MORPHOMETRY OF THE COPERNICUS SECONDARY CRATERS AS AN INDICATION ON DEPENDENCE OF CRATER DEGRADATION RATE ON CRATER DIAMETER.

A.T. Basilevsky[1,2], N.A. Kozlova[2], I.Yu. Zavyalov[2], I.P. Karachevtseva[2] and M.A. Kreslavsky[3], [1]Vernadsky Institute, Kosygin Str. 19, 119991 Moscow, Russia, atbas@geokhi.ru, [2]Moscow State University of Geodesy and Cartography, 105064, Moscow, Russia, [4]Earth and Planetary Sciences, University of California—Santa Cruz, Santa Cruz, CA, 95064, USA.

Introduction: This paper is a continuation of our attempts to revise results of [1] on estimations of absolute ages of small (<1-2 km in diameter) lunar craters from the values of the crater diameter and the crater morphologic prominence. That work used qualitative morphologic analysis of several craters of known absolute age at the Apollo landing sites, and analysis of numerous intersections of craters of various sizes and morphologic prominence from other localities of the Moon. Ages of considered craters of the Apollo sites were deduced from the exposure ages of samples taken within the ejecta of these craters. In a recent work [2], we also considered craters of known absolute age, but instead of qualitative characteristics of crater morphologies we used the depth/diameter ratios and values of maximum inner slopes measured from the appropriate DTMs that are now available thanks to LROC NAC mapping of the Moon [3]. Here we continue this approach, studying morphometry of group of craters ~350 to 950 m in diameter (Figure 1), which are believed to be secondaries of the 93-km crater Copernicus [4]. Based on analysis of Apollo-12 sample 12033 [5] considered to be Copernicus ejecta material, the absolute age of this crater is ~800 Ma [e.g., 6]; therefore, all its secondaries are of this age. We study, how their relative depth *d*/*D* and maximum angle of inner slope depend on the crater diameter *D*.

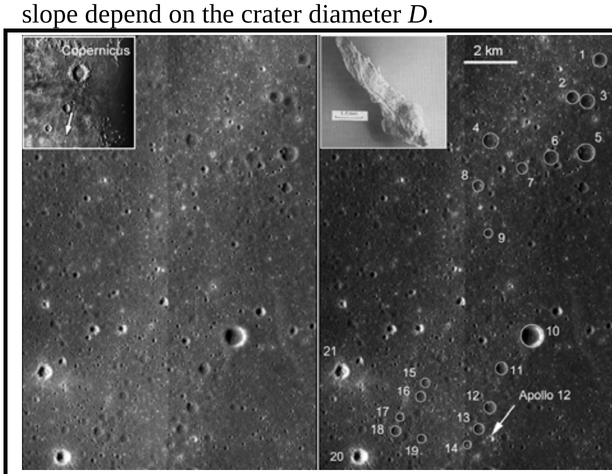

Figure 1. Left is mosaic of parts of LROC NAC images M104662862LC and RC, right – the same with studied craters outlined. Upper left insert shows location of this area. Upper right insert shows a 5 mm long piece of ropy glass, a part of sample 12033 [5].

Measurements: For our study, we selected 21 craters within the relatively light ray of Copernicus in the vicinity of Apollo 12 landing site (Figure 1). Our selection agrees with the results of regional studies [4]. Of course, some craters of this group may be misclassified, and we show below that characteristics of two craters (#20 and #21) indeed suggest that they are not Copernicus secondaries.

For measurements of relative depth and maximum angle of the crater inner slope we used the «Apollo 12 Landing Site DTM» with 2 m/pix sampling and, because it covered not all studied craters, we produced our DTM with 3 m/pix sampling based on available LROC NAC images. Using these DTMs we extracted 4 topographic profiles for each crater, corrected the profiles for local terrain tilt, and measure crater diameter *D*, relative depth *d*/*D*, and maximum slope (Figure 2).

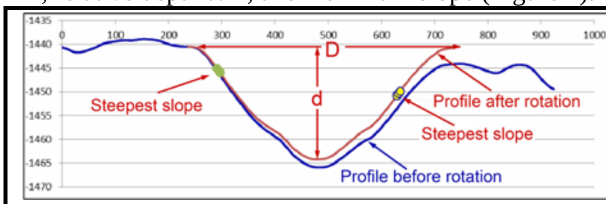

Figure 2. Scheme of rotation of the crater profile to correct its position for local tilt of the terrain.

Results: Figure 3 shows correlation of maximum angle of inner slope and relative depth of the studied craters. The correlation looks prominent, which is typical for small lunar craters [e.g., 7]. The deepest and most steep-sloped are craters #20 and #21.

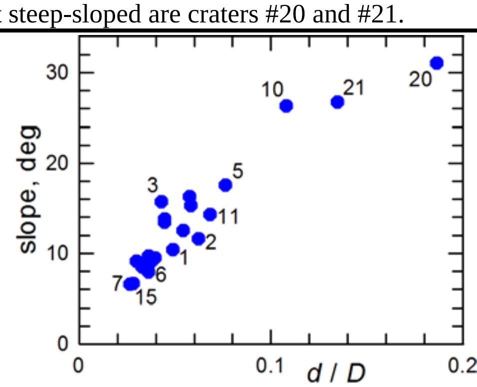

Figure 3. Maximum angle of the crater inner slope v.s. relative depth of the studied craters.

Below we consider plots of relative depth d/D and maximum angle of the crater inner slope of the studied craters v.s. crater diameters (Figures 4 and 5).

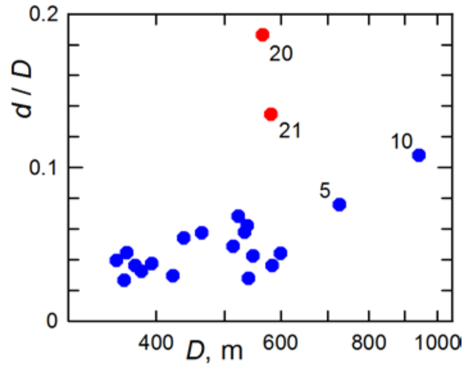

Figure 4. Relative depth of the studied craters v.s. crater diameters.

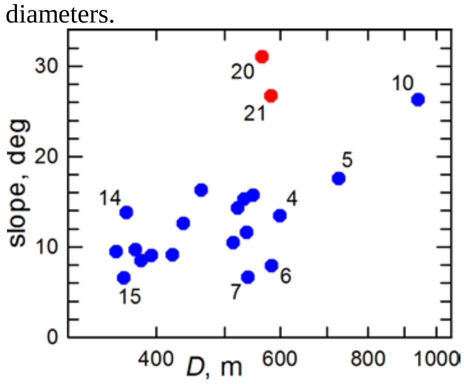

Figure 5. Maximum angle of the crater inner slope v.s. crater diameters.

It is seen in Figures 4 and 5 that symbols of majority of considered craters form elongated clusters demonstrating a dependence of crater relative depth and maximum angle of the inner slope on crater diameter. Symbols of craters #20 and #21 are obviously outside of this cluster and, if craters #1 to #19 are the Copernicus secondaries, craters #20 and #21 seem not to belong to this subpopulation.

These two craters look more morphologically prominent in Figure 1 and their freshness and obvious youth are demonstrated in Figure 6. It is seen that craters #10 and #5 representing the cluster-forming majority look subdued and have no boulders outside their rimcrests, while craters #20 and #21 look more sharp and prominent and have numerous associated boulders outside their rims. Crater #20 has 40-50 and crater #21 has 20-30 such boulders per 0.01 km^2. Comparing these observations with estimates of the boulder density in the ejecta of craters of known absolute age [8], we conclude that craters #10 and #5 are older than 300-400 Ma, crater #20 is 50-100 Ma old, and crater # 21 is 120-150 Ma old.

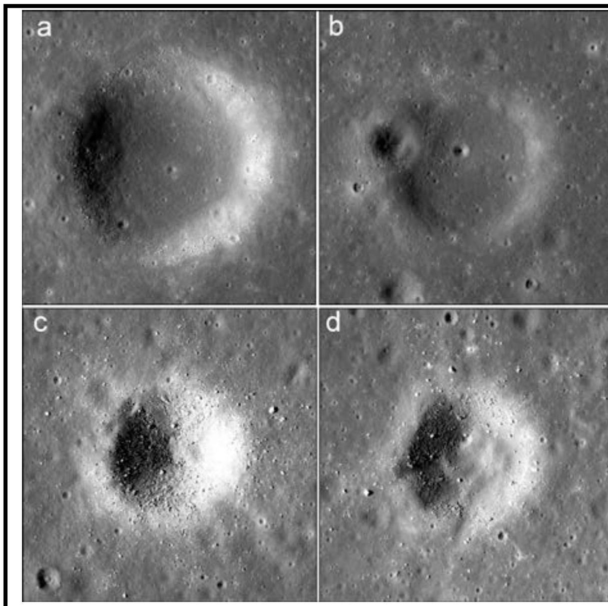

Figure 6. a) crater #10, *D*=940 m; b) crater #5, *D*=725 m; c) crater #20, *D*=565 m; d) crater #21, *D*=580 m.

Discussion and conclusions: It is seen in the above consideration that 19 craters (#1 through #19) probably are secondaries of crater Copernicus, therefore, they all are of the same age (~800 Ma). The prominent positive correlations of their relative depth and maximum angle of the crater inner slope on the crater diameter (Figures 4 and 5) suggest that the rate of morphologic evolution of small lunar craters from relatively deep and steep-sloped to shallow and subdued noticeably depends on the crater diameter. Larger craters evolve slower than the smaller ones. We do not know the initial relative depth and the steepest slope of the considered Copernicus secondaries, but if they were close to those of crater #20 (~0.15 and 30°), then comparing them with what is seen in Figures 4 and 5 (for craters with D = 1 km, 700, 500, and 350 m they are 0.11 and 25°, 0.08 and 20°, 0.05 and 15° and 0.03 and 10°), we can use these numbers for further analysis of dependence of the lunar crater evolution rate on crater size.

References: [1] Basilevsky A.T. (1976) *Proc. Lunar Sci. Conf. 7th*. 1005-1020. [2] Kozlova N. et al. (2015) *The 6th Moscow Solar System Symposium Abs.* 6MS3-MN-04. [3] Robinson M.S. et al. (2010) *Space Sci. Rev. 150*, 81–124. [4] Hiesinger H. et al. (2012) *JGR, 117*. E00H10. [5] Meyer C. (2011) Lunar sample 12033. *Lunar Sample Compendium*. [6] Eberhardt P. et al (1973) *The Moon, 8*, 104-114. [7] Basilevsky A.T. et al. (2014) *PSS, 92,* 77-87. [8] Basilevsky A.T. et al. (2015) *PSS, 117,* 312-328.