

A PETROGENETIC CLASSIFICATION FOR THE EUCRITE CLAN — PARTIAL MELTS, FRACTIONATED LIQUIDS, CUMULATES, AND ODDITIES. J.H. Jones* and D.W. Mittlefehldt**. *SN4, NASA/JSC, Houston, TX 77058. **C23, Lockheed ESC, 2300 NASA Road 1, Houston, TX 77058.

The origin of the eucrites (basaltic achondrites from the asteroid belt; Binzel and Xu, 1993) has been a matter of much discussion (Mason, 1962; Stolper, 1977). However, the recent studies of Jurewicz et al. (1991, 1993, 1995), Jones et al. (1994), and Warren (1994) have served to renew interest and provide a better focus for this debate. The original work by Mason (1962) focused on relating eucrites and diogenites (cumulate pyroxenites) and suggested that most eucrites were fractionated liquids, having crystallized significant pyroxene. Later experimental work by Stolper (1977) suggested that at least some eucrites were primary liquids and that more fractionated eucrites could be related to these primitive magmas by fractionation of pigeonite and plagioclase. Jurewicz et al. (1993) and Jones et al. (1994) provided corroboration for Stolper's hypothesis by showing that partial melts of a chondrite were nearly indistinguishable in composition from eucrites such as Sioux County, which Stolper had designated as primitive. More recently, however, Warren and Kallemeyn (1994) have challenged this interpretation. In these authors' view, Sioux County and similar eucrites are likely to be partial cumulates and, therefore, any similarity to experimental glasses is viewed as coincidental.

The Method. We have used the database of eucrite analyses compiled by Mittlefehldt to address these issues: Which, if any, eucrites are primitive? Which are fractionated liquids? And which may be partial cumulates? For this exercise we have only explored those eucrites that cluster about the Ol-Px-Pl peritectic point of Stolper (1977). Those eucrites that are classified as "cumulate eucrites" appear to be just that and are not involved in the current controversy. We exclude mafic eucrites that are rich in incompatibles, such as ALHA81001 and Pomozdino. And, because of its chemical oddities compared to other non-cumulate eucrites (e.g., Boctor et al., 1994), we have also omitted Ibitira from our classifications.

Our method is the more traditional one: to assign eucrites to either a partial melting trend ("Stannern trend") or a fractional crystallization trend ("Nuevo Laredo trend") and to then look for inconsistencies. Does a eucrite keep its place relative to other eucrites on different compositional diagrams? Are the petrologic inferences gleaned from various compositional plots consistent with experimental evidence and petrologic experience? Eucrites which change position from diagram to diagram or which fall off well-defined trends are candidates for formation by some other process, such as crystal accumulation. Initially, the two trends were defined by Bouvante and Sioux County (partial melting trend) and by Nuevo Laredo and Sioux County (fractional crystallization trend). However, no eucrite was made to belong to a trend if it behaved inconsistently.

Because very little information is gained from highly incompatible elements, we will strongly weight our discussion to those elements that are either compatible or weakly incompatible. Highly incompatible elements, such as La, are used only as reference elements.

Results. Partial melting trend. Our analysis indicates that six eucrites fall on a reasonable partial melting trend: Bouvante, Cachari, Chervony Kut, Palo Blanco Creek, Sioux County and Stannern. Beginning with Bouvante, the trend culminates in Sioux County, which has a flat REE pattern. Bouvante and Stannern, have long been thought to represent low-degree partial melts. The other members of the trend define the low CaO/Al₂O₃ group of Jurewicz et al. (1993). The eucrites of the partial melting trend mimic the major element variations seen in partial melts of the Murchison chondrite (Jurewicz et al., 1993; Jones et al., 1994), and, thus, the trend is consistent with experimental observation.

Fractional crystallization trend. Eight additional eucrites fall on the fractional crystallization trend: Bereba, Camel Donga, Juvinas, Lakangaon, Millbillillie, Nuevo Laredo, Pasamonte, Sioux County, and Y793164. Along this trend incompatible elements increase from Sioux County to Nuevo Laredo as Mg#s decrease. Y793164 sometimes falls off the trend, but the number of analyses of this meteorite is small and sampling may be an issue. It is also possible that Y793164

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is polymict. Of more concern is Pasamonte, a much-analyzed eucrite that behaves slightly differently on trace element diagrams than on plots of major elements. Interestingly, Pasamonte, too, has recently been reclassified as a polymict eucrite (Metzler et al., 1994). However, overall, the trend is well defined and closely follows the equilibrium crystallization trend of Stolper's pyroxene-plagioclase saturated liquids (Stolper, 1977).

Ungrouped eucrites. Five eucrites that do not consistently fall on either trend are: Emmaville, Haraiya, Jonzac, Padvarninkai, and Vetluga. The reasons for these exceptions are unclear. One possibility is that these eucrites are insufficiently analyzed and/or sampled. For Emmaville and Vetluga this may well be the case. However, in terms of major elements at least, Haraiya and Jonzac should have been adequately sampled.

Discussion. The successes of partial melting and fractional crystallization, in explaining the chemical diversity of most of the eucrite suite, suggest that partial crystal accumulation has not been an important mechanism in eucrite petrogenesis. Of the nineteen eucrites investigated in this study, fourteen are very adequately explained. Of the remaining five, Haraiya and Padvarninkai are the most likely candidates for partial cumulates. Within the context of their other chemical characteristics, these eucrites have slightly higher Mg#'s than would otherwise be expected. However, it is by no means certain that even partial accumulation can explain the compositions of these eucrites.

We conclude that most eucrites originated either as simple partial melts or as fractionated liquids. Because both trends follow compositional paths defined by laboratory experiments, any partial cumulates masquerading as melts must conform to stringent rules. One of these is that both pyroxene and plagioclase must accumulate in exactly the correct proportions. Even as much as five percent accumulation of pyroxene alone will leave indelible chemical signatures that are not observed within our suite of fourteen eucrites. The same is true of seven percent accumulation of plagioclase. Perhaps the most difficult case to evaluate would be if the accumulating crystals were in almost the same proportions as those in basaltic eucrites. Even in this example, however, twenty percent accumulation of a 60:40 (by weight) mixture of pyroxene and plagioclase would be clearly noticeable. Thus, while it is almost impossible to prove that most eucrites are actually liquids, there is no compelling evidence that they are not. Consequently, we favor the interpretation that the large majority of eucrites are what they seem to be — either simple partial melts or fractionated liquids of those melts.

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