NRM directions around a cm-size inclusion in Allende

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Natural Remanent magnetization (NRM) of a cm size inclusion and the surrounding matrix in Allende were measured to assess when this meteorite was magnetized.

Sample description: The sample (Fig. 1) has a light-grey coloured inclusion. Surrounding portions of the matrix are referred to as M1, M2 and M3 as shown in the figure. M1 and M2 are similar portions of chondrule-rich matrix. M3 is poor in chondrules and its boundaries with M1, M2 and the inclusion appear to be faults. A dark rim is seen along parts of the boundary between the inclusion and M1 and M2. The rim is most conspicuous at the boundary with M2 (hatched area in Fig. 1).

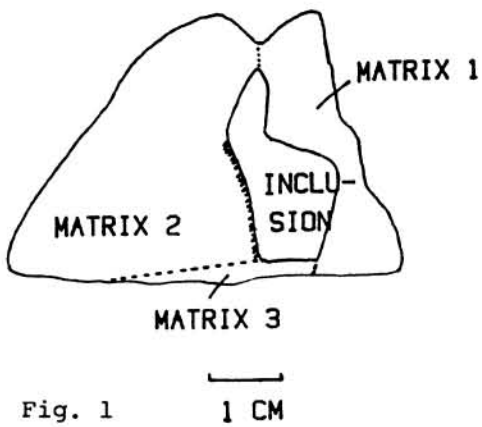

Fig. 1

Experiments: The NRM directions of small (200mg) specimens were measured with a superconducting magnetometer. A soft secondary component of NRM was detected in many specimens from the upper right corner illustrated in Fig. 1. This may be an IRM acquired by exposure to a magnet. Alternating field (AF) demagnetization was done to erase this IRM. In most cases less than 50 Oe was needed to erase the IRM. The NRM after the AF demagnetizations are shown in Fig 2. All the matrix and the inclusion samples have roughly the same NRM directions. But there are significant differences between M1, M2 and (M3 + inclusion). There is a systematic change in NRM direction among M2 specimens. Specimens from the left hand side of M2 (Fig. 1) show increasing inclinations approaching the boundary with the inclusion. The NRM direction of M2 samples near the boundary is similar to that in the M1 samples.

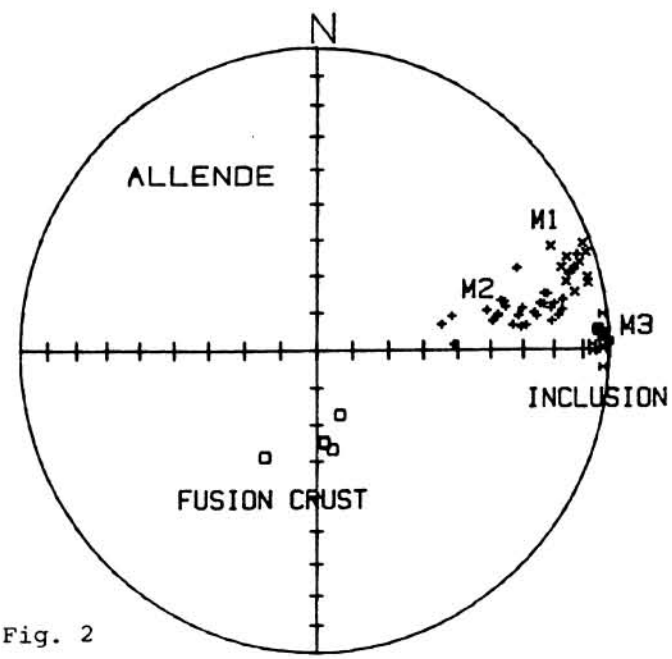

Fig. 2

Stepwise thermal demagnetization was done for many specimens. As the demagnetization temperature approaches 320 C (Curie point of pyrrhotite), the NRM directions start changing, and reach a

stable direction at temperatures above 320 C (Fig.3). This high temperature component of NRM is almost randomly distributed (Fig.4) except for the grouping shown by three specimens from the inclusion. The intensity of the high temperature component is very weak and is only several times 10^{-7} emu for each specimen.

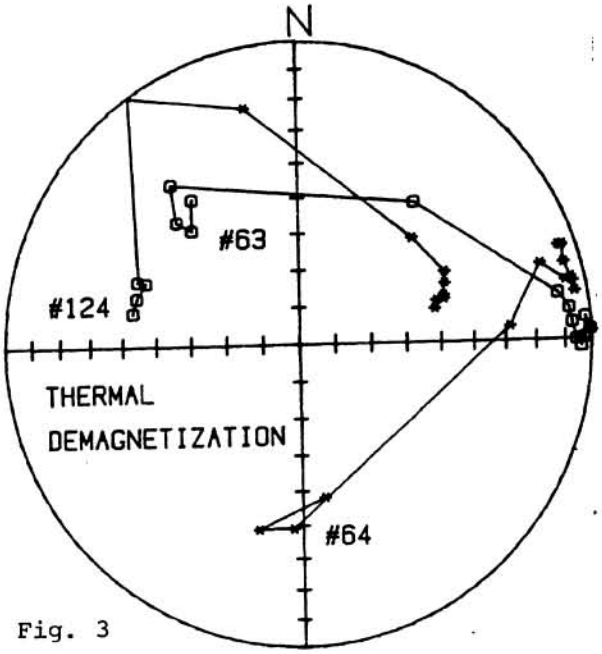

Fig. 3

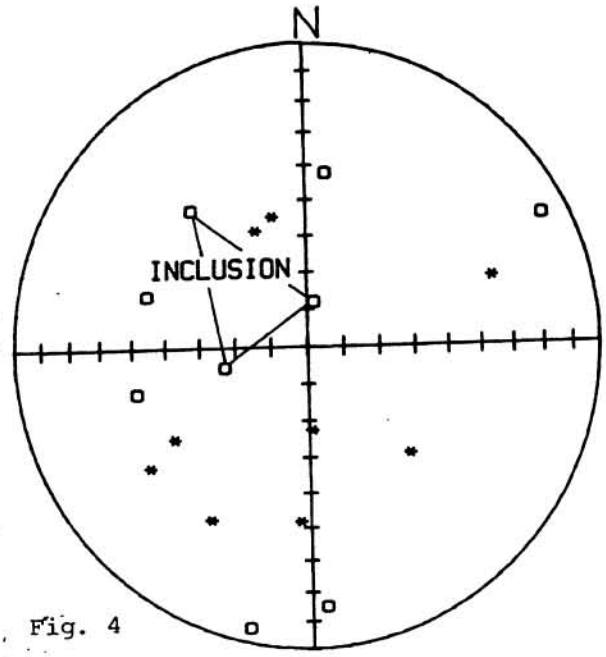

Fig. 4

NRM HIGH TEMPERATURE COMPONENT

Interpretation: Since the sample is almost homogeneously magnetized, we assume the sample wàs remagnetized (probably by chemical remanence) after accretion. Small differences among M1, M2 and (M3 + Inclusion) and the differences within M2 are thought to be a result of mechanical deformation which occurred when the faults were formed. Since the difference in NRM direction within M2 is as much as 40 degrees, quite a large deformation is required. This suggests that the matrix must have been soft and porous before the deformation.

Since the directions of the high temperature component of NRM are almost randomly distributed, the high temperature component is likely to be carried by chondrules which were magnetized before accretion (1). Intensities of the high temperature component are also well explained if they are carried by chondrules since our earlier studies showed that chondrules are weakly magnetized.

The dark rim surrounding the inclusion does not have the same high temperature component as that of the inclusion. This strongly suggests that the rim is probably not part of the inclusion, but probably represents altered matrix, which does not contain chondrules.

A detailed study of individual chondrules in the present sample will be done in the near future. The present results confirm our previous interpretation that the previous magnetic fields existed (a) during the formation of chondrules, (b) during the formation of the inclusion, and (c) during the thermochemical event which remagnetized the whole sample, but the mechanical deformation which formed faults in Allende did not cause remagnetization.

REFERENCES

(1) N. Sugiura et al. (1979) Phys. Earth Planet. Interi. 20, 342-349.