A NEW VARIETY OF EUCRITE? CLUES TO EARLY DIFFERENTIATION OF IGENOUS ASTEROIDS.

K.R. Bermingham [1], M.D. Norman[1], A.G. Christy[1] and R.J. Arculus[1], [1]Research School of Earth Sciences, Australian National University, Canberra, ACT 0200, Australia.

Introduction: Eucrites are among the oldest basaltic lavas in the Solar System. They are thought to originate from a differentiated asteroid, probably 4Vesta [1]. The aim of our project was to characterize the mineralogy and geochemistry of twelve monomict Antarctic eucrites in order to improve our understanding of eucrite petrogenesis and igneous processes contributing to early planetary differentiation.

Samples and Methods: Twelve samples were analyzed for this study: BTN00300, EET90020, EET90029, GRA98098, MAC02522, MAC041169, MET01081, PCA82502, PCA91078, QUE94484, QUE97014, and QUE99658. Textures and mineral compositions and were determined using optical and electron microscopy. Major element compositions of whole rock powders were measured using XRF and energy-dispersive SEM analysis of Li-borate fused glasses. Whole rock trace elements compositions were measured on the Li-borate glasses using laser-ablation ICPMS.

Results: Based on our observations of thin section and the whole rock chips, all of the samples are monomict and unbrecciated except for sample PCA82502, which consists of rounded basaltic clasts surrounded by fine-grained cataclasized matrix. All of the basaltic clasts that we observed in this rock are petrographically similar so we tentatively refer to this sample as monomict despite its brecciated texture.

Major mineral phases are typical of basaltic eucrites, i.e. calcic plagioclase and clinopyroxene. Minor and accessory phases include silica polymorphs, chromite, ilmenite, troilite, native iron, baddeleyite, iron rich olivine and possible phosphate phases. Abundant melt inclusions are present in cores of plagioclase within the coarser-grained samples (Fig. 1).

All of these samples have basaltic textures, but there is a range of grain size and degree of equilibration among the samples as indicated by rounding of plagioclase grains and development of pyroxene exsolution lamellae. This indicates diverse cooling rates and thermal histories, and implies different emplacement conditions of the samples. Based on pyroxene equilibration temperatures and thickness of exsolution lamellae, fine-grained samples with a low degree of equilibration (e.g. PCA82502; Fig. 1) probably erupted as surface flows whereas the coarser-grained, more equilibrated samples were likely emplaced at relatively shallow depths (<5km, e.g. EET90020; Fig. 1).

Major element data for all samples cluster near the experimentally determined peritectic reaction point on an olivine-silica-anorthite ternary plot [2] with a narrow range of MgO contents (5.8-7.0 wt%). CIPW normative mineralogy also spans a narrow range (e.g. 34.7-37.8% plagiclase). The petrography and major element compositions are consistent with the interpretation that all of these eucrites have melt compositions and are not cumulates. FeO/MnO ratios are typical for basaltic eucrites.

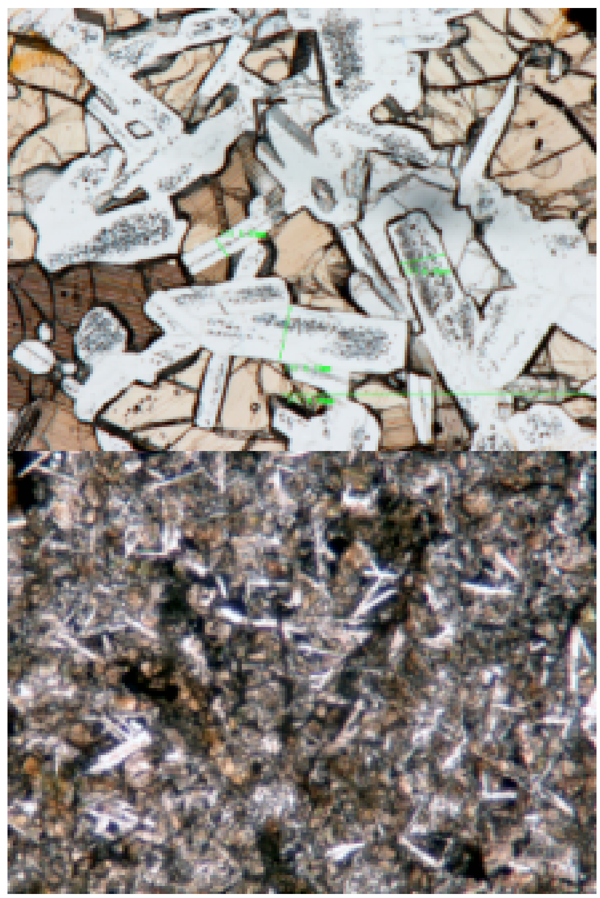

***Fig. 1**. Thin section photomicrographs of EET90020 (upper) and PCA82502 (lower). The clouding of plagioclase in EET90020 is due to the presence of abundant melt inclusions.*

Two compositional groups have been identified based on trace element characteristics. Group 1 has flat to slightly LREE-enriched patterns with negative europium anomalies (Fig. 2). This group includes samples BTN00300, EET90029, GRA98098, MAC02522, MAC041169, QUE94484, QUE97014, and QUE99658. All of these samples appear to be Main Group eucrites except for QUE94484, which has enriched levels of incompatible elements similar to Stannern Trend eucrites. The Group 2 samples have LREE-depleted patterns with positive europium anomalies (Figure 2). This group includes samples EET90020, MET01081, PCA82502, and PCA91078.

Other incompatible trace elements show similar relationships with consistently lower abundances in Group 2 samples compared to Group 1 (Fig. 3). Plagiophile elements are particularly distinctive, with Group 1 samples trending toward low, subchondritic Sr/Nd rations with increasing depth of the negative Eu anomaly, whereas the Group 2 samples trend towards markedly superchondritic Sr/Nd ratios with increasing magnitude of the positive Eu anomaly (Fig. 4).

In contrast, to the trace elements, however, there is no difference in major element indicators of fractionation such as Al_2O_3 or MgO/FeO between the two groups, and there is no obvious correlation between chemical grouping and texture, e.g. EET90020 and PCA82502 (Fig. 1) both fall into our Group 2 category.

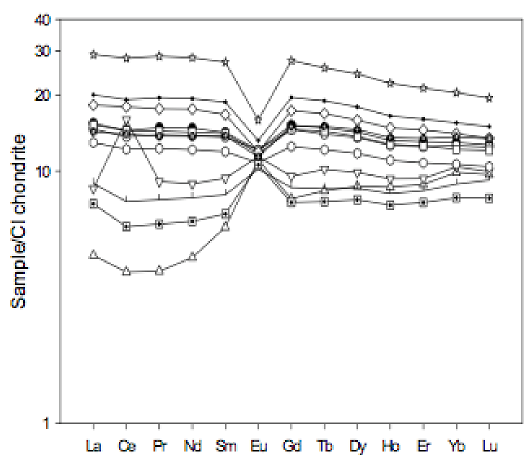

***Fig. 2**. CI-normalised REE plot showing data for all samples analyzed in this study.*

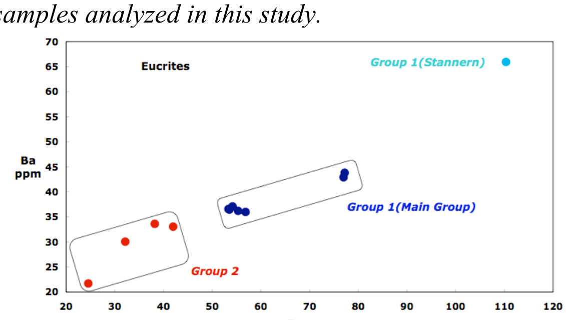

***Fig. 3**.Ba vs. Zr abundances of eucrites analyzed for this study.*

Discussion: The combination of petrographic and geochemical characteristics of our Group 2 eucrites does not appear to have been widely discussed previously and we tentatively suggest they may represent a new variety of non-cumulate basaltic eucrite. As such they may provide new insights into the early evolution of the eucrite parent body.

The positive correlation of Sr/Nd with Eu/Eu* in our samples suggests involvement of plagioclase (Fig 4), but the limited range of major element compositions and the lack of any correlation of Sr/Nd or Eu/Eu* with Al_2O_3 or other indicators of fractionation such as Mg/Fe apparently rules out accumulation or simple fractional crystallization from a common parental magma to explain the range of trace element compositions observed in the Group 1 and 2 eucrites. The Group 2 eucrites in particular cannot represent residual liquids from a crystallizing magma ocean [3,4].

The LREE-depleted patterns of the Group 2 eucrites cannot be produced by variable degrees of batch melting of a chondritic source. Preliminary modeling suggests that the general trace element characteristics of Group 2 eucrites can be reproduced by melting of a plagioclase-enriched source region, but further work is needed to evaluate the petrologic feasibility of such a model. The possibility that some of the eucrites come from a parent body other than 4Vesta must also be considered [5].

References: [1] Binzel R. and Xu S. (1991) *Science,* 260, 516-518. [2] Stolper E. (1977) *GCA*, 41, 587-611. [3] Righter K. and Drake, M. (1997) *Meteoritics & Planet. Sci.*, 32, 929-944. [4] Ruzicka A. et al. (1997) *Meteoritics*, 32-6, 824-840. [5] Mittlefehldt D.W. (2005) *Meteoritics & Planet. Sci.* 40, 665-677.

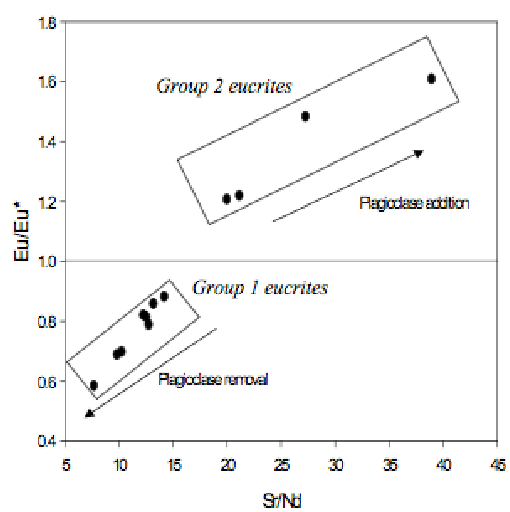

***Fig. 4**. Sr/Nd ratios plotted vs. magnitude of the Eu anomaly (Eu/Eu*) for eucrites analyzed in this study.*