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MER Physical Properties Experiments - Inferring Mars Soil Strength Properties from Rover Traction Performance along MER Rover Traverses

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Since the beginning of NASA's Mars Exploration Rover mission in January 2004 the authors have been involved in the MER physical properties experiments.

The main scientific objective of MER physical properties studies is to identify discrete materials through their strength properties, study soil stratigraphy and modification as well as transport processes (cementation by salts, aeolian transport of loose fines) along MER rover traverses by analyzing the MER rover's traction performance on a specific soil type traversed and drawing a conclusion on the respective soil parameters, which are not measured directly by specific instruments.

In detail, this means to determine the soil parameters along MER traverses by fitting observed wheel rut depths (from MER stereo images) and drive data (i.e. wheel slippage) to a wheel-soil interaction model. The model used here, based on a semi-empirical model originally developed to investigate traction performance of terrestrial off-road vehicles, has been further developed for planetary rover applications, calibrated for MER wheel size and wheel load and validated through lab measurements on a MER single wheel.

Additional constraints for solving for the soil parameters are provided by suspected correlations between visual appearance and physical properties of Martian soils. After having obtained the soil parameters, a classification of the respective soil type has been done by comparing the parameters (in consideration of the grain size distribution) with existing classifications of terrestrial soils. This concept is usually referred to as the

‘wheeled bevameter’.

The obtained results are applicable to the upper 20-30 cm of soil according to the stress dissipation for the MER wheel widths.

Here, we report on soil strength properties of Martian soils inferred through analyzing MER rover wheel rut depths along the rover traverses. Besides discussing relevant equations of the used wheel-soil theory, we will present results of laboratory experiments with a MER single wheel conducted to calibrate the theory for MER wheel size and wheel load. Accordingly, these experiments demonstrate that the used theory meets the experimentally measured MER traction performance on a reference soil, allowing to reliably solve the equations for soil strength properties using known drive data and vehicle geometry as input parameters.

Finally we give first results of several identified soil types (bearing strength, cohesion, internal friction angle, bulk density) and discuss the classification of these soils according to known terrestrial soils. First results of a comparison with compositional data will be given.