THE MOON'S REGOLITH: STRATIGRAPHY AND EVOLUTION. Wenzhe Fa, Institute of Remote Sensing and Geographical Information System, Peking University, Beijing 100871, China (wzfa@pku.edu.cn).

Introduction: The primary product of the continuous impacts of large and small meteoroids on the lunar surface is a global fragmented layer, termed as the regolith [1]. Regolith stratigraphy preserves vital clues about the geology and impact history of the Moon, and is also critical for quantifying potential resources for future lunar exploration and engineering constraints for human outposts. Regolith thickness can be estimated from geophysical experiments at the lunar surface, morphology and size-frequency distributions of impact craters, and radar and microwave remote sensing techniques [2]. The first approach has been applied only to a few regions at the Apollo landing sites, whereas applications of the last two approaches are relatively limited due to lacking of high-resolution optical images and microwave remote sensing data.

Recently, with a renewed interest in lunar explorations, it is possible to estimate regolith thickness over large regions using newly acquired data sets based on old methods. Based on results from new data sets, regolith stratigraphy and evolution can be investigated.

New Regolith Thickness from New Data Sets:

Using brightness temperature data acquired from Chang'E-1 (CE-1) microwave radiometer and a three-layer thermal emission model, mean regolith thickness of the maria is estimated to be 4.5 m, and that of the highlands is 7.6 m (Fig. 1) [3]. The thinnest regolith layers occurs in Mare Imbrium (mean value 3.6 m), and the thickest regolith occurs over Mare Fecunditatis and Mare Nectaris (7.8 m and 7.7 m).

The inversion of regolith thickness over lunar nearside is studied using newly acquired Earth-based 70-cm Arecibo radar data and a quantitative radar scattering model [2]. With several assumptions on size and abundance of buried rocks and surface roughness, results show that regolith thickness is ~3.5 m over Oceanus Procellarum and ~5.1 m over Mare Crisium, and regolith thickness over the highlands is ~7–8 m.

Using Lunar Reconnaissance Orbiter Camera optical images, 378,556 small impact craters over Sinus Iridum region were counted and their morphologies were identified. Results show that median regolith thickness is 8.0 m, and that 50% of the region has a regolith thickness between 5.1 m and 10.7 m [4].

The lunar penetrating radar at the Chang'E-3 landing site reveals four stratigraphic zones from the surface to a depth of ~20 m: a surface regolith (<1 m), an ejecta layer (~2–6 m), a paleoregolith (~4–11 m), and the underlying mare basalts (Fig. 2) [5]. Thicknesses of the surface regolith and the paleoregolith are consistent with estimations based on crater morphology (Fig. 3). With model surface ages, mean regolith accumulation rate at the CE-3 landing site is ~5–10 m/Ga for the surface regolith, and is ~1.3–3.7 m/Ga for the paleoregolith [5].

Conclusions: With new datasets from recent lunar missions, regolith thicknesses over large regions can be estimated, and cross-validation of regolith thickness between different methods is also available. The estimated regolith thickness, when combined with lunar surface age, can provide valuable information on the formation and evolution of lunar surface.

References: [1] Heiken G. H. et al. (1991) New York: Cambridge Univ. Press. [2] Fa W. and M. A. Wieczorek (2012) *Icarus, 218,* 771–787. [3] Fa W. and Y.-Q. Jin (2010) *Icarus, 207,* 605–615. [4] Fa W. et al. (2014) *JGR, 119,* 1914–1935. [5] Fa W. et al. (2015) *GRL, 42*, 10,179–10,187.

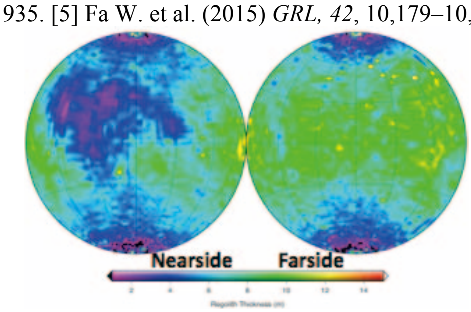

Figure 1. Regolith thickness estimated from China's CE-1 microwave radiometer observations [3].

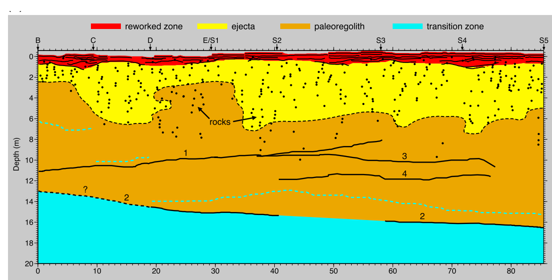

Figure 2. Regolith stratigraphy at the CE-3 landing site revealed by the lunar penetrating radar [5].

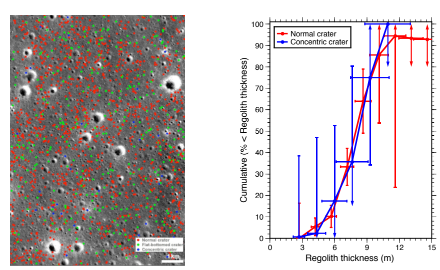

Figure 3. Counted craters (left) and cumulative distribution of regolith thickness (right) over the CE-3 landing region [5].