Unusual Spectra of Magnetic Paleointensities of Two Breccia Samples from the Moon.

T. Kamenikova[1] and G. Kletetschka[1,2,3], [1]Charles University in Prague, Faculty of Science, Czech Republic. [2]Czech Academy of Sciences, Institute of Geology of the CAS, Prague, Czech Republic [3]University of Alaska-Fairbanks, Geophysical Institute, USA.

Introduction: Research made on Lunar dynamo in past was common, recently we are focusing on method measuring thermoremanent magnetization in samples which were collected by Apollo 15 mission, the samples are two 15405.219 and 15445.277 both are significantly smaller parts of boulders imported to Earth. Both are breccia samples. The 15445 involve clasts of shocked Norite and Troctolite, the 15405 is a part of KREEP basalt (K-potassium, REE Rare Earth Elements, P- phosphorus) rich for iron. [1]

Based on that compound was used method of Empirical scaling law (ESL) which is based on techniques using determination of the NRM/SR magnetic scanning. Scans are made for thin sections, every individual magnetic grain is scanned in situ, such ability creates potential to establish magnetic paleofield in situ for individual magnetic minerals within one thin section the asset of this method that only room temperature is needed. The ESL used for magnetic mineralogy allow to characterize paleofield for rock containing specific magnetic minerals, irrespective of the domain state. [2]

The ESL relation can be enumerated for most common magnetic minerals based on their intrinsic saturation magnetizations as follows:

$$B = B(max)\varepsilon(T_r) \qquad (1),$$

Where is a ratio between thermoremanent magnetization and saturation remanence? B(max) relates to saturation magnetization of specific minerals. Using saturation magnetization constants of 1.7 e6 A/m (Fe), 8.5 e5 A/m ($Fe_{93}Ni_7Co_{0.5}$), 4.8 e5 A/m (Fe_3O_4), 3.8 e5 A/m (γ-Fe_3O_4), 9.2 e4 A/m (F_7S_8), and 2.2 e3 A/m (α-Fe_2O_3) [2;3] B(max) enumerates maximum TRM that is possible to record by specific magnetic mineral.

Ratio $\varepsilon(T_r)$is obtained for specific range of AF (alternating field) demagnetization. We call this dependence as AF efficiency spectrum. Constraining the AF range allows extracting magnetic records from mineral carriers that have larger magnetic coercivity. Low coercivity grains are affected by low magnitude magnetic fields that could have been applied to these samples during their handling history, create magnetization overprint, and are not reliable for paleofield determination.

Method:

Both samples were fragmented, 15445 to 8 and 15405 to 17 subsamples. Each of them was measured separately on 2G cryogenic magnetometer (2G Enterprises, model 755R with noise level of 10^{-11} Am^2). We obtain AF natural remanent magnetization spectrum (AFNS). Samples are stepwise demagnetized in step of 1 mT till 50 mT and then in steps of 5 mT till 100 mT. Samples were than magnetized at room temperature in an arbitrary direction with pulsed magnetic field (2.5 T) using MMPM10 (Magnetic Measurements, UK). Then we obtain AF saturation remanent magnetization spectrum (AFSS). Samples are demagnetized with the 1 mT step till 50 mT and with 5 mT step till 100 mT (same as NRM demagnetization). Ratio of the two sequences (AFNS/AFSS) provides AF efficiency spectrum (AFES). This spectrum can be transferred into the paleointensity spectrum by using equation (1). Note that (1) is listed for one specific mineral. If there are two minerals responsible for magnetic signatures, this equation cannot be used for paleointensity estimate. Following these measurements magnetic thin sections of both samples were saturated by 3T magnetic pulse field along the long side of the thin sections and magnetically scanned for location of magnetic sources within the thin section. The resolution of this technique was about 0.2 mm. [4]

Results:

Sample 15405 was sub-divided into 17 subsamples, from which one sample contained randomized dust as a magnetic noise control, five samples did not reveal anything beyond magnetic noise, three indicated an induced terrestrial magnetization, and nine revealed a potential paleofield. Eight samples, including the thin section, indicated paleofield between (1-800 microtesla).

Sample 15445 was subdivided into 8 samples, from which one sample contained randomized dust as a magnetic noise control. Five samples, including the thin section did not reveal any magnetic signature beyond magnetic noise.

When the spectrum of efficiencies increases for all samples, this is an indication of magnetic noise. This is because the NRM spectrum of magnetic noise shows constant value of NRM during the AF demagnetization. The magnetic intensity fluctuates within a narrow range while magnetic directions changes randomly. On the other hand, the SIRM magnetization (always decreases with increasing AF field. When subtracting the NRM series of data (NRM demagnetization) with SIRM demagnetization series, we divide more less constant values with decreasing values with AF. Such subtraction results in increasing paleofield values within the larger AF values. We see these phenomena in all of subsamples of 15445 and interpret that this sample did not record any paleofield from the Moon. However, several subsamples of 15405 showed real record of paleomagnetic field. Unfortunately, we cannot estimate the paleointensities of these samples because we do not know how many magnetic carriers are responsible for magnetic signature.

For this we ran magnetic scans over the two thin sections. (Figure 1) Unfortunately, the NRM scan was two weak to get sufficient resolution of magnetic anomalies that were detected during the SIRM scan.

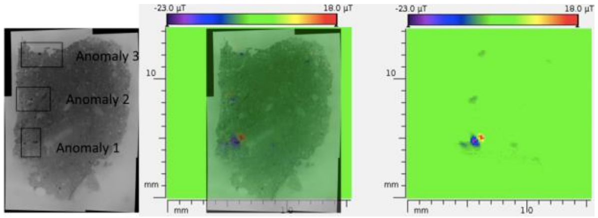

Figure 1: Magnetic scans of thin sections (15405) Left image is Scanning Electron Image, Right image is magnetic scan and middle image is overlapping of both types of data.

Acknowledgments: We thank Petr Pruner and Petr Schanbl for their help with magnetic laboratory in Průhonice._This work was supported by GACR 17-05935S, and grant RVO 67985831.

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