ORIGIN OF MAGNETIZATION IN LUNAR BRECCIAS: AN EXAMPLE OF THERMAL OVERPRINTING; Gose W.A., Univ. Texas Marine Sci. Inst., Geophysics Lab, Galveston, Tx.; Strangway D.W., Univ. Toronto, Toronto, Canada; Pearce G.W., Erindale College, Missauga, Canada.

The detailed sampling of the large boulder at station 6, Apollo 17, has provided the best sample collection with which to examine the origin of magnetization in lunar breccias. As members of the Phinney consortium we studied 26 chips from seven handspecimens. Most samples are strongly magnetized and their natural remanent magnetization (NRM) is highly stable against alternating field demagnetization.

Based on lunar surface photos, Heiken et al. (1973) mapped four stratigraphic units within the boulder. The matrix in all units is very similar (Simonds, 1975), the main difference being the texture of the matrix and the clast population (abundance and size). Unit A and transition unit A-B contain a few clasts >5 cm and the well foliated unit B has almost no clasts >5 cm. By contrast, unit C contains a large number of clasts >5 cm ranging up to 1 meter in size. The matrix is coarse grained in unit B, intermediate in unit A-B, and finest grained in unit C.

Samples 76015 and 76215 belong to unit B. Three chips from 76215 exhibit a common stable direction (Fig. 1). Except for chip 48, all samples from 76015 also cluster well (Fig. 2) (Note: due to orientation difficulties comparison between samples may have an uncertainty of up to 30°). All samples from 76315 (unit A-B) that we studied are matrix samples. The directions of their NRM exhibit a fair grouping (Fig. 3) but do not cluster as well as the samples from unit B. From unit C, four rocks were analyzed (76255, 76275, 76295, 76307). Although the individual specimens are stable against alternating field demagnetization, a large scatter of the direction of NRM is observed (Fig. 4). However, it is clearly not a random distribution.

Combining the magnetic data with microscopic and macroscopic observations leads to a fairly straightforward interpretation of the origin of magnetization in lunar breccias. It appears that the stratigraphic units in this boulder reflect different thermal regimes as suggested by Heiken et al. (1973). An ejecta blanket is a mixture of an impact melt and essentially cold clasts in which the clast population (abundance and size) determines the exact thermal history of the blanket. If the clasts are small and not too abundant, they will thermally equilibrate with the melt at some temperature higher than the Curie temperature. If, on the other hand, the clasts are abundant then the larger ones may not equilibrate and, depending on their size, will never be heated to any appreciable temperature except at their edges. Thus the NRM of breccias is the vector sum of two magnetizations, a pre-impact magnetization and a thermoremanence acquired during cooling. Depending on the clast population the NRM of a breccia may be a true TRM, a partial TRM plus the pre-impact magnetization, or simply the pre-impact magnetization. In multiple generation breccias more than two components may be present.

This model explains the data from the boulder well. The uniform direction of NRM in unit B is consistent with a true TRM. The modest scatter of directions in 76315 (unit A) can be accounted for by a high temperature
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Partial TRM plus a small pre-impact component. The large scatter of directions in unit C implies the predominance of a pre-impact magnetization. It is important to note, however, that the distribution is not random, signifying a modest degree of thermal overprinting. The thermal sequence inferred from the magnetic data parallels the increase in clast size in the boulder and also agrees with the petrographic interpretation (Simonds, 1975) and the (Ar/Ar) release pattern (Turner et al., 1975).

The interpretation of the magnetic data via a thermal overprint is amenable to a simple test, namely thermal demagnetization. While no such test could be done on the samples from the boulder, the experiment was performed on an Apollo 11 breccia, 10048. Two distinct groupings of the direction of magnetization were obtained for the temperature intervals $200^0 < T < 350^0$C and $400 < T < 700^0$C (Fig. 5). The model we propose readily explains the data. The high temperature component is the pre-impact magnetization whereas the component which is stable between $200^0$ and $350^0$ reflects the thermal overprint (PTRM) acquired during breccia formation.

We may conclude that breccias record magnetic fields at two or more different ages. The fine grained matrix was heated above $800^0$C, the Curie point of iron, while the interiors of larger clasts in general were only reheated to temperatures significantly less than the Curie point.

References

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Fig. 1 - 4:
Stereographic projection of the stable direction of magnetization with their 95% circle of confidence. x are in the lower, o in the upper hemisphere. Fig. 1-3 are in LRL coordinates, Fig. 4 in approximately lunar coordinates.

Figure 3

Figure 4

Fig. 5: Thermal demagnetization of 10048. Numbers indicate the temperature in °C.