TRACE ELEMENTS IN HIGH-CA PYROXENE & PLAGIOCLASE IN THE BILANGA DIOGENITE: IMPLICATIONS FOR THE MAGMATIC EVOLUTION OF DIOGENITES.

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Introduction: High-Ca pyroxene and plagioclase are typically present as minor phases in diogenites [1]. However, although the trace element content of diogenite orthopyroxene has been measured in a number of studies e.g., [2, 3]; almost no trace element data is available for the high-Ca pyroxene and plagioclase with which it routinely coexists in these meteorites. These data could provide insights into the nature and evolution of the melts from which diogenites crystallized in the HED parent body. In this study we have obtained initial measurements of several REEs in high-Ca pyroxene, plagioclase, and orthopyroxene in the Bilanga. Measurement of additional incompatible trace element concentrations in these phases is currently in progress.

Bilanga Diogenite: The Bilanga diogenite contains numerous aggregates of high-Ca pyroxene and in some cases plagioclase that are 10s - 100s of μm in size. Some of these appear to be remnants of trapped intercumulus melt that has been relatively undisturbed by later shock melting (Type 1 assemblages of Kolar et al. [4]). Others appear to have been partly re-melted by later shock events (Type 3 assemblages). Heterogeneously exsolved blebs of high-Ca pyroxene and chromite, more fractionated zones of silica-rich mesostasis associated with small REE-rich phosphate minerals, and exotic clasts consisting of high-Ca pyroxene, plagioclase, silica with minor K-feldspar and troilite are also observed. The average compositions of orthopyroxene and high-Ca pyroxene in all of these occurrences are mg# 80; En_{78}, Fs_{21}, Wo_{1} and mg# 89; En_{47}, Fs_{6}, Wo_{47} respectively. The Al content of orthopyroxene in Bilanga is 0.03 cations per 6 oxygens and the avg. Ti content is 0.055 wt%. Based on the observations of Fowler et al. [3, 5] this suggests Bilanga falls approximately in the mid-range of diogenites with respect to the degree of fractionation it has experienced. Plagioclase compositions are An_{88} in Type 1 assemblages, An_{79} in exotic clasts, and variable (An_{92} – An_{46}) in Type 3 assemblages. Data obtained for high-Ca pyroxene, plagioclase, and orthopyroxene in Type 1 assemblages, high-Ca pyroxene and plagioclase in exotic clasts, and high-Ca pyroxene and orthopyroxene in the Type 3 assemblages, are presented in the current study.

Analytical Methods: Analyses were made using the Cameca 4f ion microprobe at the Institute of Meteoritics, University of New Mexico. Analyses were performed using a primary beam of O^- ions accelerated through a nominal potential voltage of 10 kV. A primary ion current of 15 – 20 nA was focused on the sample over a spot diameter of 20 – 25 μm. Sputtered secondary ions were energy filtered using an energy an offset voltage of 75 +/- 25 V. All spots were ion imaged prior to analysis to assist in locating the phases of interest.

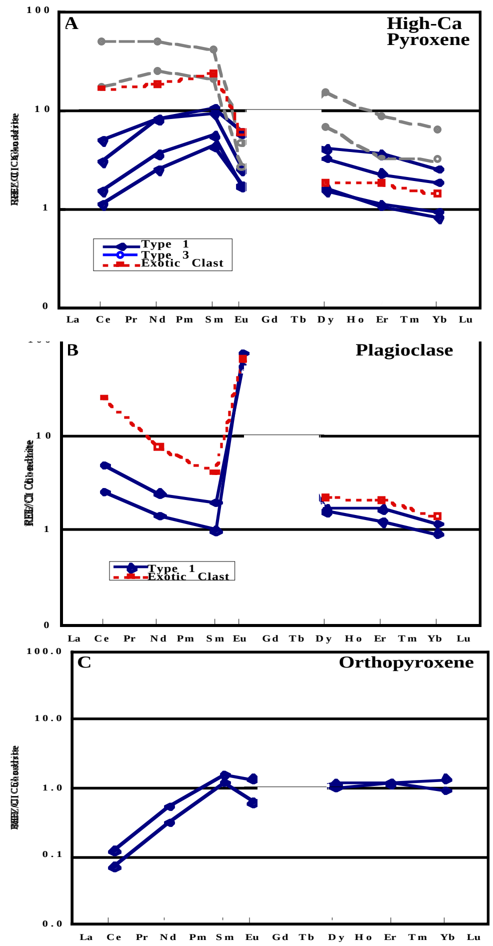

Fig. 1: Chondrite normalized REE contents of high-Ca pyroxene, plagioclase, and orthopyroxene for different petrographic phase assemblages in the Bilanga diogenite. La, Pr, Gd, Tb, Ho, Tm, Lu were not measured.

Discussion: The chondrite-normalized REE concentrations measured in high-Ca pyroxene and plagioclase in Type 1 and Type 3 assemblages, and in exotic clasts are shown in Fig. 1a and 1b. Representative analyses of orthopyroxene in grains in contact with high-Ca pyroxene and plagioclase are shown in Figure 1c. The locations of ion microprobe analyses taken in in a typical Type 1 assemblage and in an exotic clast are shown in Figs. 2 and 3.

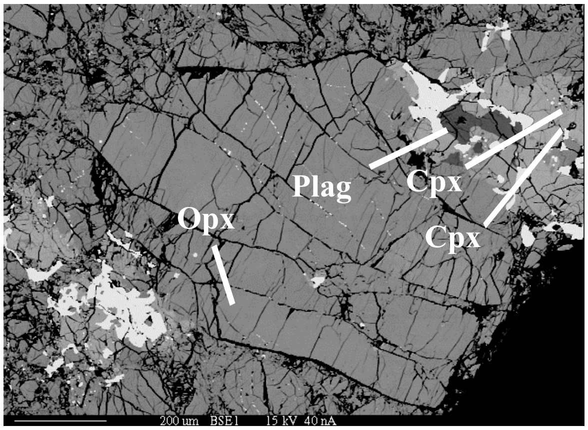

Fig 2. BSE photo showing a typical Type 1 assemblage located between two different orthopyroxene grains in the Bilanga diogenite. Arrows indicate the locations (+/- 20 μm) of ion microprobe analyses.

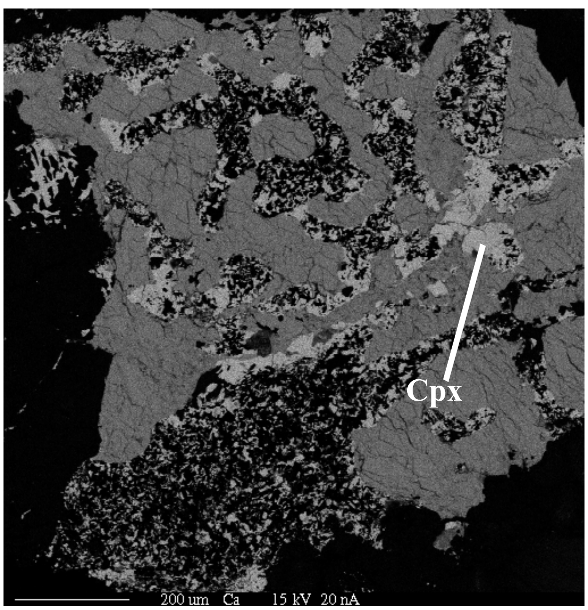

Fig 3. Ca X-ray map of an exotic clast in the Bilanga diogenite showing vermicular intergrowth of silica (black) and high-Ca pyroxene (white) in a large plagioclase grain (grey). Arrows indicate the locations (+/- 20 μm) of ion microprobe analyses.

High-Ca pyroxene in all three types of assemblages display significant depletions in the HREE elements, suggesting that extensive crystallization of orthopyroxene took place prior to their crystallization. In addition, high-Ca pyroxene in Type 3 assemblages and exotic clasts exhibits higher LREE concentrations and more pronounced Eu anomalies than does high-Ca pyroxene in Type 1 assemblages. This implies that a larger degree of fractionation and a significantly greater amount of plagioclase crystallization occurred in the parent melts of the Type 3 assemblages and exotic clasts compared to Type 1 assemblages.

Plagioclase in the exotic clasts is enriched in LREE compared to the plagioclase in Type 1 assemblages, again indicating that the clasts were derived from a more fractionated liquid. The degree of LREE enrichment appears to be similar in magnitude to that observed by Mittlefehldt [2, 5] in two exotic fragments of plagioclase from the Johnstown diogenite. The LREE content plagioclase in Type 1 assemblages is significantly lower.

Conclusions: At least some of the diopside and plagioclase bearing assemblages in Bilanga appear to have formed from trapped intercumulus melt. This melt was highly depleted in HREEs, probably due to prior crystallization of large amounts of orthopyroxene [10], which is consistent with an origin as trapped intercumulus melt in an adcumulate orthopyroxenite. Exotic clasts in Bilanga appear to have formed from a more fractionated magma after the crystallization of significant amounts of plagioclase. Trace element and petrographic data suggest that the diopside and plagioclase in the Type 1 assemblages in Bilanga crystallized from the same magma as orthopyroxene, but at a much later time. In addition, similarities between the exotic clasts and the trapped intercumulus melt assemblages (such as the identical major element composition of high-Ca pyroxene in both) could possibly indicate that the exotic clasts represent a rock type that crystallized from a more evolved fraction of the same or a related magma.

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