

# **PETROGRAPHY OF SAMPLES FOR CONSORTIUM STUDIES OF THE ELEPHANT MORAINÉ 87521 VERY-LOW TITANIUM LUNAR BRECCIA.**

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The Elephant Moraine 87521 meteorite is a lunar breccia dominated very-low-titanium basaltic clasts {1,2}. Initial descriptions of the meteorite were based on sampling of a small volume of the 30g object and revealed significant variability within the sample. The presence of highlands clast H in thin section [9] provided telling evidence for the polymict nature of the breccia. As a result, the sample has been processed at JSC for consortium study of the trace element geochemistry, the cosmogenic radionuclides, thermoluminescence, and if possible radioisotope dating of the various lithologies present. The presence of plagioclase dominated lithic clasts as well as both light and dark mafic clasts in hand sample permitted the separation of several different splits each having distinct properties. Three plagioclase rich areas [clasts W1, W2, W3] and two mafic clasts [M1, M2] were separated. Unfortunately the masses of these are very small [typically, the clean samples of these clasts are about 5-40mg]. The matrix of 87521 has both light and dark regions that reflect the abundance of black, shock glass invading the breccia {3}. Samples dominated by that glass are currently being studied by both NAA and ion probe techniques to characterise the REE enrichment relative to 'typical' VLT {2}.

**RESULTS:** Thin sections corresponding to the white, plagioclase rich clasts [W1 ,57 ,58; W2 ,59 ,60; W3 ,61] are all fine grained breccias with generally small lithic clasts. Only small areas of these clasts are exposed in the thin sections and the sections are dominated by mafic rich breccia. Only W1 [in ,57 and ,58] has abundant plagioclase and has one small area of poikilitic/granular pigeonite. Preliminary INAA results for a 2.5mg bulk clast sample of W1 indicate 1.2wt% FeO, with higher Ca and much lower Sc, Cr, Mn and Co than the bulk meteorite. The REE of W1 are also low with La=7xCI chondrites and a large positive Eu anomaly (Sm=2.6xCI, Eu=19xCI). W2 appears as a prominent clast in [60] and has ferroan pyroxene (En<sub>29-34</sub> Wo<sub>14-30</sub> with some zoning preserved). Plagioclase is An<sub>93-94</sub>. Preliminary INAA results for a 6.5mg clast sample show Fe, Sc, Cr, Mn, and Co depleted by a factor of 0.6 to 0.7 relative to the bulk meteorite whereas plagioclase associated elements Na, Ca and Ga are commensurately enriched. Concentrations of REE in W2 are much lower than in the bulk meteorite and are comparable with the typical levels in pure VLT mare basalts {2} except that heavy REE are even lower (Lu=4xCI). This presumably reflects the lower than typical pyroxene/plagioclase ratio in this sample. W2, therefore, resembles the typical VLT clasts in EET87521 and is a promising candidate for isotopic studies of pure EET87521 VLT mare basalt. The breccia portions of thin sections [57 ,58 ,59 ,60 ,61] contain pyroxene ranging from En60-65Wo8 pigeonite to En5Wo40 ferroaugite. None contains pyroxene more magnesian than ≈En67. Thus, none of these sections contain pyroxene comparable to the magnesian highland component observed {2}. However, rare magnesian olivine grains (Fo70-80) in the breccia may be derived from magnesian highland components. Most mafic clasts differ from the typical VLT clasts described previously {1,2} as they show relatively little zoning of the pyroxene and have relatively magnesian compositions (En45-55Wo10-20 pigeonite and En35-45Wo30-40 augite). Several other clasts contain relatively coarse grains of both augite and pigeonite while others have only finely exsolved (≈1μm lamellae) pigeonite. Mafic clast [61B1] contains Fo63-67 olivine coexisting with both pigeonite (En67Wo5) and augite (En48Wo36). This is the first lithic clast observed to contain the typical intermediate olivine (Fo50-70) that commonly occurs in the meteorite matrix {3}. This clast is slightly more magnesian than typical VLT material from Luna 24 but may be similar to Apollo 17 VLT {4}. Plagioclase in both the lithic clasts and matrix is typically An92-95. These mafic clasts almost certainly represent the magnesian part of the VLT compositional spectrum, although conceivably some may be derived from ferroan highlands sources. Further investigation of the distribution of major, minor and trace elements in these clasts and for the separated white clasts from these splits is currently in progress.

Thin sections corresponding to the separated basalt clasts [M1 ,64 ,65; M2 ,63] are breccias with few large lithic fragments. Both have pyroxene composition ranges that resemble the typical VLT

clasts described previously. However, both sections from the 'M1' breccia contain more abundant magnesian pigeonite (En50-65Wo10-18) than Fe rich pyroxene. Augitic pyroxene is relatively uncommon in these breccias. Both clasts appear to be breccia clasts that contain relatively little shock glass. The range of feldspar compositions is limited (An90-95). Olivine clasts in these sections tend to be more Fe rich but magnesian grains are also scattered through the matrix.

Macroscopically, the EET87521 breccia has distinct light and dark patches. Although these patches seem to correspond to the abundance of shock glass that is penetrating the breccia, the light and dark areas are often difficult to distinguish microscopically. Section [66] is a 'light' matrix sample that contains magnesian pyroxene (En50-64Wo10-20) similar to the M1 basalt breccia. Fe-rich pyroxene is relatively uncommon in this section. Section [67] on the other hand is from a sample with both light and dark regions and contains both magnesian and ferroan pyroxene. Section [66] may also be slightly coarser grained than [67]. Thus both the compositions of the mafic silicates and the grain size may influence the distribution of light and dark patches in the EET87521 breccia in addition to the abundance of the shock glass.

The shock glass that permeates this meteorite is essentially basaltic in composition. The glass shows variable degrees of devitrification and is quite heterogeneous in composition. Initial ion probe measurements of the REE contents of the glass in [8] revealed very large variations in Ce content from 10xCI to over 100xCI. Thus the glass appears to be the host for the 'excess' REE relative to Luna 24 and Apollo 17 VLT basalts. While this glass may contain a KREEP component {2} the possibility that the darker portions of the breccia, which appear to contain more glass, are more Fe rich suggests that some of the REE heterogeneity may be the result of fractionation processes in the VLT magma {cf.5}. The magnitude of the known enrichment in the glass seems much too great for this to be the only source of the REE enrichment, however, and more detailed ion probe measurements of the glass and mineral clasts in the light and dark matrix portions and in veins through lithic clasts are planned to further constrain the origin of the high REE in EET87521.

The prominence of the fairly magnesian VLT clasts in these samples and the extreme range of Fe/(Fe+Mg) suggests that the range of VLT fractionation is well represented by this meteorite. The preliminary low levels of REE in the separated clasts are consistent with the high REE pattern of the meteorite being produced by mixing of low REE VLT basalts with a REE enriched, probably KREEPy material in the shock glass. The REE variations observed by {5} may, however, suggest that the REE of the breccia may contain an additional highly fractionated component related to the VLT.

REFERENCES: {1} Delaney JS (1989) *Nature* 342, 889; {2} Warren P & Kallemeyn (1989) *GCA* 53,3323; {3} Delaney & Sutton (1990) *LPSC XXI*, {4} Vaniman & Papike (1977) *PLSC* 8, 1443 {5} Lindstrom et al. this volume :Acknowledgements: NASA NAG9-304 Delaney: