

## From Regolith to Shallow Structure of Chang'E-3 Landing Site

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### Abstract

In this paper, a complex calculation and preliminary analysis of geological characteristics of Chang'E-3 landing site, including the regolith thickness and the shallow structure of albedo boundary lying 10 km away from the Lander were provided, using the detective data both from Chang'E missions and other contemporary exploration projects.

### 1. Introduction

Chang'E-3 touched down on the east edge of Mare Imbrium beside a crater with a diameter of 430 m in the east part of Sinus Iridum. Coinciding with DEM and contour lines, its landing site is on the edge of a plateau in the mare, with the large-scale gradient of inclination being in the direction northeast-southwest. The landing site is located in the Eratoshenian basalt stratum and it has a low albedo, with a low density of craters. However, 10 km north of the landing site is a region of Mare Imbrium that has a high albedo and high crater density [1]. In order to get a thorough understanding of this area, we need to look from the surface to the interior structure.

### 2. Regolith thickness

Oberbeck and Quaide in 1967 have evaluated lunar regolith thickness from crater morphology. Based on four types of craters recognized from LO images, and lots of laboratory simulants, they got the relationship between regolith thickness and crater diameters, differing from  $D_A/3.8$  to  $D_A/10$ , depending on crater types. With these relationships, lunar mare regolith thicknesses were estimated, varying from 1-6m to 1-16m, and mare Iridum is with an average thickness of 8.5m[2]. Besides, Shoemaker [3] and Wilcox [4] developed another method with crater frequencies. In 2005, Wilcox draw the production curve and equilibrium curve of Oceanus Procellarum craters, and got the minimum thickness of 8m[4].

Chang'E-3 landing camera obtained thousands of high-resolution images, with which the small and fresh craters can be delicately recognized. After statistics of large amount craters (Figure 1, Table 1), the morphological method drew an estimated regolith thickness (Equation 1). Also, the crater distribution frequency curve tell an equilibrium diameter of about 60m, which means the maximum regolith thickness will not exceed  $(60 \times 0.2)$  m, and the mean value will be  $(60 \times 0.14)$  m [4].

$$D_F/D_A = k - (D_A/t)^{-1.2} \cot \alpha \quad (1)$$

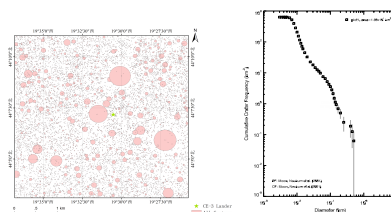


Figure 1: Crater distributions and frequency curve of landing site

Table 1: Part of fresh craters recognized from LRO\_NAC and CE3\_LCAM images (concentric and flat-bottomed)

Longitude	Latitude	Diameter (m)
-19.5044994	44.1133995	10.940
-19.5135994	44.1058998	10.114
-19.5179996	44.1016006	42.991
-19.5209999	44.1054001	19.398
-19.5151005	44.0905991	19.519
-19.5254002	44.1398010	39.887
-19.5743999	44.1408005	18.490
-19.5673008	44.1128006	19.517
-19.5028000	44.0840988	24.029
-19.5529003	44.0839996	29.106

### 3. Shallow structure of albedo boundary region

As mentioned above, an albedo boundary is located north of the landing site. It may be caused by differentiations of topography, minerals, and even the large-scale crust-mantle undulations. Figure 3 shows the DOM, DEM, free-air gravity, and mare thickness [5] of enlarged landing area, with the lines marked the albedo boundary. Figure 4 are profiles vertical to the boundaries on DEM and gravity maps.

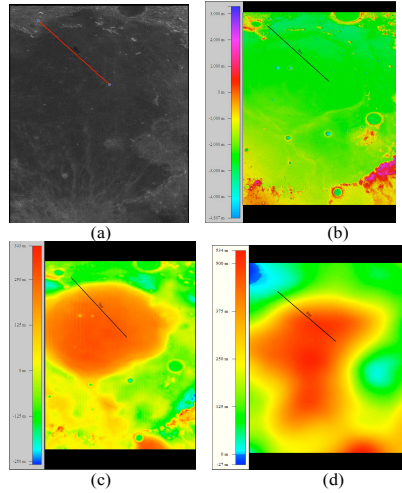


Figure 3: Boundaries in DOM (a), DEM (b), gravity (c) and mare thickness maps (d)

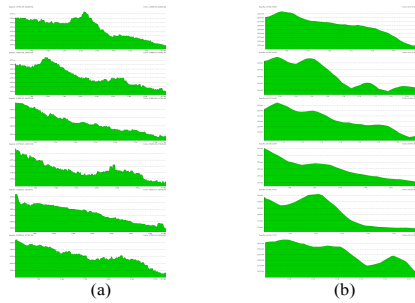


Figure 4: Profiles vertical to the boundaries on DEM (a) and free air gravity maps (b)

The topography and free air gravity show declining trend from southwest to northeast, with difference values of about 50-100m and 150mgal separately.

However, we can't find such a trend in crustal thickness by Mark Wieczorek [6]. This provides a hypothesis that the boundary is caused by lunar surface non-homogeneity such as thickness differences, instead of the large-scale undulations or mascons. Referring to Wang's inversion of mare thickness of Imbrium [5], the thickness near boundary varies from about 100mgal to 500mgal. With the six profiles vertical to boundary, we record the thickness differences of two-side values (Table 2). Under consideration of uniform mare density, the thickness on the southwest of boundary is tens of meters larger than the northeast, which may be covered by a newer magmatic eruption.

Table 2: Mare thickness differences of six profiles vertical to the boundary

Southwest thickness (m)	Northeast thickness (m)	Thickness difference (m)
490	430	60
400	330	70
470	410	60
500	450	50
505	485	20
509	495	14

### 4. Summary and Conclusions

With the latest data from Chang'E and LRO missions, the landing site regolith thicknesses were estimated with morphological and crater frequency techniques. The maximum and mean regolith thickness will not exceed 12m and 8.4m. The boundary was studied with multi-source data. We conclude that the boundary was caused by different magmatic eruptions, with the southwest thicker than the northeast, which formed this geological boundary.

### References

- [1] C. L., Li, et al. Analysis of the geomorphology surrounding the Chang'e-3 landing site, RAA, 2014
- [2] Oberbeck, et al. Estimated thickness of a fragmental surface layer of Oceanus Procellarum, JGR, 1967
- [3] E. M. Shoemaker, et al., Observations of the lunar regolith and the earth from the television camera on Surveyor 7, 1969
- [4] B. B. Wilcox, et al., Constraints on the depth and variability of the lunar regolith, Meteoritics & Planetary Science, 2005
- [5] W.R. Wang, Topography and Mare Thickness of Chang'E-3 Landing Area, AOGS, 2014
- [6] M.A.Wieczorek, et al. The crust of the Moon as seen by GRAIL, Science, 2012