ANALYSIS OF SURFACE ROUGHNESS VS WEH VALUES IN THE REGOLITH OF THE LUNAR SOUTH POLE AREA.

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Introduction: Polar regions of the Moon are known to be relatively abundant in hydrogen, which in general is naturally explained by cold-trapping and long-term preservation of water ice due to low surface temperatures, especially in the permanently shadowed regions (PSRs) [1]. Here we report on an attempt to find, whether the surface topographic roughness in the lunar South pole area correlates with values of water equivalent of hydrogen (WEH). The idea of this work is that the surface roughness of the considered scale is mostly determined by the presence of the decameter-sized impact craters formed and degraded essentially in the regolith layer. The modeling by [2] showed that cratering rate in polar areas of the Moon comparing to that in equatorial areas differ only by ~20%. The LEND data show that the water ice contents in the regolith of the considered area is ~0.1 to ~0.65 wt % [3] although LCROSS experiment showed that locally the ice content in the polar regolith may reach several percent [4]. Presence of ice in regolith should cement it, but the mechanical strength of thus cemented regolith is not known. It may be significant and influence the rates of crater formation and degradation or insignificant. In the former case surface roughness should correlate with the WEH values, in the latter case, not.

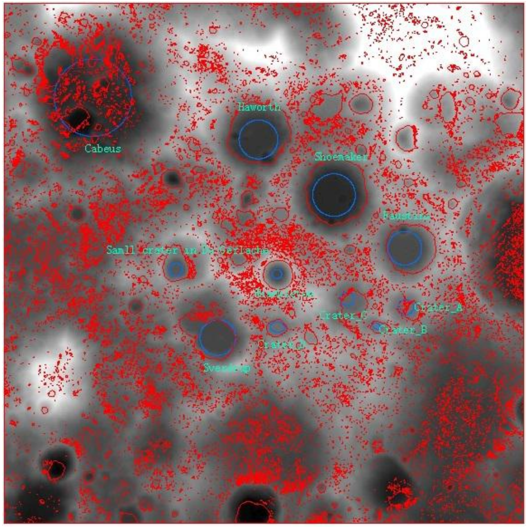

Fig. 1. Digital terrain model of the study area with the boundaries of the permanently shaded regions (red lines).

Data analysis: We use digital elevation model (Fig. 1) for the area south of 85 ° S with 10 m per pixel scaling calculated from the Lunar Orbital Laser Altimeter (LOLA) data [5]. We calculate topographic roughness as the interquartile range of Laplacian of the elevation. We used the minimum possible kernel to calculate Laplacian at the shortest possible 20 m (2 pixels) baseline. The interquartile range was calculated in circular sliding window 320 m in diameter. The WEH values (Fig. 3) are resulted from measurements by the Lunar Exploration Neutron Detector (LEND) onboard of the Lunar Reconnaissance Orbiter [6]. WEH map with resolution of 10 km/pixel are used in our study.

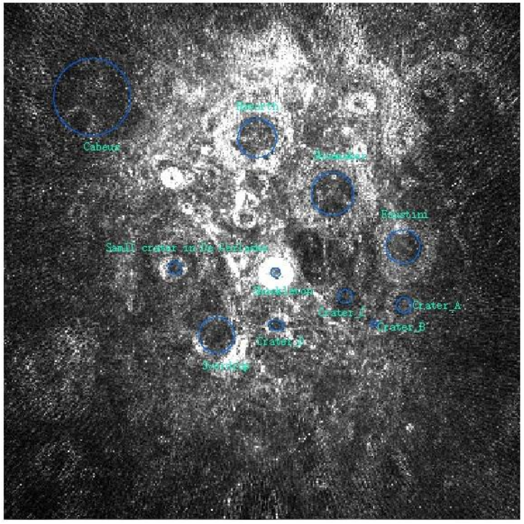

Fig. 2. Surface roughness map with studying crater floor outlined (blue lines).

As the first step of our analysis, we consider floors of 11 relatively large (D>16 km) and topographically prominent craters. For them average values of the surface roughness, WEH and the floor elevation were calculated and summarized in Table 1. Fig. 4 and 5 provide a possibility to consider presence or absence of correlations of the considered parameter.

At first glance, Fig.4 demonstrates the trend: the lower the crater floor, the higher is the WEH; Pearson correlation coefficient is -0.64. However, if we ignore craters Haworth and Shoemaker, the trend almost disappears (correlation coefficient is - 0.34).

It is seen from the Fig. 5 that no obvious correlation exists between the considered parameters (Pierson correlation coefficient is 0.15).

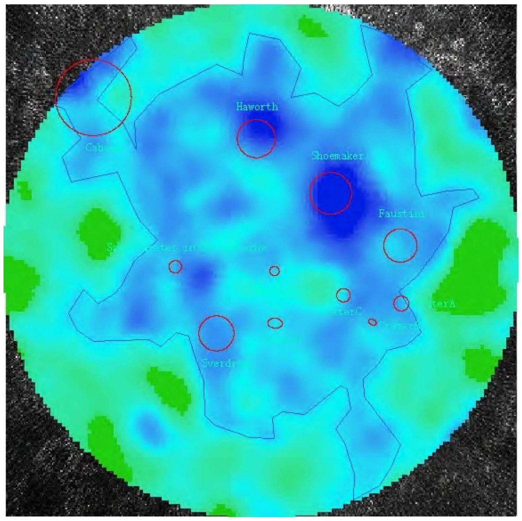

Fig. 3. Map of WEH values with studied crater floors outlined (red lines).

Table 1. Parameters of studied craters

Crater name	Average roughness in crater floor	Average WEH in crater floor (wt%)	Elevation of crater floor (m)	Diameter (km)
Haworth	0.4612	0.3598	-3411	51.4
Shoemaker	0.3290	0.4564	-3889	51.82
Faustini	0.3315	0.25	-2691	39.7
Sverdrup	0.3227	0.2829	-2838	32.7
Cabeus	0.2198	0.2512	-3818	92
Small crater in De Gerlache	0.2893	0.2633	-2280	17
Shackleton	0.6	0.2377	-2725	20.7
Crater_A	0.3042	0.2556	-1401	22.2
Crater_B	0.3514	0.2512	-1186	16
Crater_C	0.2492	0.2166	-1718	25
Crater_D	0.2737	0.2271	-1460	16

Discussion and Conclusions: The analysis of data presented in Table 1 and Figs 4 and 5 shows no obvious correlation between the content of water ice in polar regolith and the crater depths and surface roughness of their floors. All studied crater floors are inside the PSRs, so relatively high WEH values of them (>0.25 mass %) look as a reasonable effect of capture of water vapor in the cold traps. At lower elevations, the density of the putative exosphere is higher, which would increase the trapping rate and therefore the trapped water amount. However, the scale height of H_2O exosphere under typical polar (but not PSR) surface temperatures (~110 K) is ~30 km, much higher than the elevation difference between the craters. Therefore, the anticipated exosphere density differences are minor (a few per cents), and it is not clear, if they can account for the observed trend. The absence of obvious correlation between the surface roughness and WEH values shows that at the expected level of water ice content (0.20 – 0.46 wt%) its presence does not affect processes of formation and evolution of impact craters of decameter size. Observations and analysis of tracks of the meter-sized down-slope rolling boulders in the permanently shadowed areas of lunar poles showed that bearing capacity of the upper 1-2 m of regolith layer there is approximately the same as in the illuminated areas [7]. It is not clear, whether this minor ice amount can affect processes of formation and evolution of the decimeter-meter sized craters.

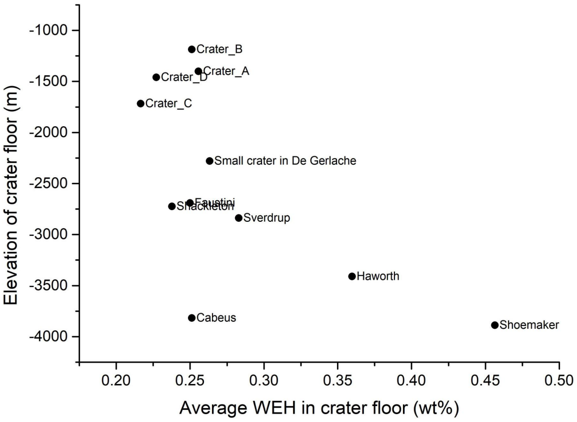

Fig. 4. Plot of average WEH values vs. average elevation of the crater floor.

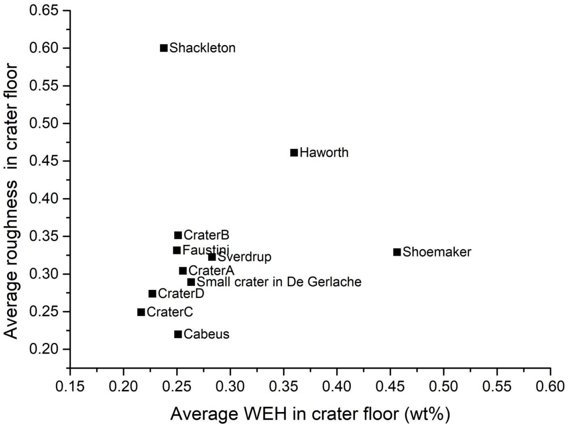

Fig. 5. Plot of average WEH values vs. average surface roughness of the crater floor.

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References: [1] K. Watson et al. (1961) *J. Geophys. Res.* 66 (9), 3033-3045. [2] Le Feuvre, M., Wieczorek, M.A. (2008) *Icarus*. V. 197, 291–306. [3] A.B Sanin et al. (2017) *Icarus* 283, 20-30 [4] A. Colaprete et al. (2010) *Science*, 330, 463. [5] Smith D. E. et al. (2010) *Space Sci. Rev.* 150, 209-241. [6] I.G. Mitrofanov et al. 2010a, *Space Sci. Rev.* 150, 183-207. [7] Sargeant H.M. et al (2020) *JGR Planets*, V. 125, e2019JE006157.