MAGNETIC RECORD IN PRIMITIVE MATERIALS. P. Wasilewski and J. Nuth, Astrochemistry Branch, Code 691, NASA, Goddard Space Flight Center, Greenbelt, Md. 20771

An important, yet almost unexploited, data set which could play a key role in understanding the interactions between the early sun and the nebular disk is the magnetic record in chondritic meteorites. Two impediments exist to the utilization of this data set. The first is a lack of understanding of the full range of processes which may have affected the magnetic information contained within the components of the meteorite from the time at which the information was recorded to present day laboratory measurments. The second is a lack of understanding of the basic magnetic properties of the Fe-Ni system and other magnetic phases in chondrites, which is the primary medium in which meteorite magnetism is observed. Almost nothing is known about the magnetic recording characteristics of FeNi alloys.

Shown in Table 1 (modified from Dodd, 1983) is a possible scenario for magnetic recording during the history of chondritic material. There are two specific ways in which the magnetic record might be utilized: The first is the vector record per se and' second the information regarding the intensity of the field which was present when the magnetic components in the meteorite were magnetized. The vector record must contain a wealth of information about the magnetic recording during the temperature-time history of the meteorite components and the process dependent aspects of meteorite history in the presence or absence of a magnetic field intrinsic to a meteortie parent body, external to the body, or a residual record. Each of the component parts, i.e. matrix, metal, inclusions, chondrule, for example, does contain an NRM record (a vector record). The paleofield record from a bulk meteorite should be accepted with caution. In almost no paleofield studies has the makeup of the NRM record for the chondrite been evaluated thoroughly. Further it is not all all clear if it is valid to apply a paleofield technique developed for earth rocks to the meteorites without serious calibration and modifications and this has not been done.

A critical review of the available literature dealing with meteorite magnetism reveals important preliminary conclusions:

- o Directional inhomogeneity of NRM in the matrix of some chondrites
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- o Directional inhomogenity of NRM between matrix and chondrules
- o Paleofields covering a wide range of values
- o Indication of NRM directional stability associated with specific mineralogies
- o Indications of overprints during specific processes which are not clearly identified
- o Almost no information about magnetization, recording mechanisms or behavior of FeNi recorders related to shape effects,magnetic interactions, atomic ordering, etc.
- o The importance of tetrataenite in essentially all chondritic meteorites
- o Importance of magnetic petrology, i.e. relationship between magnetic record and the microstructure which reflects the thermophysical history.

This record clearly identifies the NRM in meteorites to be of extraterrestrial origin; the effects of entry into the earth's atmosphere (fusion crust) and contamination by man are easily accounted for. Careful attention to the meteorite literature, particularly the FeNi phase diagram studies by Goldstein and Colleagues enables a reasonably coherent evaluation of magnetic phase relations consequent to slow cooling of the meteorites. A review of shock effects studies, and remanence acquisition studies (for which almost no information exists) and attention to the literature relevant to processes which might alter the meteorite magnetic record suggests all of the research should be viewed as preliminary, including the paleofield estimates. One cannot directly apply the principles and techniques of terestrial paleomagnetism and rock magnetism to extraterrestrial materials. (There is no rock magnetism framework for the FeNi alloys and for paleointensity studies the principles are applicable although the basis for the record is vague at present).

In meteoritic magnetic material the following details must be considered.

- o metal shape anisotropy
- o anisotropy due to taenite lamellae and rims
- o magnetic interactions
- o atomic ordering
- o shock induced 1st and 2nd order magnetic transitions and induced anisotropy
- o chemical gradients in the M/shaped profile wherein the magnetically hardest components reside
- o development of magnetite from 'gels' or 'solutions'
- o recovery and recrystallization in deformed kamacite

The microstrutural consequence of most of the above aré readily identified via microscopic analysis of polished and nital etched sections.

This presentation will consider the magnetic recording scenario for chondrite meteorites and the state of our knowledge of the magnetic materials embodied in this scenario. A critical review of the current state of meteorite research will then be followed by a brief statement about where we are and what we must do to ensure a credible meteorite magnetism research program.

TABLE 1:MAGNETIC RECORDING DURING THE HISTORY OF CHONDRITE MATERIAL

Nucleosynthesis	t>5BY	o No magnetic record
Circumstellar Processes	t>5BY	o Possible record in metal during metal/silicate fractionation
Interstellar Processes	t>5BY	o Possible record in metal or metalsulfides formed during various thermal and shock processes
Condensation/Metamorphism	t~4.6BY	o Possible record in metal associated with metal/silicate fractionation in recondensed grains
Particle Agglomeration	10-100 my duration	o Magnetic recording in pre-existing metal grains
Chondrule Formation		o Chondrule magnetic recording during cooling and in metal nuggets lost during the formation process
Accretion		o Numerous scenarios associated with assembly and different processes during consolidation
Static Metamorphism		o Presence of thermal threshold modifications
Impact Reworking		o Magnetic modifications dependent on shock level and associated thermal effects
Ejection from Parent Body		o Parent Body impact event
Earth Impact		o Fussion crust...
Recovery		o Possible contamination...
Laboratory Study		