

RECENT AND CONTINUOUS SLOPE DEFORMATION OF THE SOUTH MASSIF, IN TAURUS-LITTROW VALLEY, APOLLO 17 LANDING SITE. G. Magnarini¹, P. M. Grindrod¹, and T. M. Mitchell²,
¹Department of Earth Sciences, Natural History Museum, London, UK ²Department of Earth Sciences, University College London, UK, (giulia.magnarini@nhm.ac.uk).

Introduction: Taurus-Littrow Valley, location of the Apollo 17 landing site, hosts recent, late-Copernican geomorphological landforms and tectonic structures, namely the Light Mantle avalanche deposit and the Lee-Lincoln lobate scarp. The Light Mantle deposit represents a unique case of a hypermobile avalanche on the Moon [1][2]. Suggested to have been triggered by the Tycho impact event 110 Ma, the Light Mantle has recently been interpreted as made of two distinct units, based on albedo variations [2][3]. The Lee-Lincoln lobate scarp is the surface expression of a recent thrust fault [4], which is considered to be the source of strong seismic shaking throughout Taurus-Littrow Valley [5][6], and potentially still active [7].

The Light Mantle deposit represents a geomorphological marker. Surface change superposed on the Light Mantle deposit, and on the slope from which it was generated (the NE-facing slope of the South Massif), must post-date the landslide event. As the absolute age of the deposit is known thanks to the Apollo 17 returned samples, such surface changes demonstrate that recent processes have occurred at this location during the last 70-110 Ma. For example, small scale grabens (10-20 m wide) associated with the Lee-Lincoln lobate scarp are found superposed on the young Light Mantle unit [4]. These troughs likely formed less than 50 Ma ago [8] and are thought to be generated by the flexural bending of the hanging wall [4][8].

Here we present evidence of slope deformation and surface changes that have occurred since the emplacement of the Light Mantle deposit (Fig.1).

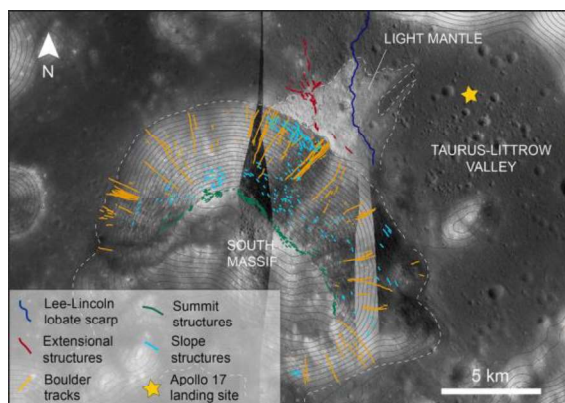


Figure 1. Ortho-view of the South Massif and Taurus-Littrow Valley (NASA/PDS). Different types of surface features are mapped.

Boulder Tracks and Regolith Disturbance: We identified 116 boulder fall events. We observed cross-cutting relationships at times, which provide evidence of subsequent episodes of boulder falls.

Regolith disturbance from downslope creep is thought to be the expression of recent seismic activity [7] or to be the product of continuous downslope creep under the effect of gravity (e.g., [9]). We observed widespread disturbed regolith on the slopes of the South Massif, in particular on the NE-facing slope, which corresponds to the slope from where the Light Mantle originated. The disturbed regolith appears in patches that are characterized by a crenulated pattern. These patches are reminiscent of terrestrial soil creep.

We observe regolith disturbance affecting boulder tracks, by means of attenuation and even obliteration of their morphological evidence. We also observe boulder tracks overlapping disturbed regolith. Such superposition relationships provide evidence of the concurrence of boulder falls and downslope creep (Fig. 2).

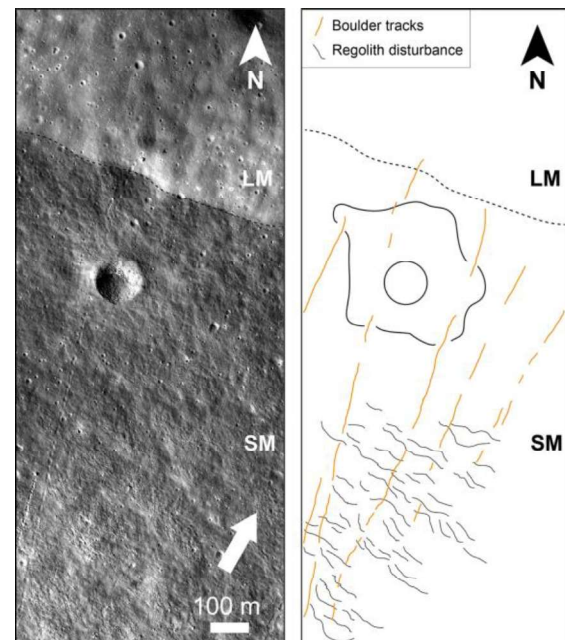


Figure 2. Examples of modification of boulder tracks by regolith disturbance and impact cratering.

Summit Structures: All along the South Massif summit we report the presence of linear structures parallel to the crest of the massif. At the summit of the

NE-facing slope, we observe structures that resemble terrestrial crestal grabens (Fig. 3). In this location, the uphill-facing surfaces are about 1 m high. The origin of crestal graben is associated with gravitational slope deformation.

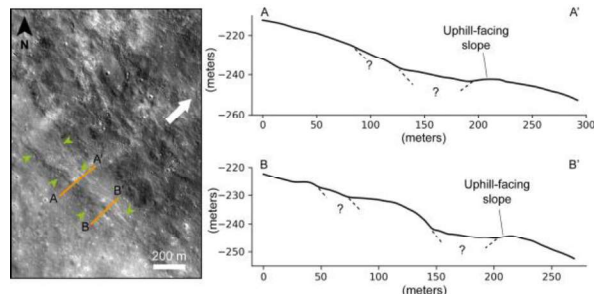


Figure 3. Structures observed at the summit of the NE-facing slope of the South Massif resemble crestal grabens (light green arrowheads).

Linear Slope Structures: The upper part of the South Massif slope is characterized by linear structures that are parallel to contour lines. Some of them produce slope benches, about 20 m long (in the downslope direction) and about 100-200 m wide (in the contour-parallel direction), which correspond to breaks in slope (Fig. 4a).

On the lower part of the NE-facing slope, the linear structures appear to have a longer extent than the ones on the upper part, in the order of several hundreds of meters (Fig. 4b). Moreover, the lower linear structures appear to be at an angle ($\sim 30^\circ$) with the contour lines.

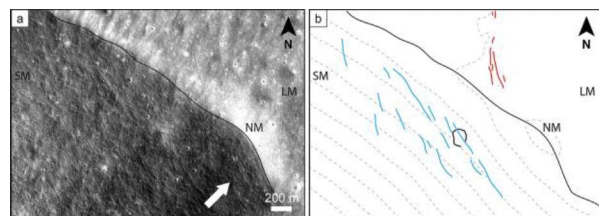


Figure 4. Examples of linear structures at an angle with contour lines at the base of the SE-slope of the South Massif.

Discussion: Boulder tracks found on the NE-slope of the South Massif are younger than 70-110 Ma, as they post-date the young Light Mantle unit. The presence of obliterated sections of boulder tracks is evidence that efficient processes of surface modification have taken place. The two processes that we identified are impact cratering and regolith disturbance. Regolith disturbance is by far the most extensive process that alters and removes boulder tracks. We infer that the efficiency of the regolith creep along the NE-slope of the South Massif in modifying boulder tracks is evidence of reiterate ground-shaking perturbation. Given the proximity of the Lee-Lincoln scarp, which is suggested

to be the trigger mechanism for the landslides [2][6] and boulder falls [7] in Taurus-Littrow Valley, it is possible that the main perturbation component of regolith disturbance is provided by seismic shaking over impact-induced shaking.

We consider the origin of the slope structures at an angle to contour lines as linked to other forces that are not gravity. Their location in the lower part of the NE-slope of the South Massif, and so their proximity to the Nansen Moat, and their orientation close to that of the extensional structures on the Light Mantle deposit, may suggest that they are originated by the local tectonic stresses at play. Instead, we attribute the formation of crestal graben and linear slope structures parallel to contour lines to the effect of gravity only. Commonly, terrestrial crestal graben form due to gravitational spreading of a mountain slope that is no longer in equilibrium following the retrieval of lateral or basal support. The extensional stress that may have generated the Nansen Moat [2] may have left the NE-slope unsupported, causing a gravitational adjustment that manifested in the formation of crestal graben, slope structures parallel to contour lines, as well as regolith creep.

Conclusions: We conclude that the NE-facing slope of the South Massif has been recently and continuously affected by slope deformation processes. We suggest that the efficiency of these processes is the product of lasting, and perhaps ongoing, effects of tectonism in Taurus-Littrow Valley. We will search for present-day surface changes in this region to further investigate the possible active-state of the Lee-Lincoln scarp.

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