PALEOMAGNETIC INVESTIGATION OF THE OLDEST-KNOWN ANDESITE ERG CHECH 002

C. Maurel[1] (cmaurel@cerege.fr), J. Gattacceca[1] and J.-A. Barrat[2] – [1]CNRS, Aix Marseille Univ, IRD, INRAE, CEREGE, Aix-en-Provence, France; [2]Univ Brest, CNRS, IRD, Ifremer, LEMAR, F-29280 Plouzané, France

Introduction: Magnetic fields likely play a prominent role in the formation of the first planetesimals by enhancing momentum transport in protoplanetary disks [1]. Paleomagnetic studies of meteorites provide us with estimates of the field that existed in the solar nebula, at a given time and distance to the Sun [1]. Such data represent important constraints for models of disk evolution and planetary accretion. However, given the temporal field variations and spatial heterogeneities expected in protoplanetary disks, it can be challenging to reconcile existing models with the relatively sparse meteorite paleomagnetic record. It is therefore essential to increase the representativity of our database of nebula field intensities by studying more meteorites carrying a nebular record.

Erg Chech 002 is the oldest-known andesitic meteorite, which crystalized from its parent melt 1.80 ± 0.01 Ma after calcium-aluminum-rich inclusions (CAI) formation [2]. Erg Chech 002 cooled fast, at a rate of ~5 °C y^{-1} between 1000 and 1200 °C and > 350 °C y^{-1} below 900 °C [3]. This abrupt change in cooling rate is interpreted as the consequence of an excavation or ejection by impact a few decades after crystallization [3]. Here, we propose a first characterization of the magnetic properties and paleomagnetic record of Erg Chech 002. We aim at understanding whether Erg Chech 002 experienced a magnetic field upon cooling on its parent body, and determine the intensity of this paleofield. The fast cooling of this achondrite makes it an excellent candidate for paleomagnetic investigation for two reasons. First, it implies the meteorite may contain abundant submicron ferromagnetic grains, capable of preserving the record of a magnetic field over geological timescales. Second, such fast and early cooling could point to a record of the solar nebula field, which dissipated ~5 Ma after CAI formation [1].

Methods: We measured the natural remanent magnetization (NRM) of fourteen unoriented samples weighting between 0.2 and 6 g. Six were set aside due to unfortunate remagnetization by magnets. We are now conducting alternative-field (AF) demagnetizations of the NRM on each of the remaining samples, as well as further paleomagnetic analyses: AF demagnetization of anhysteretic remanent magnetization (ARM) and isothermal remanent magnetization (IRM), anisotropy of remanence and thermal demagnetization with controlled oxygen fugacity. We characterized the rock magnetic properties of multiple samples, including susceptibility and its anisotropy, hysteresis parameters, coercivity spectrum and FORC diagram. In addition, we analyzed the composition of metal grains using EPMA.

Preliminary results: *EPMA.* The metal grains analyzed in Erg Chech 002 are Fe-Ni kamacite with 100.11 ± 0.56 wt.% Fe and 0.040 ± 0.02 wt.% Ni (1 s.d., N=5). *Rock magnetism.* The coercivity spectrum indicates a single population of magnetic minerals, with mean coercivity of 30 mT, consistent with kamacite. The hysteresis parameters (M_{rs}/M_s=0.13; B_{cr}/B_c=1.95) and FORC diagram rule out multidomain grains as dominant magnetic carriers and rather point to grains in the magnetic vortex state. Kamacite grains in such domain state were found to be very stable magnetic recorders [4]. The saturation magnetization indicates a metal content of ~0.2 wt.%. Susceptibility ranges between 0.5 and 5.5×10^{-6} m^3 kg^{-1} (N=14) with an anisotropy degree between 2 and 9% (N=4). *Paleomagnetism.* The NRMs of the five samples we AF-demagnetized exhibit very similar behaviors: a low-coercivity component (< 10 mT; likely a viscous magnetization acquired on Earth) and a well-defined, origin-trending component isolated above 10 mT.

Discussion: The most likely scenario to account for this high-coercivity component is a thermoremanent magnetization acquired upon cooling below 770°C (Curie temperature of kamacite with < 3 wt.% Ni) in the presence of a magnetic field. Following [5] and [6], we estimate the intensity of this magnetic field was in the 15-30 µT range. Additional experiments will be conducted to confirm and refine this estimate. If Erg Chech 002 indeed experienced a 15-30-µT field upon cooling, the field must have been active ≲ 2.5 Ma after CAIs given the crystallization age and fast cooling of the meteorite. The two most plausible sources of the paleofield are a parent body dynamo and the solar nebula. However, models of planetesimal dynamo activity suggest that the earliest dynamos would have started ~5 Ma after CAI formation [7], ruling out this field source for Erg Chech 002's magnetic record. On the other hand, chondrules of the Semarkona LL chondrite (originating from the inner solar system like Erg Chech 002 [3]) hold the record of a 54 ± 21 µT solar nebula field acquired < 3 Ma after CAI formation [8]. Our preliminary results are consistent with these published data and strongly suggest Erg Chech 002 could carry a record of the solar nebula field.

Acknowledgment: We thank Jean Redelsperger for loaning us the samples. C. M. thanks the Marie Slokowska Curie Actions programme for funding.

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