Origin of the rock observed by Yutu-2 rover of Chang'E-4. H. Lin[1], Z. He[2], Y. Lin[1*], W. Yang[1], R. Xu[2], Y. Wei[1], C. Zhang[1] and S. Hu[1]. [1]Institute of Geology and Geophysics CAS, Beijing 100029, China. [2]Shanghai Institute of Technical Physics CAS, Shanghai 200083, China. (linyt@mail.iggcas.ac.cn)

Introduction: Chang'E-4 (CE-4) have successfully landed in the Von Kármán crater within the South Pole-Aitken (SPA) basin of the Moon on 3 January, 2019 (Fig. 1a). The CE-4 landing site is located on NE-SW ejecta strips radiating from Finsen crater, which superpose the SE-NW dome-like ridge directed towards Alder crater (Fig. 1b). The surface at the landing region has the model age of ~ 3.6 Ga [1, 2]. The panorama camera (PCAM) onboard the Yutu-2 rover reveal the surface is relatively homogeneous regolith with many small craters, scattering with few rocks (Fig. 1c) [3]. The lunar penetrating radar suggest the Finsen ejecta has a thickness of ~36 m including ~11.1 m fine-grained regolith [4]. Fortunately, a rock (Fig. 1d) was observed by Yutu-2 in the third lunar day of mission operations, providing a great view to understand the compositions on the SPA basin floor.

Data and method: *Instruments and data reduction.* The Visible and Near-Infrared Imaging Spectrometer onboard the rover Yutu-2 consists of a Complementary Metal-Oxide Semiconductor (CMOS) imager (450-950 nm) with 256 by 256 pixels and a short-wavelength near-infrared (SWIR) detector (950-2395 nm) with single-pixel [5]. We started the data reduction from the level 2B radiance data, which has been in flight calibrated using the valid measurements of the Lambertian reference plate onboard the rover [6]. The reflectance was retrieved from radiance by divided by the solar irradiance. The spectral slope and absorption strength are significantly affected by the viewing geometry implied by the *in situ* photometric experiments [7, 8]. Thus, we have corrected the spectra to standard viewing geometry (incidence angle=30°, emission angle=0° and phase angle=30°) based on illumination simulations conducted with lunar regolith simulants [3].

Method. A Hapke radiative transfer model was applied to the rock spectrum to retrieve the mineral abundances [3, 9]. The endmembers used in this study are high-calcium pyroxene (HCP), low-calcium pyroxene (LCP), olivine (OLV) and plagioclase (PLG).

Results: *The texture of the rock.* The rock measured by Yutu-2 is >20 cm in size (Fig. 1d), sitting on the regolith surface. According to the image with high spatial resolution (~0.6 mm/pixel), no grains can be clearly identified on the surface, suggesting a fine- or medium-grain-size texture (Fig. 1e).

The composition of the rock. The rock shows clear absorptions at ~1 and ~2 μm (Fig. 1f). Hapke radiative transfer modeling [9], which has been validated by the lunar samples and meteorites [10], suggest the rock contains 48.0±3.1% PLG, 38.1±5.4% LCP and 13.9±5.1% OLV (Fig. 1g).

Discussion: The surface materials at the CE-4 landing site are predominantly ejecta from Finsen crater, with little contribution from the local mare basalt [1, 3]. The rock analyzed by Yutu-2 is likely the original bedrock of SPA basin. The bedrock of SPA basin could be the original plutonic rocks crystallized directly from Lunar Magma Ocean, or may have formed from crystallization of the SPA impact melt pool. The PLG-abundant and OL-poor modal composition of the rock is consistent with the origin of the lower crust rather than the mantle. The deep interior origin would also expect coarse-grained textures, typical of plutonic rocks (3 mm or larger) [11]. However, the observed fine- to medium- grain-sized texture of the rock suggests a fast cooling thermal condition, which is consistent with crystallization from the SPA impact melt pool [12]. The numerical simulations of impacting suggest that the SPA scale event could generate a transient cavity with a diameter of 840 km and a melt pond with ~50 km depth (Fig. 1h). The SPA impact melt would have been a mixture of the lunar crust and upper mantle materials. Finsen crater is located close to the margin of the melt pond. It is likely that the Finsen impact event excavated shallow layer rocks crystallized from the SPA melt pond and delivered them to Von Kármán crater [3], where they were measured by the rover Yutu-2 (Fig. 1i).

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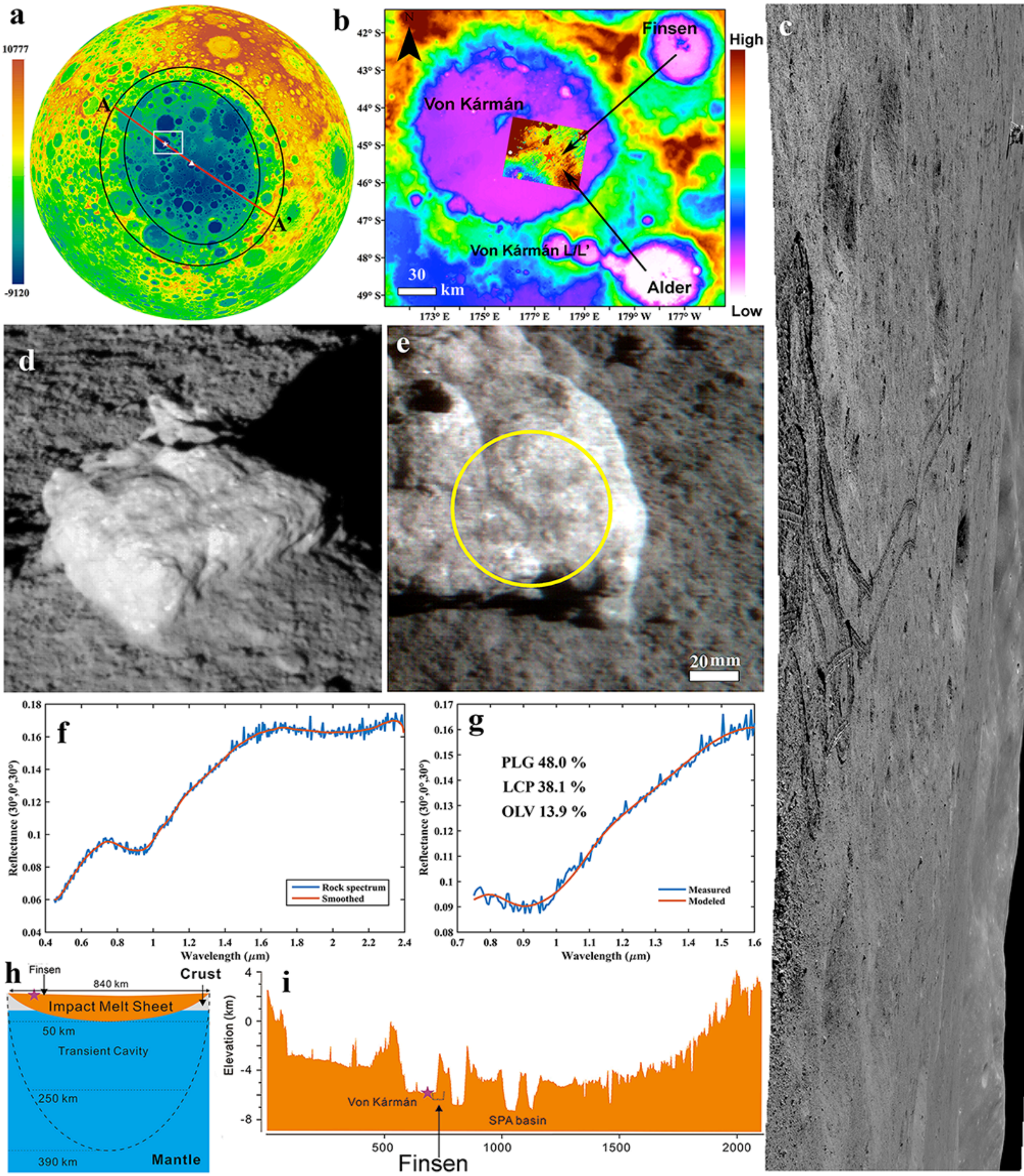

Figure 1 | The origin of the rock observed by the lunar rover Yutu-2 on the farside Moon. a) The location of the Chang'E-4 landing site (pentagram). The white rectangle is the region of b) The morphology around the landing region [3]. c) The mosaic panoramic image along the rover's traverse. d) The image of the rock acquired by panorama camera. e) The color image of the rock measured by CMOS imager. The yellow circle is the SWIR field. f) The rock's reflectance spectrum after photometric correction. g) Hapke modeling of the rock spectrum. h) Schematic illustration for the origin of the rock analyzed by Yutu-2 [3, 12]. i) The topographic profile [3] from A to A' as indicated in Fig. 1a.