Magnetic Memory of two lunar samples, 15405 and 15445.

G. Kletetschka[1,2], T. Kamenikova[1], M. Fuller[3], and K. Cizkova [2] Charles University in Prague, Faculty of Science, Czech Republic. [2]Czech Academy of Sciences, Institute of Geology, Prague, Czech Republic kletetschka@gmail.com , [3] University of California, Santa Barbara, USA

Introduction: Lunar samples 15405.219 and 15445.277 collected by Apollo 15 mission are both breccia samples. Sample 15445 has shocked Norite and spinel Troctolite clasts. Norite is a mafic intrusive igneous rock composed from largely of calcium rich plagioclase orthopyroxene and olivine. Spinel Troctolite is a mafic intrusive rock type and consists of olivine and calcic plagioclase and pyroxene. Sample 15405 contains KREEP basalt (K-potassium, REE Rear Earth Elements, P- phosphorus.

Magnetic analyses on the lunar samples suggest the existence of an ancient lunar magnetic field. Magnetic carriers are mostly made out of iron. Due to empirical scaling law [1][2] minerals that have different saturation magnetization have different recording properties due to microcoercivities being affected by intrinsic demagnetizing field. This phenomena allows estimating a maximum recording capacity that specific mineral can hold. For example, magnetite can record maximum magnetic field of few mT. However, iron with larger demagnetizing intrinsic field can record maximum magnetic field up to ten mT. For example Mare basalt (10058) suggests paleo field on the order of 10-100 microteslas and high magnetic stability [3]. About 40 % of Lunar breccia magnetically measured indicate the past magnetic field of similar intensity (70019, 72275, 77135, 77017, 78155, 60015, 15415). However there were few with more intense paleo field detection getting closer to 1 mT (62235, 65095).

Results: Sample 15405 was fragmented into ~17 sub specimens and one thin section. One sample contained dust, five samples showed magnetic noise, three showed induced terrestrial magnetization, and nine showed potential paleofield. Eight samples, including a thin section, indicated a field between (10-100 microtesla). One subsample suggests field approaching 1 mT. Sample 15445 yielded 8 sub-samples and they with the thin section were investigated magnetically. One sample contained dust as a control for magnetic noise. Five samples, including the thin section contained only magnetic noise. Two samples with the largest masses provided the maximum limit from IRMs normalization of 80 microtesla along with a viscous component.

We performed magnetic scans of two thin sections (15405 and 15445) to obtained information of the magnetic sources residing under the magnetic anomalies [4]. Additionally we estimated *in situ* magnetic coercivities of magnetic sources [5]. This parameter can constrain the magnetic forces required to magnetically move rock around using magnetic crane when terraforming Moon's surface.

Sample 15445 is magnetically soft and reversed its magnetization in about 15 mT. However, sample 15405 was magnetically much harder requiring magnetic field totaling of 75 mT to reverse its magnetic moment.

Scanning Electron Microscope. 15445 indicated that magnetic signal is contained within the iron nickel magnetic carriers. 15405 showed two types of magnetic carriers. One was containing coarse-grained iron as part of the coarse-grained breccia. Stable magnetic sources requiring 75 mT were made from fine-grained iron grains in submicron material contained within the breccia.

Discussion and conclusions:

Sample 15445 contained Fe-Ni as a magnetic carrier and showed no significant evidence of stable magnetic paleofield. Its magnetic sources have microcoercivites of remanence about 15 mT pointing towards 5 mT coercivities. Sample 15405 contained iron as a magnetic carrier in two magnetic types. One type was included in coarse-grained nature of the brecciated sample and had coercivities of remanence close to 12 mT (coercivity of 2.4 mT). A second carrier type contained very fine micron size dust-like material that became part of the sample during the brecciation. Molten bulk sample crystalized into a coarse-grained matrix while fine dust-like component was capable of recording reliable paleofield (~80 mT) at the time of solidifying this breccia.

Acknowlegments: We thank Petr Pruner and Petr Schanbl for their help with magnetic laboratory in Pruhonice. This work was supported by MEYS grant LK21303, and grants RVO 67985831 and RVO 67985939.

References:

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