

EXPERIMENTALLY INDUCED THERMAL FATIGUE ON LUNAR AND EUCRITE METEORITES – INFLUENCE OF THE MINERALOGY ON ROCK BREAKDOWN.

M. Patzek¹ and O. Rüsçh², ¹Institut für Planetologie, Westfälische Wilhelms Universität Münster, 48149 Münster, Germany. markus.patzek@uni-muenster.de

Introduction and experimental design: Regolith evolution on airless planetary surfaces needs to be understood at the spatial scale from meters to microns. Diurnal temperature variations due to insolation on airless planetary surfaces is a common feature of planetary systems that plays a role in regolith nature and evolution [e.g., 1-5]. We present a new laboratory experiment and the results obtained on the lunar anorthosite breccia Northwest Africa (NWA) 11273 and the eucrite Northwest Africa (NWA) 11050. The experiment is based on an evacuated cryostat cooled with liquid nitrogen and cartridge heater installed in the base of a cold finger. Sample cubes, previously investigated by scanning electron microscopy (SEM) to proof their low degree of terrestrial weathering with sizes of $\sim 10 \times 10 \times 10 \text{ mm}^3$ are placed on the copper cold finger. Temperatures are measured on different location and on a monitor sample 10 mm wide (El Hammami, H5). The samples are cycled from 200 K to 375 K and investigated via SEM after 0, 10, 20, 50, 100, and 400 cycles, respectively.

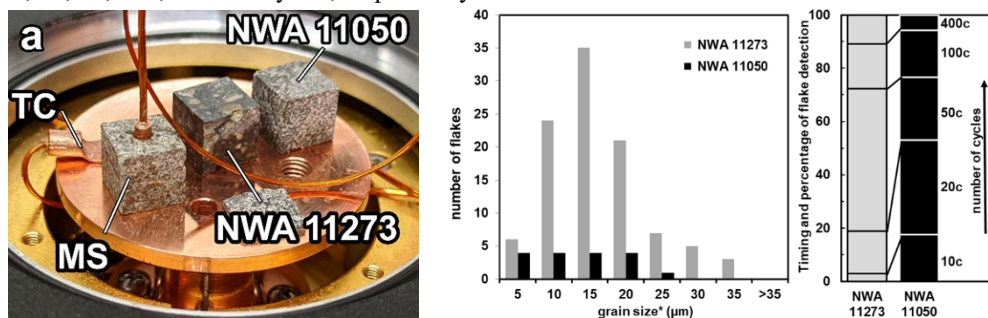


Fig. 1: (a) Photograph of the monitor sample (MS) and the NWA-samples on the coldfinger with attached thermocouple (TC). (b) Histogram of micro-flake grain sizes and their time of occurrence.

NWA 11273: Micro-flaking: The lunar anorthosite breccia NWA 11273 revealed 101 flakes with lengths ranging from ~ 6 to $\sim 46 \mu\text{m}$. Flake occurrence is not limited to a specific silicate mineralogy within the sample, i.e., appears on glass fragments, in matrix areas as well as on anorthite and olivine grains. **Cracking:** A total of 27 crack formations and/or extensions could be detected after 400 cycles on NWA 11273. Most of these cracks (24 out of 27) create micro-flakes and lead to their detachment.

NWA 11050: Micro-flaking: 17 micro-flaking grains were determined after a total of 400 cycles. **Cracking:** 41 cracks on NWA 11050 were detected on the samples with lengths ranging from ~ 5 to $\sim 636 \mu\text{m}$. A majority of the cracks is forming along grain-grain boundaries or in brecciated, fine-grained, areas between different lithologies, and mineral fragments, i.e. between anorthite and pyroxene ($\sim 60\%$), in polycrystalline anorthite-dominated areas ($\sim 15\%$), and brecciated fine-grained cataclystic areas (20%). Only $<5\%$ of the cracks develop in pyroxene grains.

Implications: We report for the first time the occurrence of micro-flaking due to thermal stresses. Micro-flaking on the surface of the lunar anorthosite is $\sim 5\times$ more abundant, when compared to that of the eucrite sample, very likely due to strong mineralogical difference between the two samples. The observed micro-flaking on NWA 11273 is acting on the average grain size fraction, observed for Apollo 16 soils [e.g., 6]. Assuming constant micro-flaking rates over long period of times, the abrasion rate can be estimated to be $\sim 0.02 \text{ mm/Myr}$ for rock surface on the Moon of the same composition as NWA 11273, which is an order of magnitude lower than the average value of abrasion associated to micrometeoroid bombardment [7].

The crack growth rate for the eucrite sample studied here is only $\sim 50\%$ of that for samples studied in [3]. We propose that surfaces exposing solid primary rocks (e.g., basalt such as eucrites) are less likely producing fine-grained soil by thermal fatigue but larger fragmented (blocky) regolith. Mature regolithic rocks with high abundance of (impact) glasses such as the lunar anorthosite breccias are contributing to a fine-grained, tenth-of- μm -sized, soil.

References: [1] Levi F.A. (1973) *Meteoritics* 8:209-221. [2] Molaro J. L. and Byrne S., (2012) *Journal of Geophysical Research* 117:E10. [3] Delbo M. et al. (2014) *Nature* 508:233-236. [4] Molaro J. L. et al. (2015) *Journal of Geophysical Research* 120:255-277. [5] Ravaji B. et al. (2019) *Journal of Geophysical Research* 124:3304-3328. [6] Warren, P. H., and Korotev, R. L. (2022) *Meteoritics & Planetary Science* 57:527-557. [7] Crozaz, G. et al. (1971) *LPS III* 2543 -2558.

Acknowledgments: The authors are supported by a Sofja Kovalevskaja Award Project of the Alexander von Humboldt Foundation.