**EVIDENCE FOR INTERNALLY GENERATED MAGNETIC FIELDS ON THE CV CHONDRITE PARENT PLANETESIMAL.** B. P. Weiss[1], L. Carporzen[1], L. T. Elkins-Tanton[1], and D. S. Ebel[2], [1]Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, 54-814, 77 Massachusetts Avenue, Cambridge, MA 02139, USA, [2]Department of Earth Planetary Sciences, American Museum of Natural History, Central Park West at 79th St., New York, NY 10024, USA.

**Introduction:** The aggregational texture and bulk chemical composition of chondrites demonstrate that they are not the products of planetary melting processes. As a result, chondrites have traditionally been thought to samples bodies that have not undergone large-scale differentiation [1]. However, it has long been known that CV and other carbonaceous chondrites carry a stable natural remanent magnetization [2-4]. The origin of this magnetization has been a long-standing mystery because it was in many cases acquired following accretion of the parent body [4, 5]. The spinning, orbiting body would have been unlikely to record the spatially and temporally variable magnetic fields associated with the T Tauri sun and the protoplanetary disk [6]. On the other hand, the possibility of an internally generated dynamo field [5] has been discounted due to the assumption that chondrites are samples of undifferentiated bodies [6]. We have conducted a paleomagnetic study on the Allende CV3 carbonaceous chondrite. Our goal is to determine the nature and acquisition time for the magnetization in Allende in order to distinguish between core dynamo and external field sources.

**Measurements:** We conducted alternating field and thermal demagnetization, rock magnetic, and paleointensity measurements on 51 mutually oriented subsamples of Allende sample AMNH 5056 (Fig. 1). Most of our subsamples contain a mixture of matrix, chondrules and/or refractory inclusions, although several consisted of nearly pure CAIs.

*Interior samples:* Samples from the interior (> 1 mm from fusion crust) have natural remanent magnetization (NRM) composed of at least two components: a low coercivity (LC) component up to ~10 mT and an extremely high coercivity (HC) component from ~10 to > 290 mT (Fig. 2). The HC magnetization is uniformly oriented throughout the meteorite's interior (Fig. 2). ARM and IRM paleointensities (following [7]) indicate that the paleointensity of the magnetizing field was of order 10 μT (for comparison, Earth's present surface field strength is ~50 μT). Similar results were obtained by [8, 9]. Our thermal demagnetization analyses demonstrate the presence of a stable magnetic component ranging from ~320-500°C and confirm results from previous investigators [6, 10] that most of the NRM is carried by pyrrhotite and other sulfides, with a small contribution from magnetite and possibly metal.

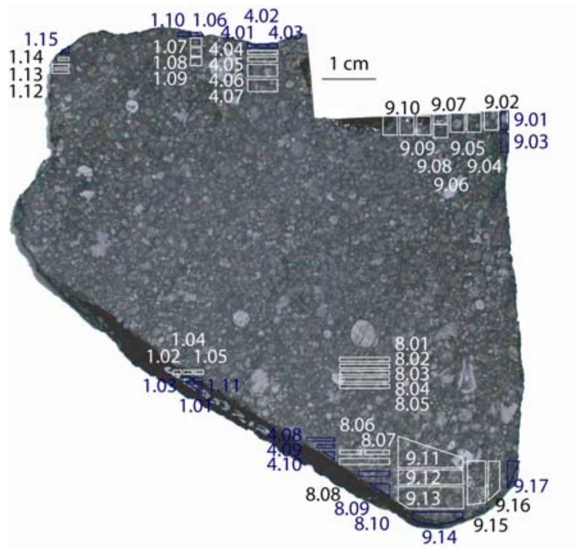


**Fig. 1.** Photograph of Allende sample AMNH 5056 showing our sampling locations (polygons) and corresponding subsample numbers. Blue = 18 fusion-crusted subsamples, white = 33 interior subsamples. Samples are all mutually oriented.

*Baked contact test*: Samples containing fusion crust, which must have been partly remagnetized by the Earth's field during atmospheric passage, are magnetized in different directions from the interior to >95% confidence and indicate average paleointensities of ~45 μT (Fig. 3). This constitutes a baked contact test (similar to that of [4]), demonstrating that the interior magnetization is preterrestrial.

**Implications:** We have demonstrated that most of the HC magnetization in Allende is unidirectional throughout the meteorite. *This unidirectionality requires that the magnetization was acquired after accretion.* The reason for this is that the main magnetization carriers are secondary pyrrhotite and magnetite, and there is growing petrologic evidence that most of these alteration minerals originated on the parent body rather than in the nebula [11-13]. Furthemore, I/Xe chronometry [14-16] and a diversity of geothermometers demonstrate that postaccretional metasomatism of Allende reached peak temperatures of ~350-600ºC [11-12, 14, 17-18] that lasted for at least 10 million years (Ma) after the formation of the solar system. Therefore, the NRM in Allende is a thermoremanence or thermochemical remanence that is likely too young to have been produced by early external field sources like the T Tauri Sun or magnetorotational stabilities in the protoplanetary disk. Furthermore, the long (at least several Ma) duration of the metamorphic event also would have made it difficult for such fields to have magnetized the spinning, orbiting CV parent body. This timescale also precludes impact-generated fields (which last < 1 day even for the largest impactors [19]). Finally, the low ratio of NRM to saturation isothermal remanent magnetization precludes nebular lightning as a field source.

Hf/W chronometry indicates that metallic cores formed in planetesimals prior to the final assembly of chondrite parent bodies [20]. Recent paleomagnetic analyses of angrites [7] in context with thermal modeling of early planetesimals heated by $^{26}$Al decay [21] indicate that dynamos were likely generated in many planetesimal metallic cores lasting for ≥11 Ma after solar system formation. Because these bodies should have melted from the inside out, some may preserve an unmelted, relic chondritic surface [20-22] which could be magnetized during metasomatism in the presence of a core dynamo.

Probably the simplest interpretation of Allende's paleomagnetic record is that the CV parent planetesimal is in fact such a partially differentiated object. Allende paleointensities are consistent with theoretical expectations for dynamos on planetesimals with radii > 80 km [7]. The presence of basaltic clasts in Allende [23] and the discovery of several achondrites with oxygen isotopic composition in the CV field [24] are consistent with this hypothesis. We develop this further in an accompanying abstract [25].

**References:** [1] Trieloff M. et al. (2003) *Nature 422,* 502-506. [2] Stacey F. D. et al. (1961) *JGR 66*, 1523-1534. [3] Banerjee S. K. and Hargraves R. B. (1971) *EPSL 10*, 392-396. [4] Butler R. (1972) *EPSL 17,* 120-128. [5] Funaki M. (2005) *J. Magn. Soc. Jpn. 29*, 918-925. [6] Sugiura N. and Strangway D. W. (1988) in *Meteorites and the Early Solar System* (U. Arizona Press, Tucson) pp. 595-615. [7] Weiss B. P. et al. (2008) *Science 322*, 713-716. [8] Acton G. et al. (2007) *JGR 112*, B03S90. [9] Wasilewski P. (1981) *PEPI 26*, 134-148. [10] Wasilewski P. and Saralker C. (1981) *PLPSC 12*, 1217-1227. [11] Blum J. et al. (1989) *GCA 53*, 543-556. [12] Krot A. N. et al. (1995) *Meteoritics 30*, 748-775. [13] Krot A. N. et al. (1998) *Meteorit. Planet. Sci. 33*, 1065-1085. [14] Swindle T. D. (1998) *Meteorit. Planet. Sci. 33*, 1147-1155. [15] Pravdivtseva O. V. and Hohenberg C. (2001) *LPSC XXXII*, abstract 2176. [16] Pravdivtseva O. V. et al. (2003), *GCA 67*, 5011-5026. [17] Huss G. R. and Lewis R. S. (1994) *Meteoritics 29*, 811-829. [18] Weinbruch S. et al. (1994) *GCA 58*, 1019-1030. [19] Hood L. L. and Artemieva N. A. (2008) *Icarus 193*, 485-502. [20] Kleine T. et al. (2005) *GCA 69*, 5805-5818. [21] Hevey P. J. and Sanders I. S. (2006) *Meteorit. Planet. Sci.* 41, 95-106. [22] LaTourrette T. and Wasserburg G. J. (1998) *EPSL 158*, 91-108. [23] Kennedy A. K. and Hutcheon I. D. (1992) *Meteoritics 27*, 539-554. [24] Irving A. J. et al. (2009) *GCA*, submitted. [25] Elkins-Tanton L. T. and B. P. Weiss (2009) *LPSC XL*, submitted.

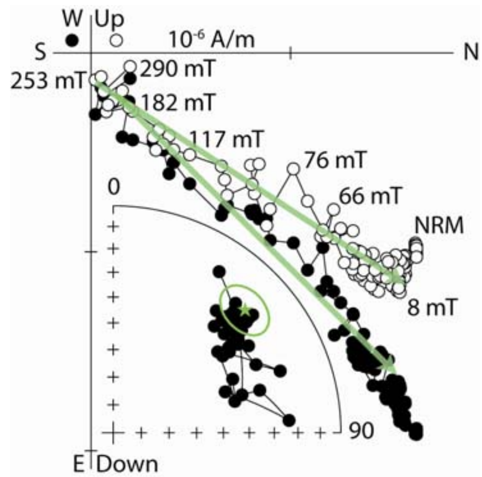


**Fig. 2.** Alternating field (AF) demagnetization of AMNH 5056 subsample 1.02 reveals mainly a single-high coercivity (from 10 to > 290 mT) component (green) of magnetization due to the high coercivity of pyrrhotite.

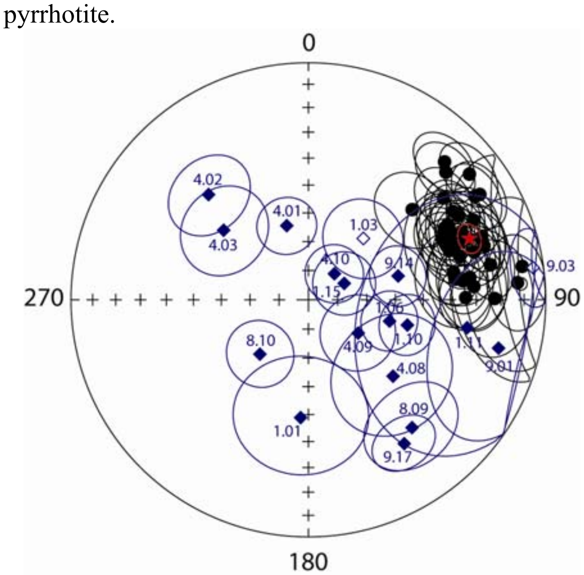


**Fig. 3.** Equal area plot showing directions of NRM in Allende sample AMNH 5056. Fusion crust samples (blue) have scattered NRM directions: they were magnetized while the meteorite was passing through Earth's atmosphere. Interior samples (black) have well clustered directions (mean values shown in red with 95% confidence interval) distinct from the fusion crust: their NRM is post-accretional and pre-terrestrial.