**THE CHRONOLOGY OF PYTHAGORAS AND SHARP B CRATERS IN THE ADJACENT HIGHLANDS OF THE CHANG'E-5 LANDING SITE.** Xuting Hou[1],Xiaohui Fu[1], Chengxiang Yin[1], [1] Shandong Provincial Key Laboratory of Optical Astronomy and Solar-Terrestrial Environment, Institute of Space Sciences, Shandong University, Weihai, Shandong, 264209, China.(fuxh@sdu.edu.cn).

**Introduction:** The Chang'E-5 (CE-5) was successfully launched on November 23 2020. The spacecraft landed in the northeastern of Oceanus Procellarum (43.0576° N, 308.0839° E). The CE-5 is the first lunar sample mission in years after Apollo 17 and Luna 24. It has returned about 1731 g lunar regolith samples. The CE-5 mission will contribute more diverse lunar samples, which would complement the existing lunar samples collected by the Apollo and Luna missions. The CE-5 samples are of great significance to the interpretation of lunar geological history.

The CE-5 landing site is located in the young mare unit within the northeastern Oceanus Procellarum. The Oceanus Procellarum is the largest basalt-filled depression on the Moon. According to previous studies based on terrestrial observation and remote sensing data, mare volcanism within this region actived from 3.93 to 1.2 Ga[1]. The CE-5 landing site is located within young P58 unit (1.33Ga) [2], which is among the youngest mare units on the Moon.

The CE-5 landing site has been contaminated by ejecta from the adjacent highlands. The regolith developed on the mare plains of CE-5 site were mixed by the distantly sourced particles ejected from highland craters, such as the Pythagoras, Aristarchus, Copernicus, Sharp B, Harpalus, Robertson, Hausen, Philolaus and Carpenter[3]. These highland materials probably were collected by CE-5 mission.

Both the ages of mare basalt and highland eject fragments could be measured by laboratory radiometric dating in future study. These materials would also provide new calibration points for lunar crater chronology in this region. Among above craters, the absolute model ages (AMAs) of Pythogaras and Sharp B craters are poorly investigated (Figure 1). Here we performed crater size-frequency distributions (CSFD) for the two crater to determine their AMAs and N(1) values (i.e., the cumulative number of craters with diameters >1 km) using recent orbital data.

**Data and Methods:** Both Lunar Reconaissance Orbiter (LRO) Narrow Angle Camera (NAC) images and Kaguya Terrain Camera (TC) were used to identify small craters in this study. We used the CraterTools to determine the size of craters and perform crater counting. CraterTools is an extension of ArcGIS and can automatically adjust for map-projection distortions to prevent mismeasurement of crater diameters and count area [4]. The CSFDs were plotted using Craterstats[5]. The AMAs were obtained using a cumulative fit and the production and chronology function [6].

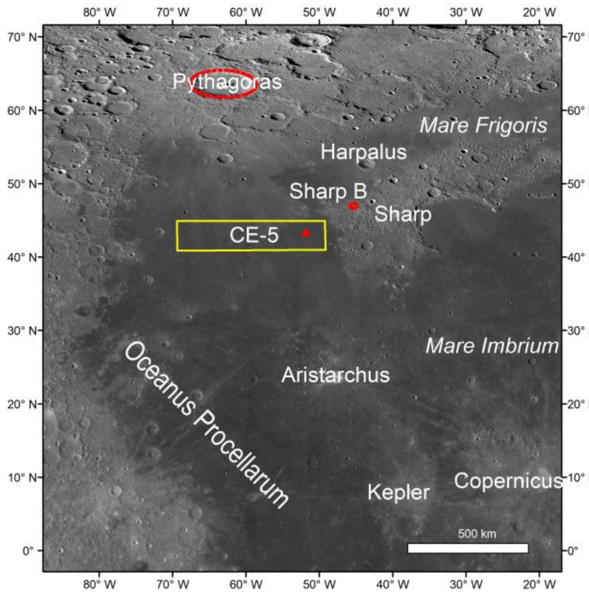


**Figure 1 Pythagoras crater and Sharp B crater (red dashed line). The yellow box represents the CE-5 candidate region (41-45° N, 49-69° W). The CE-5 landing site is shown as a red triangle.**

**Results:** The AMA of Pythagoras crater was measured on three representative areas of this crater: proximal ejecta blanket, crater floor and impact pools. We identified craters with diameters larger than 500 m on the southern ejecta blanket on Kaguya TC images. The crater diameters used range from 500 m to 3.8 km. The ejecta blanket area yields an N(1) value of $1.79\times10^{-3}$ and an AMA of 2.13±0.16 Ga (Figure 2). On the crater floor, we identified the craters larger than 250m in diameter. The absolute model age determined is 2.04±0.20 Ga and the N(1) is $1.71\times10^{-3}$. For the impact melt pools, we selected seven areas to count the craters with diameters over 200 m and derived AMA of 2.17±0.18 Ga (N(1) $=1.82\times10^{-3}$).

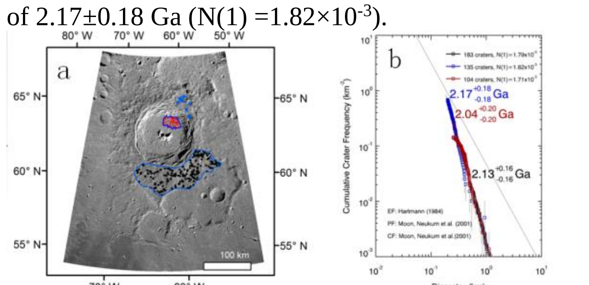


**Figure 2 Selected count area of Pythagoras and AMAs of different region a) crater count area were outlined in blue**

**line, b) AMAs for impact pools(blue), for floor of crater(red) and for ejecta blanket (Black).**

The ejecta blanket and crater floor of Sharp B were selected for performing crater count. The identified 110 craters on the ejecta blanket range from 200 m to 1 km in size (Figure 3). We measured CSFD for the ejecta blanket of Sharp B crater ($3.64\times10^{2}$ $km^{2}$), and obtained a value of N(1) = $1.0\times10^{-3}$ and an AMA of~1.20±0.11 Ga. On the floor of the Sharp B crater, we counted 70 craters larger than 50 meters in diameter (5.30 $km^{2}$). We derived an AMA of ~957±110 Ma and a N(1) of $8.02\times10^{-4}$.

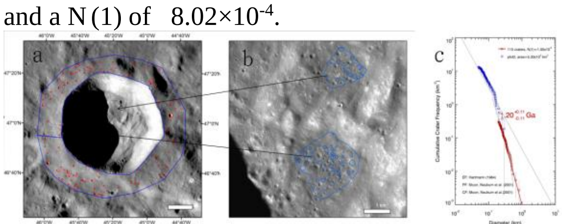


**Figure 3 CSFD measurement areas of Sharp B a) ejecta blanket of crater outlined with blue ring, b) the floor of crater was outlined with blue line. c) the CSFD of crater floor of Sharp B (blue) and ejecta blanket (Red)**

**Discussions:** The AMAs measured on the ejecta blankets, crater floor and impact pools of Pythagoras crater show slight differences among these each other (Figure 2b). These AMA values are within each other's error bars. The excellent agreements indicate that the Pythagoras crater has an AMA of ~2.1 Ga. The Pythagoras age obtained by this study is older than previous work (2.68 +0.28/-0.32Ga) in [3], in which the large western- and southern ejecta blanket was used. The age difference is probably due to several factors such as the counting area selection [7]. This present study minimized the possible effects of self secondary craters and subsequent secondary craters produced by the relative large craters in the counting area. For Sharp B crater, we prefer the AMA of 1.20±0.11 Ga measured on its ejecta blanket. Because the counting area on its crater floor is quite small (5.30 $km^{2}$), which may cause a large error.

The derived ages of the two crater may provide insight into the geological history and regional stratigraphic relationship of the CE-5 landing site. According to the geological mapping of the CE-5 site in [8], the ages of main Im2 and Em4 mare units in the northern Oceanus Procellarum are 3.39 Ga and 1.21 Ga, respectively. The Pythagoras impact event is clearly younger than the western Im2 unit but older than the eastern Em4 unit. This indicates that the ejecta of Pythagoras should overlie the Im2 unit but was covered by the young mare unit Em4 in the CE-5 landing site. Sharp B crater is slightly younger than the unit Em4, suggesting that the Sharp B ejecta should cover the whole young mare flows as well as the CE-5 landing site.

The ejected materials from Pythagoras and Sharp B craters likely collected by the CE-5 mission, which would fill in the gap (950 Ma-3.1Ga) of the current lunar chronology curve (Figure 3). This study would provide important data for subsequent construction of calibration points of lunar chronology curve.

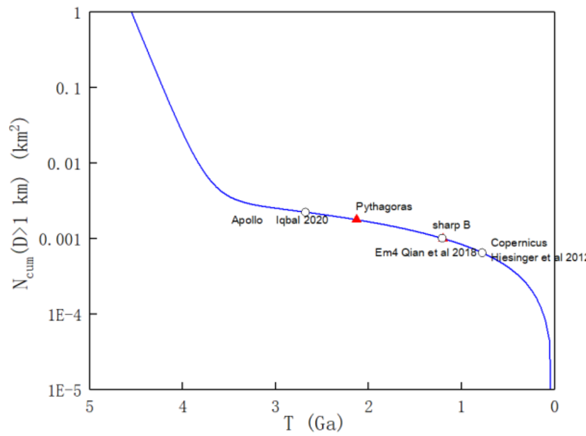


Figure 4 Lunar chronology curve and key calibration points [8,9,10].

References: [1] Giguere T.A., et al. (2020), 51st *LPSC, #2070*. [2] Hiesinger H., et al. (2003), *JGR, 108(E7)*. [3] Xie M., et al. (2020), *JGR, 125(5)*. [4] Kneissl T., et al. (2011), *PSS, 59(11)*, 1243-1254. [5] Michael G.G. and Neukum G. (2010), *EPSL, 294(3)*, 223-229. [6] Neukum G., et al. (2001), *Space Sci. Rev, 96*, 55–86. [7] Gou S., et al.(2021), *Icarus, 354*, 114046. [8] Qian Y. Q., et al.(2018), *JGR, 123(6)*, 1407-1430. [9] Iqbal W., et al. (2020), *Icarus, 352*, 113991. [10] Hiesinger H., et al.(2012), *JGR, 117*.