PASAMONTE-LIKE CLASTS IN EUCRITE POLYMICT BRECCIAS. M. Miyamoto
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Four distinct types of pyroxene crystallization relationships have now
been observed in eucrites (1), which apparently reflect differing environments
and rates of crystallization. These include: (a) Pasamonte-type, in which
pyroxenes are strongly zoned, but do not have exsolution lamellae (2); (b)
common eucrites (e.g., Juvinas, Nuevo Laredo), in which the pyroxenes are not
compositionally zoned, but which have exsolution lamellae of augite on the
(001) plane of host pigeonite; (c) Moore County-like, with compositionally
uniform host pigeonite, complexly exsolved and partially inverted to ortho-
pyroxene, and (d) Binda-like, with inverted low-calcium pyroxene with blebby
exsolved augite on (100). The sequence (a)-(d) may be related to increasing
depth of crystallization (3). Most eucrites are monomict breccias, in which
only one pyroxene crystallization type occurs. However, Yamato-74159 contains
clasts of both types (a) and (b) (4). The bulk compositions of Yamato-74159,
Pasamonte and common eucrites are essentially identical (5).

Two eucritic clasts a few mm in diameter were found in Yamato-74159.
The fine-grained clast shows an ophitic texture with lath-shaped plagioclase.
The other coarse-grained clast shows a gabbroic texture. The chemical trends
of their pyroxenes are plotted in the pyroxene quadrilateral (Fig. 1, 2). This
meteorite also contains fragments of Juvinas-like clinopyroxene, with augite
lamellae on (001).

In order to see detailed chemical trends of the zoned pyroxenes, several
samples in a thin section of Pasamonte supplied by E. King were selected for
microprobe traverses. The chemical trends were obtained for several traverses
perpendicular to the c axis, from the center of the crystal towards the rim,
where either plagioclase or mesostasis phases are in contact with pyroxenes.
Some typical trends are shown in Fig. 3. The core pigeonites (confirmed by
X-ray diffraction) have an uniform chemical composition with very high Mg
concentration. The chemical zoning of the Pasamonte pyroxene can be grouped
into two typical chemical trends, Fe-enrichment and Ca-enrichment. The Fe-
enrichment trend is represented by zoning from around Ca$_6$Mg$_{61}$Fe$_{33}$ towards
Ca$_7$Mg$_{38}$Fe$_{55}$. This trend was mainly observed from the core to the boundary at
plagioclase. The Ca-enrichment trend covers the compositional range from
about Ca$_{1}$Mg$_{36}$Fe$_{63}$ to Ca$_{32}$Mg$_{27}$Fe$_{41}$, and was observed around rims of crystals
towards mesostasis-rich areas. In some cases, these two trends are observed
in a single traverse from core to rim, the Fe-enrichment being followed by the
Ca-enrichment (Fig. 3) towards the mesostasis-rich portion. There is an in-
crease in Ti with increased degree of crystallization.

Ca-Fe-Mg variations for pyroxenes from the Pasamonte-like clast in Yamato-
74159 (Fig. 1) show general trends similar to those described above for
Pasamonte. Although the ophitic texture of the Y-74159 clast is finer than
that of Pasamonte, the compositions of the first pigeonite to crystal-
lize and that of the last augite are almost identical to those of Pasamonte.
The major element variation of the other coarse-grained lithic clast of Yamato-
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74159 is not as extensive as Pasamonte, but minor zoning is present. To demonstrate the contrast of pyroxene mineralogy in ordinary eucrites, Figure 4 shows pyroxene variations in the Nuevo Laredo meteorite. Pigeonites studied by X-ray diffraction show very fine exsolution lamellae on (001).

The chemical zoning of the Pasamonte and Yamato-74159 pyroxenes is different from that of Shergotty, the only known unbrecciated meteorite which shows extensive chemical zoning (6) and from that of lunar mare pyroxenes. The chemical zoning of this type has been explained by crystallization conditions which involve rapid growth from a super cooled melt by Takeda et al. (2). Delayed plagioclase nucleation has been considered responsible for chemical zoning of some lunar mare pyroxenes (7). However, in Pasamonte, several lines of evidence suggest that plagioclase crystallized early and continuously along with the pyroxene. In zoning toward plagioclase boundaries, no enrichment of Ca or Al is observed, as might be the case if plagioclase crystallization was suppressed. Enrichment of Ca and Ti in late state pyroxenes implies that as crystallization proceeded these elements increased in the residual liquid. Pyroxene variations similar to those of the common eucrites have not been observed in the lunar basalts.

It has long been recognized that howardites are polymict breccias, composed of eucrites as described above and diogenite-like material (orthopyroxenite) in various proportions, and are interpreted to be produced by impact processes on a planetary surface (1, 8). Defined on the basis of containing clasts with different cooling histories, two Yamato eucrites (74159, 75011) are also polymict. They contain rock fragments of the type described above and, in the matrix, fragments of Mg-rich pigeonites along with Juvinas-like pigeonites with coarse exsolution lamellae of augite with (001) in common. Reexamination of a pyroxene concentrate of Pasamonte indicated that it also contains several unzoned pigeonites with fine exsolution lamellae with (001) in common such as those described for the Juvinas eucrite. Comparisons of the chemical trends of the matrix pyroxenes previously reported (4) with those of pyroxenes in the clasts indicate that the Mg-rich pigeonites are fragments of the cores of zoned pigeonites. They are compositionally similar but crystallographically different from the orthopyroxene host of the inverted pigeonites in the cumulate eucrites such as Moama. These facts support an idea that many eucrites are breccias containing relatively rapidly cooled basalt fragments from a variety of depths. These compositional and crystallographic data are consistent with a range of crystallization textures in individual eucrites that also suggest a variety of crystallization rates.

The coarsest exsolution lamellae of augites in the Yamato 74159 pigeonites developed at an estimated depth of a few km in the crust of the parent body (3). Some of the compositionally zoned pyroxenes may have formed very close to the surface. Thus, regolith-like surface, derived from materials of up to a few km depth apparently formed on the parent bodies of the Yamato-74159, Yamato-75011 and Pasamonte meteorites.

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References


Fig. 1. Pasamonte-like clast in Y-74159. Fig. 2. Gabbroic clast in Y-74159.

Fig. 3. Traverse normal to γ for Pasamonte pig. Fig. 4. Nuevo Laredo.