ANOMALOUS ENSTATITE METEORITES QUEEN ALEXANDRA RANGE 94204 AND PAIRS: THE PERPLEXING QUESTION OF IMPACT MELTS OR PARTIAL MELT RESIDUES, EITHER WAY, UNRELATED TO YAMATO 793225. D. van Niekerk[1] and K. Keil[1], [1] Hawaiʻi Institute of Geophysics and Planetology, University of Hawaiʻi at Manoa, Honolulu, HI 96822, dionysos@higp.hawaii.edu.

Introduction: Queen Alexandra Range 94204 (QUE 94204) is an anomalous enstatite meteorite. It has been presumed to be paired with QUE 97289/97348/99059/99122/99157/99158/99387, as listed in Antarctic Meteorite Newsletters. QUE 94204 was studied by [1], [2], and [3]; all of these studies came to different conclusions with respect to its petrogenesis. [1] advocated that QUE 94204/97289/97348 probably represent impact melts. [2] advocated that QUE 94204 crystallized from a total EH chondrite melt that was produced "internally" to the parent body (presumably by shortlived nuclide decay). Based on a study of QUE 94204 [3] advocated that QUE 94204/97289/97348 did not melt completely, and are residues of partial melting analogous to transitional acapulcoites. [3] also advocated that these three meteorites belong to a new enstatite meteorite grouplet that includes Northwest Africa 2526 (NWA 2526), Itqiy, and Yamato 793225 (Y-793225). NWA 2526 and Itqiy was shown by [4] and [5], respectively, to be residues of partial melting and thus the first primitive achondrites analogous to lodranites. [5] originally suggested that unsusual features of Y-793225 could indicate that it belongs in a grouplet with QUE 94204.

In a petrographic and mineralogic study, we present new data for QUE 94204 and Y-793225, and for the first time present data for all of the other QUE pairs. In summary, we find that there is some heterogeneity between the QUE meteorites, but that they are likely paired, regardless. We find that QUE 94204, taken on its own merit, is unlikely to be a residue of partial melting. Petrology of these QUE meteorites is most consistent with an impact melt origin, however, when heterogeneity in the pairs is taken into account, a stronger case can be made that the QUE meteorites might be products of partial melting. However, that would require deviations from what is known about partial melting through the study of acapulcoites/lodranites and experiments. We find that Y-793225 is not related to these meteorites, and is probably an EL6.

Results and Discussion:

Yamato 793225. [5] found that Y-793225 is depleted in plagioclase (~3.8 vol%) relative to other enstatite chondrites. We find that it does not; it contains ~11 vol%. The discrepancy might be linked to [5]'s apparent use of only one(Si)-element X-ray map to identify plagioclase, whereas we used three-element X-ray map combinations. In the one-element X-ray maps for this particular meteorite, enstatite and plagioclase appear to have overlapping Si-intensities. Y-793225 has many characteristics in common with EL6 meteorites. Its texture and smaller grain sizes are unlike that of the QUE meteorites, and very much like that of an EL6. The Mn and Zn contents of daubréelite are very much like those of EL6s, which are distinct from EHs. The Ca-content of plagioclase is very much like that of EL6s, which are distinct from EHs. The meteorite contains alabandite, which is characteristic of ELs. As [5] points out, the Ti-content of troilite is anomalous (higher than EL6s). We conclude that Y-793225 is unrelated to the QUE meteorites and is best described as an EL6.

Queen Alexandra Range 94204/97289. These meteorites have similar textures, and similar modal abundances. Equigranular enstatites ~1 mm across sometimes have 120° triple junctions. FeNi metal, troilite, and plagioclase fill in the interstitial space between enstatite with the appearance that it was molten and conformed to the enstatite crystals. This texture could be interpreted as either metamorphic or igneous. Normal zoning in plagioclase feldspar is consistent with crystallization from a melt, implying that all plagioclase was molten. Inclusions of plagioclase, troilite, metal, cristobalite, and aluminum-alkali-rich silica glass are contained in enstatite. These may be either melt inclusions trapped during crystallization of enstatite from a total melt, or partial melts trapped during grain growth of enstatite during metamorphism and partial melting. The modal abundance of minerals that should melt first during partial melting (troilite, metal, and plagioclase) are unfractionated relative to enstatite chondrites. There is every indication that these minerals were molten in these meteorites, and thus pose a problem for a partial melting model. A rock that has been partially melted up to ~25 vol% should not retain an unfractionated composition. Impact melting, on the other hand, may preserve a chondritic composition via total instantaneous melting followed by initially rapid cooling. Furthermore, the strongest evidence for a partial melting origin of NWA 2526 is its fractionated composition; because QUE 94204 does not have a fractionated composition one cannot surmize that the latter is a product of partial melting based on the similarity in texture with NWA 2526.

Queen Alexandra Range 97348/99387/99158. These meteorites are texturally similar (Fig. 1) to QUE 94204/97289. We have not determined the modal abundances of QUE 99158, but the other two meteorites have different modal abundances from QUE 94204/97289. They are depleted in metal but unfractionated in terms of plagioclase. Their mineral chemistry is similar to that of all the other pairs discussed here.

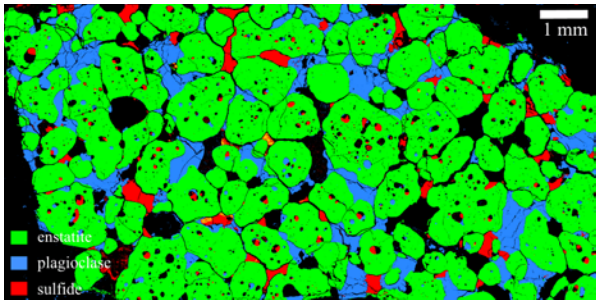

Figure 1: S-Mg-Al X-ray map mosaic of a thin section of QUE 99387. Metal is black between the green enstatite.

Queen Alexandra Range 99059/99122. These meteorites have different textures from the pairs mentioned above (but contain the same inclusions in enstatite, as do all the pairs) and have different modal abundances. Their textures are less regular and more chaotic (Fig. 2) due to the fact that (i) enstatites are not equigranular like the QUE 94204-like meteorites, (ii) minerals are heterogeneously distributed, (iii) enstatites are larger than in the QUE 94204-like group and have large irregular embayments in them that are filled with metal, troilite and plagioclase. Metal outside embayments occur in large patches. These meteorites are enriched in metal and depleted in plagioclase.

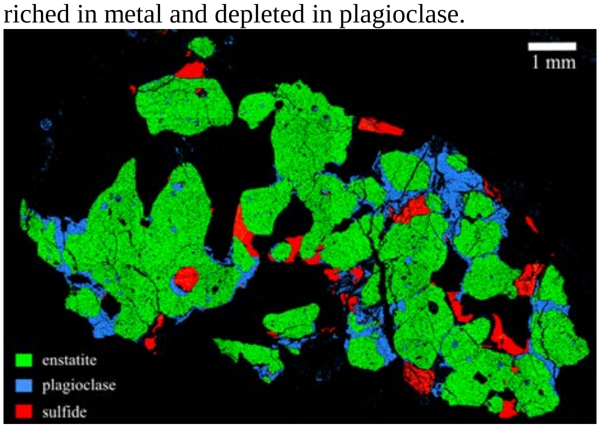

Figure 2: S-Mg-Al X-ray map mosaic of a thin section of QUE 99122. Metal is black between the green enstatite.

Queen Alexandra Range 99157. This meteorite is slightly different from the others in its modal abundance and texture. It has the least metal of the pairs and is unfractionated in terms of plagioclase. Its does not contain the large partches of metal of QUE 99059/99122. It contains the largest enstatite crystal of all the meteorites.

Petrogenesis of the pairs. Despite various degrees of enrichment and depletion of metal and plagioclase in these meteorites, none of them are completely devoid of troilite, metal, or plagioclase. They might still be thought of as broadly chondritic. NWA 2526 and Itqiy are completely devoid of plagioclase and troilite. The textural and modal abundance heterogeneities among these meteorites may be due to heterogeneous crystallization during cooling of an impact melt, but it could also reflect partial melting processes. The textures of the QUE 99059/99122 meteorites, especially, evoke visions of partial melting and migrating melt. There are however several discrepancies relative to the results expected from partial melting. Firstly, there is evidence that all of these meteorites underwent large scale melting—perhaps complete melting. Why are they not severely fractionated? The local “sinking” of metal and “rise” of plagioclase in their former stratigraphic setting on the parent body could be reflected in this, but that does not explain the unfractionated compositions of QUE 94204/97289. Secondly, the first eutectic silicate melts that are expected to form in enstatite chondrite-like precursors subjected to partial melting should be granitic. This corresponds to observations of [6] with respect to phase equilibria in the system Fo-Ab-Si during partial melting. Also, in partial melting experiments on EH chondrite Indarch, [7] observed 7 vol% granitic melt at the eutectic temperature. Where are these melts in the QUE pairs? If these eutectic melts were extracted during partial melting, why wasn’t troilite and plagioclase also severaly fractionated like in NWA 2526 and Itqiy? Where are the small melt veins that should form at low degrees of partial melting, in analogy to acapulcoites/lodranites, prior to melt migration? If these QUE meteorites are residues of partial melting, the mechanics of partial melting operated differently on their parent body than would be expected. On the other hand, all these meteorites may have formed by impact melting, which is more likely to preserve the broadly chondritic compositions.

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