LUNAR SOUTH POLE BOULDERS AND BOULDER TRACKS: IMPLICATIONS FOR CREW AND ROVER TRAVERSES. Valentin T. Bickel[1,2] and David A. Kring[3,4], [1]Max Planck Institute for Solar System Research (bickel@mps.mpg.de) [2]ETH Zurich [3]Center for Lunar Science and Exploration, Lunar and Planetary Institute, Universities Space Research Association [4]NASA Solar System Exploration Research Virtual Institute.

Introduction: The lunar South Pole is the target for a human landing within the next five years [1]. To assist NASA with that endeavor, we initiated a study of boulders and boulder tracks around the South Pole to identify potential targets for geologic sampling and assess geomechanical conditions that may affect crew and rover traverses. This work builds on a recent landing site and traverse study of the region [2] and assessments of trafficability based on boulder tracks in pyroclastic [3] and permanently shadowed regions [4].

Methods & Results: More than 500 boulders >3 m in diameter, including 79 boulders with tracks (Fig. 1), were identified in the vicinity of the South Pole applying a Deep Neural Network trained for lunar rockfall detection [5]. Using LRO NAC images, the geometric characteristics of 8 boulders with tracks (Fig. 2) were used to estimate the bearing capacity, q_f, of the south polar regolith as a function of depth and slope, based on a recently established method [3]. The performed measurements indicate that the south polar regolith q_f values (kN/m^2) follow the same trend as found in [3] with depth D (m):

$$0 - 1 \text{ m depth:} \qquad q_f = \frac{D + 0.140}{0.026}$$

which is similar to that of material in other regions of the Moon that have already been traversed successfully.

In addition, the rolling resistance coefficient C_{rr} of the regolith was estimated based on: (1) slope angle where boulders stopped rolling; (2) boulder track depth and width (elastic assumption); and (3) the modulus of subgrade reaction and an exponent of soil deformation [6]. Measurements suggest that boulders encounter average C_{rr} values of 0.21, 0.18, and 0.03, respectively, which are similar to those of loose sand-like and worn cobble-like terranes, depending on the applied method. The coefficient C_{rr} is a measure for the rolling resistance of the regolith and enables estimates of a vehicle's slope climbing abilities and energy consumption, among others.

Discussion: Extreme illumination conditions at the poles complicate track depth measurements. A statistical relationship between rockfall volume and track depth was used to refine the measured depth values. However, precision of estimated track depth, q_f, and C_{rr} values might be reduced.

Conclusion: The estimated bearing capacity can be used to assess the sinkage of landers and rover concepts, such as NASA's LER and ETH Zurich's SpaceBok, in the vicinity of the South Pole as function of the topography. In combination with the estimated C_{rr} coefficient, illumination maps, and other data, a bearing capacity map can be used to perform detailed trafficability studies for future human and robotic landings and traverses.

References: [1] J. Bridenstine (2019) *NASA Release 19-022*. [2] E. J. Allender et al. (2019) *Adv. Space Res. 63, 692-727.* [3] V. T. Bickel et al. (2019) *JGR: Planets*, in press. [4] H. M. Sargeant et al. (2019) *LPS L*, Abstract #1587. [5] V. T. Bickel et al. (2018) *IEEE TGRS*. [6] W. D. Carrier et al. (1991) Chapter 9, in *Lunar Sourcebook, Cambridge University Press*.

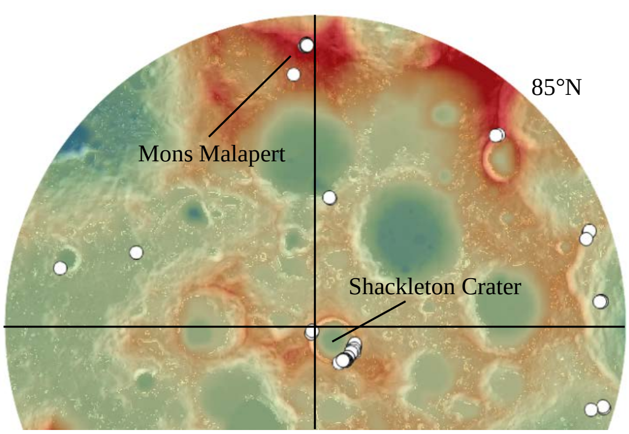

Fig. 1. Boulders with tracks at the South Pole; on LOLA DEM.

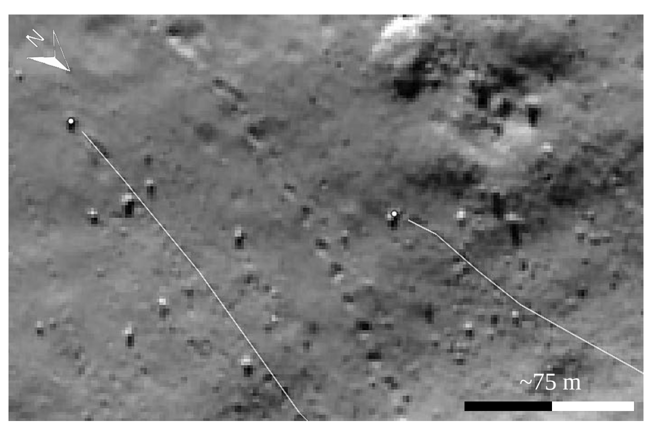

Fig 2. Rockfalls in Shackleton crater, slope dips to the upper left.