AUTOMATED IMAGE ANALYSIS FOR MEASURING SIZE AND SHAPE OF MARTIAN SAND GRAINS: A TOOL TO ESTIMATE THRESHOLD SHEAR VELOCITIES AND TO COMPARE DIFFERENT SAND SAMPLES. J. Kozakiewicz[1], [1]Institute of Geography and Spatial Management, Jagiellonian University, PL30-387 Krakow, 7 Gronostajowa St., Poland, and also Astronomical Observatory, Jagiellonian University, PL30-244 Krakow, 171 Orla St., Poland, (j.kozakiewicz@uj.edu.pl).

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Introduction: In order to study the aeolian transport on Mars, it is necessary to acquire some information on material being transported. The most important information is related to the size, density and shape of loose particles which can be subjected to aeolian transport.

Martian deposits are clearly visible in images obtained during various missions. It is possible to estimated the size, and shape of visible grains from these images, and it has been done manually in several publications [1, 2].

In this work, the images obtained with the MI instrument during the MER mission were analyzed using the automated method. It allows for fast estimation of the size and shape of Martian sand grains. The obtained grain-size distributions of the Martian deposits were compared and several types of sand were distinguished. The threshold shear velocities for these different sands were estimated and discussed.

Methodology: The image processing and analysis techniques are commonly used in many disciplines to determine particle size distribution of materials. This methodology was also used with regards to Martian deposits [3].

In this work, an image analysis tool for particle detection and measurement was developed. This fully automated approach is based on the algorithm which enables to detect individual grains and measures their size and shape. The algorithm uses a set of image processing operations associated with filtering, extraction and segmentation and is implemented in Wolfram *Mathematica*.

Firstly, the tool was tested on the terrestrial samples. The terrestrial material was collected from the Grand Falls dune field, a Martian analog, located ca. 70 km NE from Flagstaff, Arizona, USA. The Grand Falls dune field deposit consists of a light-toned, fine- to medium-grained quartz sand and dark, medium- to coarse-grained basalt sand [4]. The terrestrial material was analyzed using the developed method as well as sieve, laser diffraction analysis. The cumulative grain-size distribution curves obtained by the method and the sieve analysis are presented in Figure 1.

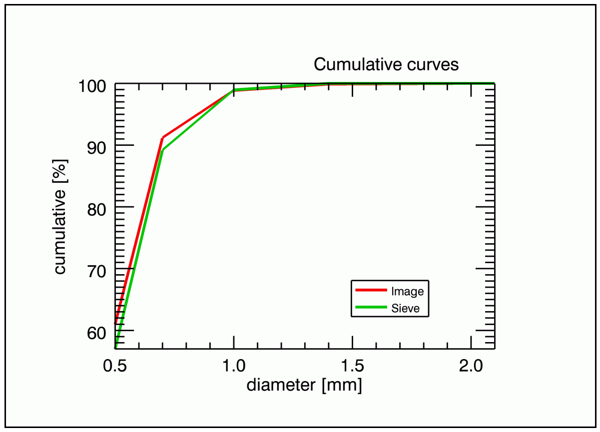

Figure 1. The granulometric curves of the tested sample obtained by the method and the sieve analysis.

Martian material analysis: The MI images acquired along the traverse of the Spirit rover in the Gusev Crater and the Opportunity rover in Meridiani Planum were investigated. Knowing the physical size of the area covered in the MI images, it was possible to estimate the size of grains. Only sand grains larger than 0.15 mm were considered. Smaller particles could not be distinguished due to the low resolution of the MI instrument (ca. 30 microns/px). Particles truncated by the image or partially buried were automatically omitted as their size and shape cannot be fully determined. An example of such a detection is presented in Figure 2. In this example only larger grains were selected as not to obscure the result.

The grain diameter was defined as the diameter of the equivalent disk. The size-distribution curves were generated for every image. Some grain properties such as circularity or elongation were measured.

The results were statistically analyzed. Several types of deposit were distinguished. For each type of deposit the values of the statistical parameters, related to the grains size, sorting and shape, were determined. Also some properties associated with particles surroundings, such as their location or influence of other grains, were discussed.

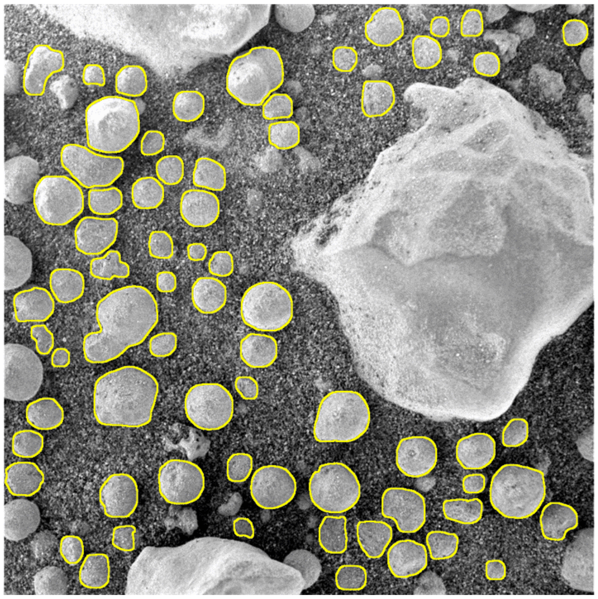

Figure 2. Detection of spherules in Meridiani Planum (1M206839802EFF74N8P2956M2M1). Truncated or partially buried grains were automatically omitted; image is 32 mm across.

Estimation of threshold shear velocity: The threshold shear velocity is a critical shear velocity for initiation of motion for a particular grain. The static and dynamic threshold velocity was estimated for each type of Martian sand using the approach described in the work of Jerolmack *et al.* [5]. The grains most susceptible to mobilization through aeolian processes (0.13-0.16 mm) are on the edge of the resolution limit of the MI instrument. The threshold shear velocity depends on the particle density. In this work the density of the Martian particles was assumed to be between 2.7 and 4.2 g/cm^3.

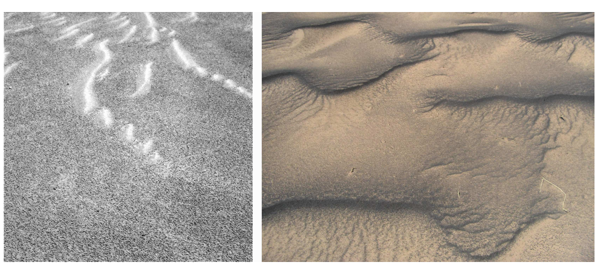

Figure 3. On the left: ripples in Meridiani Planum (1P133336423EFF0830P2215L5M1), the image is ca. 1 m across; on the right: ripples in the Grand Falls dune field; the image length is ca. 1.3 m.

Results: The automated image analysis was used to compare the terrestrial and Martian material which builds crests of coarse-grained ripples. The material from the ripples in Meridiani Planum and the Grand Falls dune field was analyzed. Examples of such ripples are presented in Figure 3. The histograms for the sands obtained by the method are presented in Figure 4. In both situations the material is well-sorted.

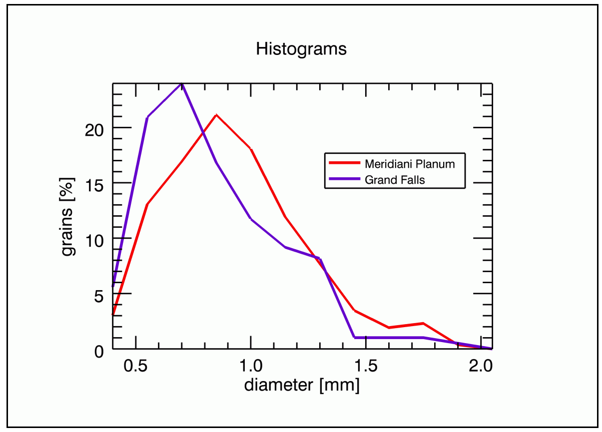

Figure 4. The histograms of grain counts for the coarse ripple crest sand from Grand Falls dune field and Meridiani Planum.

The average grain diameter (d_{50}) of Grand Falls dune field and Meridiani Planum ripple crest sands are respectively: 0.84 mm and 0.95 mm. The sand from the Grand Falls dune field has a density ρ = 2.7 g/cm^3. The threshold shear velocity for this sand is then u_c = 0,48 m/s. In case of the sand from Meridiani Planum the threshold velocity is u_c = 3.02 m/s (the particle density was assumed to be 4.1 g/cm^3). The difference in the values of the threshold velocities in this situation is mainly caused by the differences in the gravity acceleration and the atmospheric density of these two planets.

Future work: The types of the Martian sands will be compared with sands collected in other terrestrial deserts.

References:

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