ANOMALOUS EUCRITES: USING FE/MN TO SEARCH FOR DIFFERENT PARENT BODIES. R.C.F. Lentz[1], E.R.D. Scott[1], and T.J. McCoy[2], [1]HIGP, University of Hawaii, 1680 East West Rd., Honolulu, HI 96822; rcflentz@higp.Hawaii.edu, [2]Dept. of Mineral Sciences, Smithsonian Institution, Washington, DC 20560-0119.

Introduction: The bulk of the basaltic non-planetary achondrites in the meteorite collection have been classified as eucrites, which are assumed to come from the asteroid Vesta. Recently, however, at least two other basaltic parental bodies have been suggested based on eucrite-like meteorites with distinct oxygen isotope compositions: NWA 011 [1] and Ibitira [2]. Ibitira was further examined by [3] to investigate other distinguishing geochemical characteristics, including Fe/Mn. [3] found that the molar Fe/Mn ratio in Ibitira was different from several basaltic eucrites he measured (~34-36 vs. ~30-32), supporting the inference that it derives from a distinct parent body.

The detailed O-isotope study by [2] also identified three other eucrites as being slightly anomalous compared to the average HED meteorite value: Pasamonte (~4σ), Caldera (~3σ), and ALHA78132 (2.5σ). They attributed these values to either distinct parent bodies or oxygen isotope heterogeneity on the HED parent body (i.e. Vesta). We propose to follow up the study of [3] by examining Fe/Mn ratios for these other slightly anomalous eucrites to evaluate these alternate suggestions for their parental source.

Fe/Mn behavior: Since Mn^{2+} behaves similarly to Fe^{2+} in geochemical systems, the two are not easily fractionated during igneous processes, particularly in more reducing conditions. Distinct primordial ratios, set during accretion and reflecting initial heterogeneity in the solar nebula, are thus maintained during planetary differentiation. Fe/Mn is therefore commonly used, alongside O-isotopes, as a diagnostic tool for planetary origin [4].

[4] demonstrated resolvable ranges of Fe/Mn in basaltic pyroxenes from Vesta, Mars, Earth, the Moon, and even the angrite parent body. However, there is a degree of scatter in these values, so it becomes relevant to discuss how much variability would be expected for a given body.

The Fe/Mn values presented by [4] for the lunar and terrestrial data sets show considerable scatter: 62±18 (Moon) and 40±11 (Earth) for 37 and 513 data points, respectively. This variability is attributed to volatile depletion in the Moon from its hot, impact-generated origin [4]. On the other hand, pyroxenes from Vesta, from 38 diogenites and eucrites, show an average Fe/Mn of 30 ± 2. This tighter range supports the interpretation that Ibitira Fe/Mn values of 34-36 are inconsistent with a Vesta origin for that meteorite.

Preliminary results: So far, we have conducted electron microprobe analyses of pyroxenes in Pasamonte (18), Caldera (15), and Ibitira (16) (Fig. 1) for comparison to other literature values. We hope to also include ALHA78132 and other "regular" eucrites for comparison.

We have plotted our data with that from the literature for Ibitira [3], Pasamonte [5], and thirteen other eucrites [5,6], and Fig. 1 illustrates several interesting points. Our Ibitira values match well with those found by [3], supporting his results and emphasizing the distinct band of Fe/Mn values defined by that meteorite. Note that the two clumps (defined by a bimodality in Fe/Mg) inversely reflect the Wo content of the pyroxenes (Fig. 2), with the higher Fe/Mg having the lower Ca content (Wo_{3-15}) and the augites (Wo_{28-41}) having a lower Fe/Mg. This relationship is also seen in the Caldera data, but not in Pasamonte. In fact, there is a steep positive correlation in those pyroxenes. The rest of the eucrite literature data are more scattered.

The ratio data for Pasamonte (28.7 ± 2.0) and Caldera (30.1 ± 1.2) match the general Fe/Mn values of the rest of the eucrite ratios from the literature [3-6], although Pasamonte has a lower average than the group average (29.5 ± 2.6). It is interesting to note that in the plot of Fe/Mn to Fe/Mg (Fig. 1), there are actually two portions to the group trend: a horizontal trend between Fe/Mg = 0.8 and 2.0, but a positively correlated trend for Fe/Mg < 0.8. Pasamonte mimics this path defined by other eucrites in the literature, probably accounting for its lower average value. [3] suggests that a positive correlation between Fe/Mn and Fe/Mg could be due to Fe redox.

Conclusions: Our results so far lead us to a few preliminary thoughts and conclusions. 1) Our Ibitira data support the results and interpretations of [3] that, with the strongly anomalous O-isotope ratios, Ibitira likely comes from a distinct parent body. 2) Despite their slightly anomalous O-isotope values, Pasamonte and Caldera do not show distinct values for Fe/Mn from those of thirteen other eucrites from the literature. 3) Of the two initial explanations for the anomalous O-isotopes, more likely is that there was a degree of O-isotope heterogeneity on the HED parent body. It is interesting to note that [2] measured 24 eucrites, and if one assumes a normal Gaussian distribution of the data, it is not unexpected to find 5% of the data (i.e. 1-2 meteorites) falling beyond the 2σ range of the aver-

age. We hope to examine ALHA78132 to add to this picture.

One other meteorite has sparked our interest, as well: Bouvante. The average pyroxene value of 39.6 given in [6] puts Bouvante as the sole eucrite with Fe/Mn higher than Ibitira. This bears verification, since the O-isotopes for Bouvante are well within the standard HED range [2]. It also raises the question of whether a higher Fe/Mn ratio on its own requires a separate parent body, or whether there may be some other mechanism that could account for such an elevated Fe/Mn ratio in this eucrite.

References: [1] Yamaguchi A. et al. (2002) *Science, 296,* 334-336. [2] Wiechert U.H. et al. (2004) *Earth & Planet. Sci. Lett., 221,* 373-382. [3] Mittlefehldt D.W. (2005) *Meteorit. & Planet. Sci., 40,* 665-677. [4] Papike J.J. et al. (2003) *Amer. Mineral., 88,* 469-472. [5] Pun A. and Papike J.J. (1996) *Amer. Mineral., 81,* 1438-1451. [6] Mittlefehldt D.W. et al. (1998) *Rev. Mineral., 36,* 4-1 to 4-195.

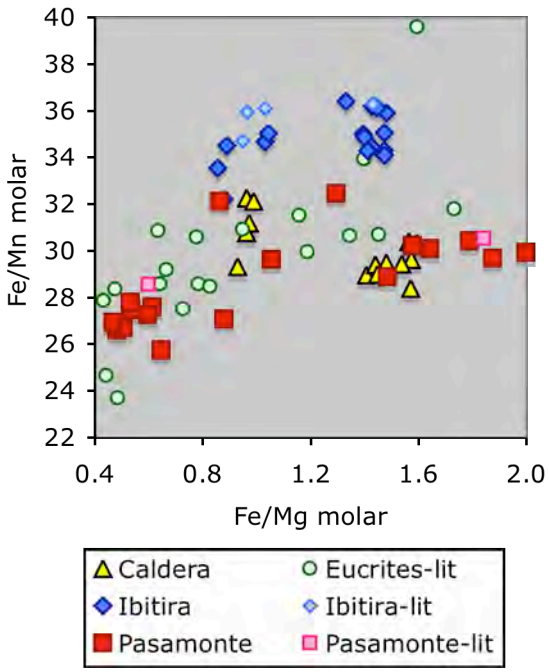

Fig. 1: Pyroxene data from our measurements and from the literature ("lit") illustrating the relationships of the three anomalous meteorites Caldera, Ibitira, and Pasamonte compared to 13 other normal eucrites. The one literature Fe/Mn value above Ibitira is for Bouvante.

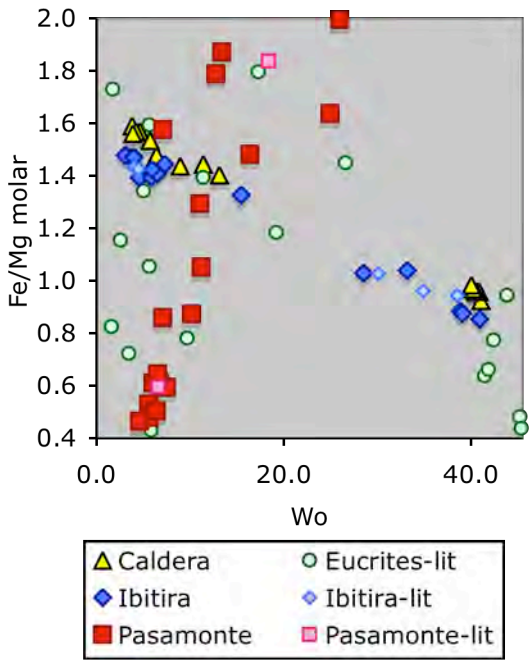

Fig. 2: The same new and literature data plotted vs. Wo to illustrate the reverse correlation and clustering seen in Ibitira and Caldera, and the positive correlation in Pasamonte.