STUDY ON IMPACT CRATER DEGRADATION CHARACTERISTICS SINCE 3.85 GA ON THE MOON.

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Introduction: Impact craters are the most common geological structural units on the moon, and also an important basis for the study of lunar chronology. The chronology method based on crater morphology has been widely used [1-3]. The impact crater morphology will change due to later geological activities (such as later impact construction, volcanism, and mass wasting etc.) Figure 1 shows the morphological characteristics of impact craters in different diameter (~30km, ~45km, ~95km) and in different stratigraphic ages (Copernican, Eratosthenian, Upper Imbrian, Lower Imbrian). It can be seen that with the developing of time, the impact craters degradation mainly manifested in the impact crater rim, crater floor, crater wall, crater depth. Now many researchers have studied the degradation of impact craters, focusing on qualitative research and quantitative research. Based on the morphology characteristics of impact craters, the qualitative research is conducted by selecting different morphologic characteristics, such as crater ray, continuous ejecta, satellite crater, crater rim sharpness, crater wall morphology (terrace, smooth), impact crater edge polygonality, and crater rim texture to classify the impact craters and finally assign absolute age values [4-6]. Quantitative research is based on quantitative indicators of crater morphology, such as crater depth-diameter ratio [7-11]. Some researchers are also estimate the crater age through topographic diffusion and the crater erosion rate [12-14]. The study of the lunar chronology based only obtain the absolute age of impact craters, but also provide reference for the impact craters chronology of other planets.

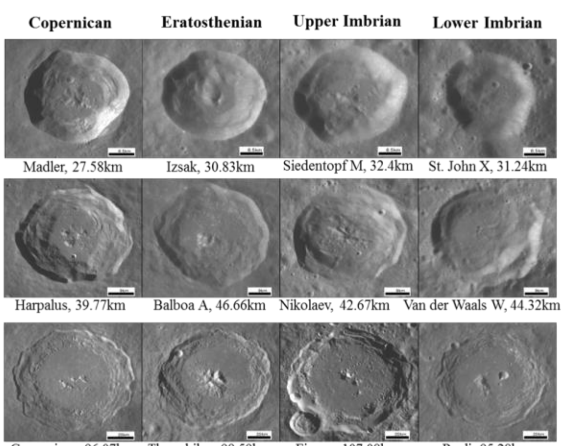

Figure. 1 Morphology characteristics of lunar impact craters at different stratigraphic age and diameter.

Data and Method: The lunar impact crater database released by Lunar and Planetary Institute in 2015 were used in this research [15]. In this study, the craters were assumed to be circular and basalt-filled craters were excluded. Based on the Lunar Reconnaissance Orbiter Camera (LROC) Wide Angle Camera (WAC), Digital Elevation Model (DEM), and slope image, 360 azimuth profile lines were extracted at 1° radial interval within the distance of 1.5r from each impact crater, and the mean radial azimuth average profile and error (1 standard deviation) were calculated in order to more accurately evaluate the characteristics of crater wall and reduce the influence of abnormal local changes,. Then, the impact crater radius, the maximum value of the crater wall and the crater floor radius were extracted respectively. By this method, crater wall width, crater wall slope and crater radius are calculated. 403 craters which in different era are chosen, within them 90 craters in Lower Imbrian(3.85Ga–3.8 Ga), 125 craters in Upper Imbrian(3.8Ga–3.16Ga), 119 craters in Eratosthenian (3.16Ga–0.8 Ga), and 69 craters in Copernican (0.8 Ga to present) [16].

Result and Discussion: In this study, the quantitative expression of crater degradation mainly focuses on two aspects: the relationship between crater radius and crater wall width (Figure. 2) and the relationship between crater radius and crater wall slope (Figure. 3).

Crater radius to crater wall width ratio: At the same size, the older the impact craters are, the smaller the crater wall width will be (Figure. 2). After the formation of the impact crater, due to the later impact disturbance, crater wall materials and rim materials will be collapsed into the interior of the impact crater [17]. and the craters will be filled by the later impact crater ejecta materials [18]. Combined with the above two factors, the impact crater floor will be uplifted, crater wall would be partially buried. So the net result is that the average wall width will decrease.

At the same age, as the diameter of the crater increases, the wall width of the crater increases. There is an exponential relationship between the crater wall width and crater radius as $w = ar^b$, in which, w is crater wall width, r is crater radius, a, b is constant. In the same age and with similar radius, the time of impact crater formation is different, so the difference of crater wall width can be compared with each other to obtain the sequential relationship.

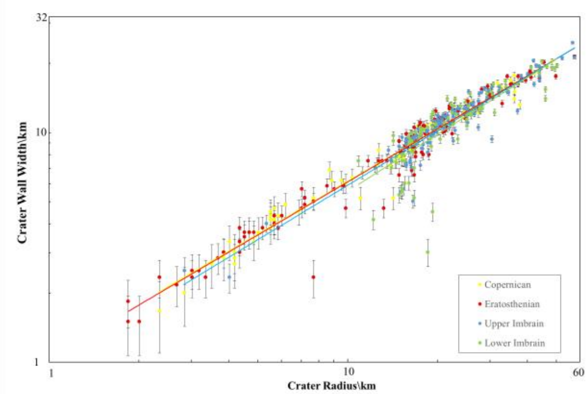

Figure. 2. The linear relationship of crater wall width(log) and crater radius(log). Different colored dot represent craters at different stratigraphic ages. The lines show best‐fit power law relationships for Copernican (yellow), Eratosthenian (red), Upper Imbrian (blue) and Lower Imbrian (green).

Crater radius to crater wall slope ratio: At the same crater radius, the older the craters are, the smaller the slope of the crater wall will be (Figure. 3). Due to the later crater ejecta material buried and weathering, the crater wall get smoother over time. And the difference of crater wall slope also can be compared with each other to obtain the sequential relationship [19].

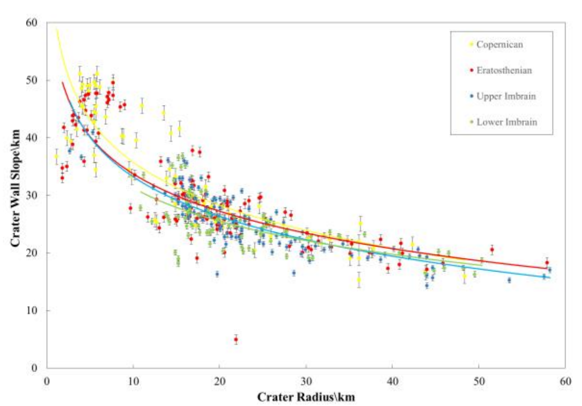

Figure. 3. The logarithmically relationship of crater wall width and crater radius. Dots and lines of different colors represent craters and power law relationships of different ages, respectively (Copernican (yellow), Eratosthenian (red), Upper Imbrian (blue) and Lower Imbrian (green)).

At the same age, the carter wall slope decreases logarithmically as the radius increases. They all fit the formula $s = a\ ln(r) + b$, in which, s is crater wall slope, r is crater radius, a, b is constant. Because with the increase of diameter, the more complex of the impact crater morphology, the crater floor will expand, and there are more landslide materials near concentric circles on the crater wall. This factors will cause the reduction of the crater wall slope.

Conclusion: After the Imbrian period, the impact crater morphology changes were mainly influenced by exogenic process, mainly impact (It mainly focuses on two aspects of crater wall material landslides and ejecta deposition), which would result in the change of the crater wall width and wall slope. In other words, the older the impact crater was, the smaller the two research indicators would be. At the same age, the crater wall width increases exponentially with the radius, and the crater wall slope decreases logarithmically with the radius. This provides an objective and useful method to study the degradation of impact craters.

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