REMANENT MAGNETISM OF HED METEORITES - IMPLICATIONS FOR THEIR EVOLUTION AND ANCIENT MAGNETIC FIELDS: D.W.Collinson and S.J.Morden, Department of Physics, The University, Newcastle upon Tyne, England.

The magnetic properties of extraterrestrial materials, in particular natural remanent magnetization (NRM), is a potentially useful study for detecting ancient Solar System magnetic fields and for elucidating meteorite evolutionary processes. Results reported here are for howardites Kapoeta, Petersburg, Le Teilleul and EET 87503, eucrites Sioux County and Millbillillie, and diogenites Shalka and Johnstown. Significant features of their magnetism are within-sample inhomogeneity of NRM directions in several of the meteorites and within-sample uniformity of axes of anisotropy of magnetic susceptibility. Both these phenomena bear on the meteorites' evolution and the timing of the magnetization process.

The carrier of the magnetic properties in these achondrites is mainly low-nickel kamacite. Intensity of magnetization, as received, is mainly in the range (1 - 70) x $10^{-6}Am^2kg^{-1}$, with Petersburg, which contains considerably more kamacite than the others, around $10^{-3}Am^2kg^{-1}$.

The character of the NRM is investigated by alternating field demagnetization, to test for primary and secondary components, and by breaking samples into mutually oriented fragments (typically 1 g mass) and comparing directions of NRM in these fragments. A range of behaviour is observed when these techniques are applied. Petersburg, Kapoeta, Sioux County and Johnstown show scattered within-sample NRM, together with highly irregular behaviour on demagnetization. Erratic changes occur in both direction and intensity of NRM, with no clear evidence of secondary magnetization components: however, during the demagnetization process a component of stable NRM does persist in all these meteorites.

Shalka and EET 87503 show approximately homogeneous, initial within-sample NRM, which persists during demagnetization in Shalka. In EET 87503, homogeneity is lost on demagnetization, and relatively well-defined but scattered primary NRM directions are revealed in different fragments.

More conventional demagnetization behaviour is shown by Le Teilleul and Millbillillie. Although there is within-sample scatter of NRM directions in Le Teilleul, the intensity decays smoothly on demagnetization, and the NRM is stable in different fragments. Millbillillie differs from the other achondrites studied in that there is uniformity of primary NRM direction throughout the sample with smooth intensity decay curves.

Thus, a range of NRM properties and demagnetization behaviour is observed in these achondrites. The significance of the scattered within-sample NRM is that the constituent fragments must have acquired their magnetization before their final accumulation into the meteorite material, and that there were no subsequent magnetizing events. Such an event, e.g. heating above $\sim 70°C$ and cooling, would remagnetize the meteorite uniformly if a magnetic field was present, or demagnetize it in the absence of a field. The event resulting in the formation of the meteorite as now seen clearly did not remagnetize the fragments.

With two exceptions, a magnetic property common to these meteorites is within-sample uniformity of anisotropy of magnetic susceptibility. This reflects a common fabric in the samples caused by the shape of magnetic particles, and foliation (disc-like shape) is commonly observed. This fabric appears to have been imparted to the meteorites through shock at the time of final accumulation, or during a subsequent shock event. The

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exceptions are Millbillillie and Johnstown, in which the anisotropy axes are randomly directed among different fragments.

The evidence from these magnetic properties of HEDs is generally of a magnetizing event on the parent body prior to break-up and re-accumulation of meteorite material. The latter event did not substantially alter the NRM of the accumulating fragments, nor was there subsequent remagnetization. The most likely origin of the NRM is a thermoremanence, acquired when the material was heated on the parent body to > ∿ 800°C and cooled in the presence of a magnetic field. It is this magnetization which is now seen in the separated meteorite fragments. Millbillillie and Le Teilleul appear to have had a somewhat different history. Their uniform NRM indicates that it was acquired either during or after final accumulation, possibly during the shock event which broke them off the parent bodies.

Whether the magnetic field which imparted NRM to the HEDs was of internal or external origin cannot be definitely determined, but a parent body field of internal origin is not ruled out. The ability of asteroidal sized bodies to support core dynamo-generated magnetic fields is uncertain, but accumulating evidence from lunar magnetism (1) and other meteorite studies (2) now points to the existence of such fields. Because of NRM inhomogeneity, only in Millbillillie and Le Teilleul can any estimate of magnetizing field strength (palaeointensity) be made. Two independent methods applied to Millbillillie are in good agreement, giving a mean value in the range 20 - 30 μT (3), similar to other achondrite estimates (2). In view of the widespread occurrence of NRM inhomogeneity in meteorites (4)(5), a check on this phenomenon should be an essential preliminary to palaeointensity determinations.

Current research in progress includes investigation of irregular demagnetization behaviour, which prevents important evidence of different NRM components from being obtained. If present, these components would point towards other magnetizing events and thus other meteorite evolutionary events. A parallel study of remanent magnetism is being carried out on a range of lunar breccias, to investigate whether their similarity to HEDs extends to their magnetic properties. Preliminary results suggest that the breccias so far investigated were magnetized at the time of their formation.

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