FE AND MN SYSTEMATICS IN OLIVINE-BEARING DIOGENITES.

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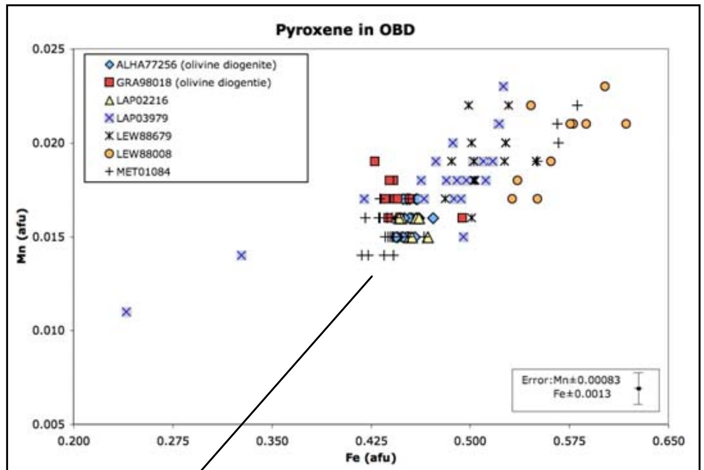
Introduction: Howardite, eucrite, and diogenite (HED) meteorites are a unique suite of achondrites, thought to originate from asteroid 4 Vesta [1]. Diogenites are orthopyroxenites containing minor amounts of olivine and troilite, with trace FeNi metal and chromite. They represent a cumulate layer below the surface of Vesta, that was derived from a basaltic magma [2]. Diogenites contain varying amounts of olivine, which occurs in roughly 40% of those recovered in Antarctica. Three diogenites contain greater than 5% modal olivine and have been named “olivine-diogenites” [3].

Fe/Mn signatures in pyroxene and olivine are diagnostic for each planetary body in our solar system [4, 5]. This provides a method of identifying the origin of planetary pyroxene and olivine grains. Fe/Mn in pyroxene and olivine can also indicate different crystallization events, such as low and high Ti lunar pyroxenes [6]. Examining Fe/Mn systematics in olivine-bearing diogenites (OBDs) allows for: 1) defining a Fe/Mn ratio for olivine from Vesta, and 2) further quantification of Fe/Mn in pyroxene from Vesta. A different pyroxene Fe/Mn in OBDs than in regular diogenites would suggest complex crystallization processes on Vesta.

Results and Discussion: Seven OBDs (listed in Figs 1 & 3) were examined in this study using an electron microprobe. Two of the seven are “olivine-diogenites” [3]. All of the samples consist of predominantly orthopyroxene (~$Wo_3En_{73}Fs_{24}$), with minor exsolved clinopyroxene (~$Wo_{45}En_{47}Fs_8$), and olivine (~Fo_{71}). Accessory troilite, FeNi metal and chromite are also found.

Pyroxene: Fe/Mn values for pyroxene in the “olivine diogenites” are less varied than the other OBDs, with the exception of LAP02216 (Fig 1). This could be the result of the “olivine diogenites” having less pyroxene to analyze compared to other OBDs, or possibly greater metamorphic equilibration. The concentration of data points for LAP02216 is the result of a lack of usable data.

The two “olivine diogenites” have less Fe and Mn in pyroxene compared to most of the other OBDs. This suggests that the pyroxene in the “olivine diogenites” may have crystallized from less fractionated melts than in the other OBDs Two samples, LAP03979 and MET01084, have pyroxene grains with Mn and Fe less than or equal to the “olivine diogenites”. The very low Mn and Fe pyroxene values in LAP03979 (Fig 1) correspond to small (~40μm) orthopyroxene inclusions in olivine. These low Fe and Mn values are most likely the result of equilibration with the surrounding olivine and not initial Fe and Mn signatures in pyroxene. The location



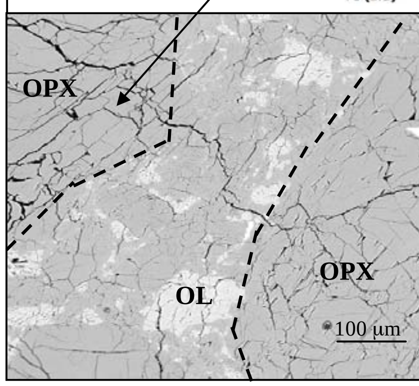


Figure 1. Fe/Mn for pyroxene in OBDs (above). Low Fe and Mn pyroxene in MET01084 occur as large, subhedral clasts separated by olivine-rich intercumulus material shown in BSE (left).

of the low Fe and Mn pyroxenes in MET01084 can be correlated with a distinctive texture shown in Fig 1. This texture may be a result of early low Fe and Mn pyroxene crystallization (outlined in Fig 1) followed by a filling of higher Fe and Mn pyroxene, and olivine from residual liquid. Low Fe and Mn in pyroxene, coupled with high concentrations of olivine in the intercumulus material suggest a primitive origin for this section of MET01084. These measurements are not consistent throughout MET01084, possibly due to post-crystallization brecciation.

The Fe/Mn regression line for pyroxene in OBDs has a slightly higher slope than the average diogenite [7] line (Fig 2). The higher slope might result from crystallization processes of olivine in diogenites, such as those proposed by [3, 8]. However, these trends are not distinguishable, within analytical uncertainty.

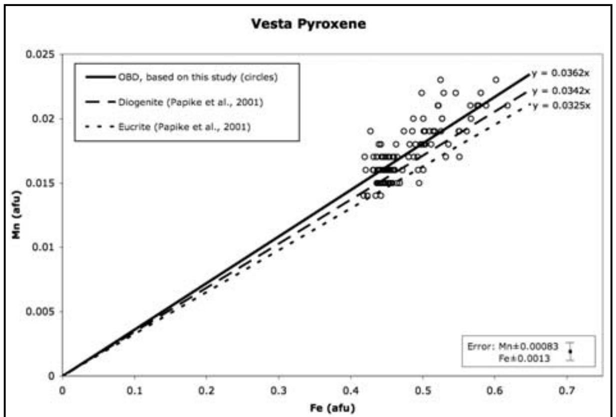


Figure 2. Fe/Mn in pyroxenes from Vesta.

Olivine: “Olivine-diogenites” have slightly lower Fe and Mn in olivine than most of the other OBDs, with the exception of LAP02216 and some grains in MET01084 and LEW88679 (see Fig 3). This pattern is very similar to Fe and Mn in pyroxene, although olivine Fe/Mn is confined to a narrower range. This phenomena is likely a combination of a higher Fe/Mn distribution coefficient in olivine than pyroxene on Vesta [9], and metamorphic equilibration of the these phases.

A regression line for Fe/Mn in olivine from OBDs does not match the pyroxene Fe/Mn regression line, as predicted by [7] (Fig 4). Ideally, the olivine Fe/Mn line for Vesta should have a higher slope, around 0.03. Low Fe/Mn for olivine from Vesta can be attributed to: (1) high olivine Fe/Mn distribution coefficients coupled with metamorphic re-equilibration, as mentioned above, and/or (2) analytical uncertainty. Re-evaluating

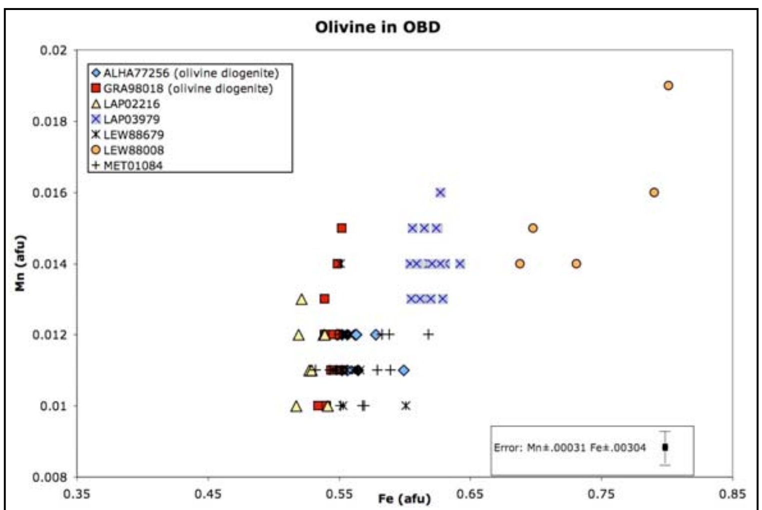


Figure 3. Fe/Mn for olivine in OBD

these samples using methods described by [10] will help determine the accuracy of these measurements.

Conclusion: Low Fe and Mn pyroxenes from OBDs show a slight correlation with abundance of olivine. This may be linked to crystalization sequences of diogenites on Vesta. The OBDs as a group also have a higher Fe/Mn in pyroxene than average diogenites. While these results are possibly due to different crystallization events between OBDs and diogenites, analytical uncertaintiy has yet to be constrained. Further analysis, using new microprobe techniques, is needed to confirm these findings.

Fe/Mn in olivine for OBDs retains the same pattern, but is much lower than in pyroxene. This is unusual for planetary olivine, but is probably the result of metamorphic equilibration and higher distribution coefficients for olivine on Vesta.

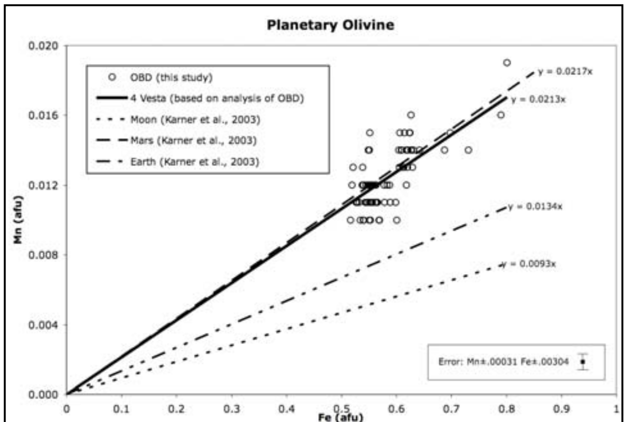


Figure 4. Fe/Mn for planetary olivine

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