THICKNESS OF MARE BASALTS AT THE LANDING SITE OF CHANG'E-3, THE NORTHERN MARE IMBRIUM L. Qiao[1], L. Xiao[1] and Z. Y. Xiao[1], [1] Planetary Science Institute, China University of Geosciences, Wuhan 430074, China. Email: le.qiao@cug.edu.cn.

Introduction: Accurately estimating thicknesses of lava flow units is essential to constrain the volume of extrusive volcanism on the Moon. Previous researchers had proposed several techniques, such as analyzing crater size-frequency distributions [1], crater excavation depths [2], and gravity data [3], to measure the thickness of mare basalts. However, these techniques usually cannot provide precise constraints on basalt thickness, and sometimes their results are ambiguous, especially for small regions of basalt units. Therefore, results derived from these methods would not be convincingly validated until in-suit measurements were performed.

In December 2013, the Chang'E-3 spacecraft, carrying the Yutu (Jade Rabbit) rover, successfully landed on the northern Mare Imbrium, the Moon. The rover carries a set of ground penetrating radars (GPRs) to detect the shallow subsurface information of the Moon [4]. The GPRs have two channels: Channel 1 operates at the VHF band, with ~140 m penetration depth and ~10 m thickness resolution, and Channel 2 operates at a UHF band, with ~30 m penetration depth and ~30 cm thickness resolution. Data obtained from the GPRs will provide an unprecedented opportunity to investigate the thickness of mare basalts at the landing site.

Geological Setting of the Chang'E-3 landing site: The Imbrium Basin is one of the largest multi-ring impact basin on the Moon. The basalt flows filled within the basin are differentiated for their unique compositional characteristics. Using the reverse-calculation method for TiO_2 content of lunar mare basalts advocated by [5], the basalt flows at the Chang'E-3 landing site has a TiO_2 content of ~6 wt. % (Fig. 1). Compared with the Apollo samples that are either high-titanium basalts (A11 and A17) or low-titanium basalts (A12 and A15), the mare basalts at the landing site of Chang'E-3 represent an type of unsampled lunar basalts. Moreover, these basalts are substantially richer in olivine compared with older basalts that were emplaced in the east nearside of the Moon [6]. Additionally, these basalt flows at the landing site are also distinguished for their anomalously high thorium (Th) element abundance [7].

The basalt flows of the Chang'E-3 landing site are also scientifically interesting for their unique stratigraphic features. The surface model age of these basalt flows derived from crater counts was estimated to be ~2.5 Ga [8], which is much smaller than that of the returned lunar basalt samples (most Apollo basalt samples are dated larger than 3.0 Ga). On the other hand, the mare surface to the north of the landing site was reported to have much lower titanium content but an larger model age from crater counts (estimated to be ~3.32 Ga by [8]). The boundary between these two mare basalt units is only ~10 km away from the landing site. The Chang'E-3 mission is expected to provide key constraints on regional geological evolution for this region.

Thickness of Basalt Flow Units at the Landing Site: Among the various techniques for determining lava flow thickness [1, 2, 3], the utilization of crater excavation depths provide the highest accuracy [2]. Thomson et al. [2] used this method to estimate the accumulated thickness of basalt flows in Mare Imbrium region, our test find that this method is also appropriate for individual lava flow unit. The basalt flows at the Chang'E-3 landing site (Em2 in [8]) have a higher content of titanium than the lower and older basalt layers (Im1 in 8). Some small craters postdating the younger and high-titanium basalt flows may have penetrated into the low-titanium basalt materials in the lower layer, thus depositing ejecta with lower-titanium compared with the outer region. Alternatively, some small craters may formed entirely within the high-titanium basalt layers, thus these craters do not exhibit ejecta of low-titanium. Therefore, judging by the relationship between crater excavation depths and diameters, we can constrain the maximum and minimum thicknesses of the high-titanium basalt flow units.

We investigated all small craters >300m in diameter around the Change'E-3 landing site and measured the rim-to-rim diameter of these craters. Excavation depths of simple craters are approximately 0.084 that of the crater rim-to-rim diameters [9]. We find two craters can provide usage constraints on the thickness of the younger basalt units. The first crater is centered at 44.20°N, 19.33°W, ~550 m in diameter (the excavation depth is ~46 m), and it has penetrated through the whole high-titanium lava layer. The second crater is located at 44.20°N, 19.64°W, ~490 m in diameter (the excavation depth is ~41 m), and it did not excavate low-titanium units. From the two craters, we believe that the thickness of the high-titanium lava unit is ~41–46 m thick. Our result is well consistent with precious results of both Schaber et al. [10] (30–35 m, range 10-63 m) and Hiesiger et al. [1] (32–50 m, +11/-5 m), while can provided the highest accuracy.

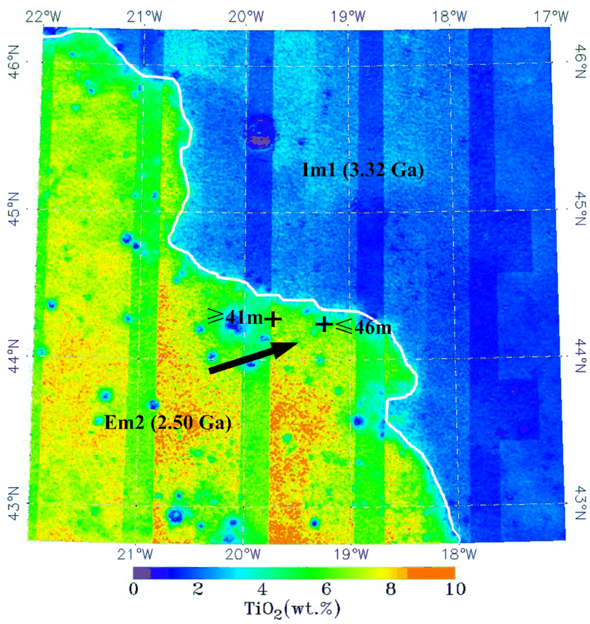

Fig. 1. TiO_2 content map of mare basalts at Chang'E-3 landing site. The black arrow indicates the landing site of Chang'E-3, the black crosses mark the two craters which provide useful constraints on the thickness of the high-titanium basalt flow unit. The TiO_2 content is calculated using the algorithm proposed by Ohtake et al. [5] based on the SELENE (Kaguya) Multiband Imager data. The map is in Lambert conformal projection centered at 44.5°N, 19.5°W.

Discussion: Since the formation of the younger basalt units at the landing site, the basalts flows have been exposed to space weathering and impact gardening, thus forming a layer of regolith of certain thickness [11]. The regolith thickness at the landing site was estimated to be 2–3 m [12]. Based on the thicknesses of the regolith layer and the high-titanium basalts, we can build a three-layer subsurface structure model of the landing site (Fig. 2), which would be verified by the ongoing detection of the GPRs carried by Yutu. The Channel 2 GPR should be able to detect the regolith layer with unprecedented accuracy. The Channel 1 GPR should be enough to penetrate the whole uppermost high-titanium basalt flow unit. These data will significantly promote our understanding of the geological history at the landing site.

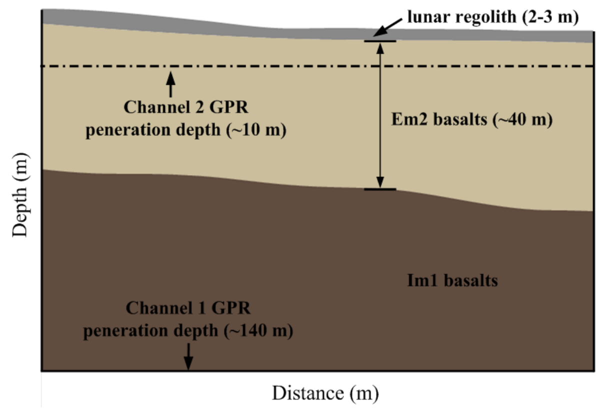

Fig. 2. A schematic diagram shows a three-layer subsurface structure model at the landing site.

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