from paleointensity estimates. The paleointesity estimates of Esquel (low-Δ^{17}O) and Imilac (high-Δ^{17}O) [11] differ by a factor of ~2 suggesting different locations of these meteorites in the protoplanet suggesting they originated at depths of 40km and 10km respectively.

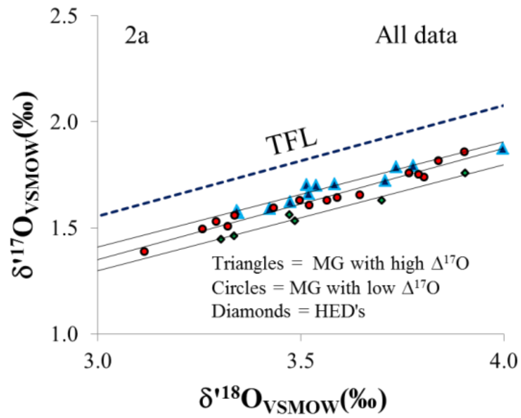

Figure 2a. Triple O-isotope plot of MG pallasite olivines and HED bulk samples. Data of all replicate analyses included.

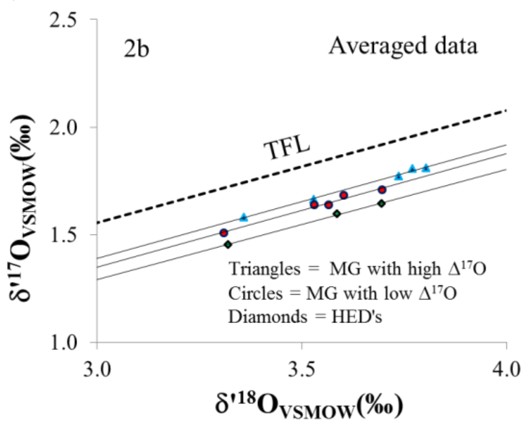

Figure 2b. Triple oxygen isotope plot of MG pallasite olivines and HED bulk samples. Averaged data of replicate analyses are included.

Taken together, the bimodality in triple oxygen isotopes, Fo-contents, and paleointensity data suggest that main group pallasites may either represent components from an impactor and the parent body's mantle and core, originated at different locations in the parent body after collisions with one or more impactors, or may derive from at least two different parent bodies.

Summary: High-precision oxygen isotope data of MG pallasites and HEDs indicate that these meteorites did not originate from the same parent body. Our new oxygen isotope data supports the suggestion of [8] in distinguishing between MG pallasites and HEDs. However, our data further resolve the MG pallasites into two subgroups, high-Δ^{17}O and low-Δ^{17}O that has not been previously reported. Based on oxygen isotopic and geochemical evidence i.e., Fo-contents, we propose here the existence of bimodality in the triple oxygen isotope values of MG pallasites.

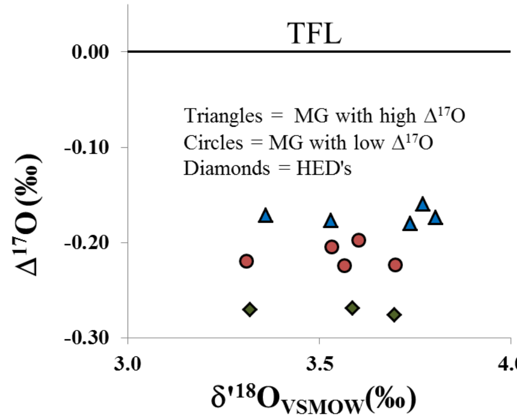

Figure 3. Δ^{17}O (‰) vs. $\delta^{18}O_{VSMOW}$ plot for MG pallasites and HEDs. Averaged data of replicate analyses included.

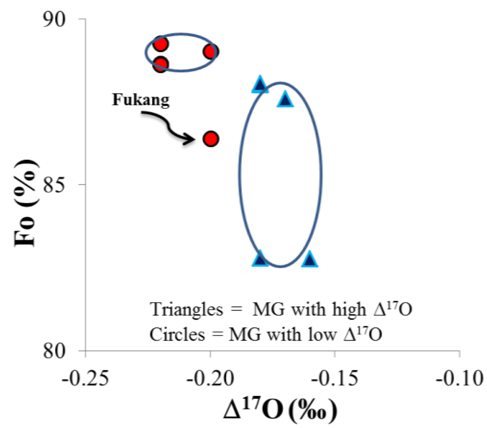

Figure 4. Δ^{17}O (‰) vs. Fo (%) plot for MG pallasites.

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