

GEOLOGIC CHARACTERISTICS OF THE LUNOKHOD 1 AND YUTU ROVER LANDING SITES, NW MARE IMBRIUM OF THE MOON

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This work is a part of a joint research project between the Vernadsky Institute, Moscow, Russia, Brown University, Providence, RI, USA, Nanjing University, Nanjing, China and China University of Geosciences, Wuhan, China. We compared and assessed the results of measurements and observations by the Lunokhod 1 and Yutu rovers, both of which explored the northwestern part of Mare Imbrium [1-7,12] (Figure 1). Both sites are within the distinctive Eratosthenian-aged lava flow geologic unit and our comparisons showed that the geologies of these exploration sites are very similar.

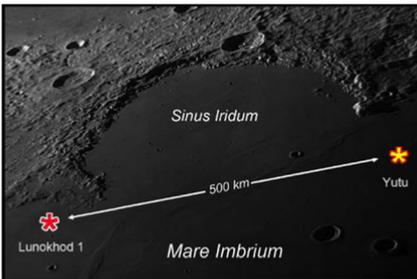


Fig. 1. Area of work of Lunokhod-1 and Yutu rover at the NW part of Mare Imbrium. Image source: <http://www.visit-the-moon.com/sinus-iridumr13-04-05-07>.

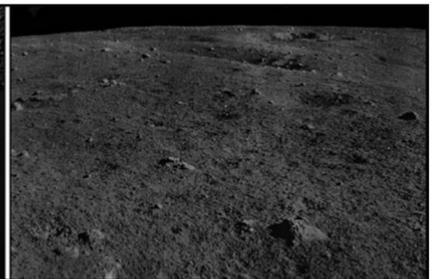


Fig. 2. Typical landscape at the Lunokhod-1 work area. Small craters and rock fragments are dominating features. Portion of Lunokhod-1 panorama L1_D09_S05_P10.

As in the majority of other areas of the Moon, the dominant landforms in these sites are small impact craters, having various degrees of morphologic prominence and states of preservation, and rock fragments, mostly associated with the rims and interiors of fresh craters (Figures 2 and 3). The shape and the degree of preservation of the observed rock fragments in these two sites are similar.

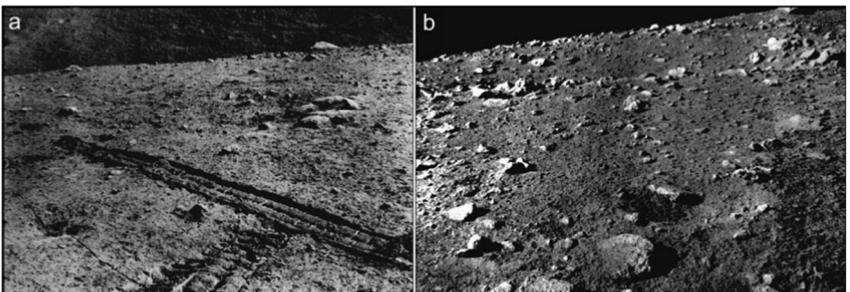


Fig. 3. a) Moderately rocky surface in the WSW part of the rim of the relatively large ($D = 470$ m) crater Borya. In the upper part of the image the opposite internal slope of this crater is seen. The Lunokhod track width is 20 cm. b) Rocky surface on the western internal slope of crater Borya. Parts of panoramas L1_D07_S04_P08 and L1_D06_S02_P03.

In both sites sporadic rock fragments were observed whose morphologies suggest that their source rocks had columnar jointing (Figure 4). Localization of these specific rocks on the rims of 450-470 m in diameter craters implies that the source rocks are at depths of 40-50 m.

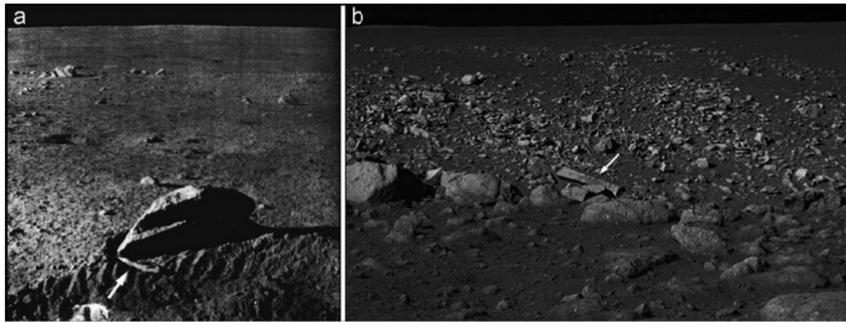


Fig. 4. Fragments of rocks whose morphology suggests a columnar jointing. Portions of Lunokhod-1 panorama L1_D05_S01_P01 and Yutu image ID: CE3_BMYK_PCAML-C-015_SCI_N_20140113191514_20140113191514_0008_A.

Regolith in the study areas is typically a few meters thick, but locally can be much thicker. The ground penetrating radar of the Yutu rover revealed the multilayer regolith structure [10,11, 13,14], which is determined by superposition of crater ejecta. With some local variations, this type of the regolith stratigraphy should be typical of the majority of lunar mare sites. The physico-mechanical properties of the regolith in these two sites appear to be rather similar and close to values measured by PROP instrument along the Lunokhod-1 route [9]: the bearing capacity ranges from 0.04 to 1.44 kg/cm², with a modal value ~0.45 kg/cm², and the shear strength ranges from 0.02 to 0.1 kg/cm², with a modal value ~0.05 kg/cm². Both these parameters decrease by a factor of 3 to 4 with an increase of surface slope from ~2 to 12°. The chemical composition of surface materials determined by the rover instruments at these two sites differ from those derived from the remote sensing data for the Eratosthenian-aged basalts on which the two sites are located. This could be partly due to low measurement accuracies, especially in the case of Lunokhod 1, but may also represent real variations in the composition of the surface materials compared to returned lunar samples.

Recommendations for future lunar rover missions are: 1) to use ground penetrating radar and a robotic arm, and 2) to employ radial study tactics for impact crater documentation and analysis.

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