ESTIMATING THE ORIGIN AND TRANSPORT PROCESS OF GRAINS EXPECTED TO FIND DURING THE DRILL OF EXOMARS ROVER MISSION. Kereszturi A.[1] Újvári G.[1] Bradak B.[1] [1]Research Center for Astronomy and Earth Sciences (e-mail: kereszturi.akos@csfk.mta.com).

Introduction: The first in-situ drill up to 2 m depth is planned to be realized by ExoMars Rover mission in the next years [1]. It will give the first ever "look" below more than few cm of the surface. Based on Earth analogs, several parameters important in geology and astrobiology [2] could be analyzed by such drill that provide information on the origin and transport processes of small grains. Below we outline the research strategy in a project started in Hungary.

Methods: Grains in sediments provide information on the original source material, the transport and the lithification process too. To achieve such infromation the size, shape and composition of grains should be analyzed. During the planned drilling activity by Exo Mars Rover (EXM) and the subsequent analysis in its laboratory, substantial information will be gained, and a part of it could be used to estimate the past history of these grains before the lithification. In the following the observational possibilities and parameters are listed that are useful in the research. The following detectors can be used for direct and indirect grain analysis).

MaMiss (Mars Multispectral Imager for Subsurface Studies): miniaturized spectrometer integrated into the drilling system, to record spectra between 0.4-2.2 micrometer from the excavated borehole wall [2]. The borehole wall will be illuminated on a 1 mm diameter spot for collecting the scattered light of 100 micrometer diameter spot, to acquire spectra during the vertical movement of the drill (column image), or during the rotational movement of the drill (ring image).

CLUPI (colour close up imager): will observe the fines come out of the drill hole [4]. At 10 cm, the resolution is 7 micrometer/pixel in color. Core drill observation will be also acquired in the sample drawer at a spatial resolution of 15 micrometer/pixel in color.

MicrOmega (Micro-Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité): visible and infrared imaging spectrometer to image the material after crushing, and to identify particularly interesting grains, e.g. carbonates, sulfates, and clays, and assign their position coordinates (within an individual sample). Earth analog samples could help to estimate the expected grain size after crushing [5], which might still contain aggregates or can be representative for original grains, or at least for the strongest mineral particles.

RLS (Raman Laser Spectrometer): could detect silicate, clay, carbonate, oxide, sulfate minerals indicative of igneous, metamorphic, sedimentary, and water-related processes (chemical weathering, precipitation from brines, etc.) to elucidate source rocks' properties.

MARS-XRD (Mars X-Ray Diffractometer): elemental composition information of crushed sample, also for source rocks' type identification.

Used parameters: the following characteristics could be used that will be acquired by the rover, in order to estimate properites of the source area and transport method of the deposited grains on Mars.

Sedimentary texture analysis: the original sedimentary structures, the locations of larger grains (bound to layers, style of their occurrence, etc.) could be analyzed in the borehole wall images (MaMiss) with up to cm size. Earth analogs help in the interpretation of expected features, such as wind deposited loess layers in Hungary. An example is visible in Fig. 1. [6,7], where microscopic image (left), and graphical interpretation (right) of a 5 mm wide area on a poorly sorted silt/aleurite is seen from Verőce, Hungary, with possible deformation bands or tracks of clay migration.

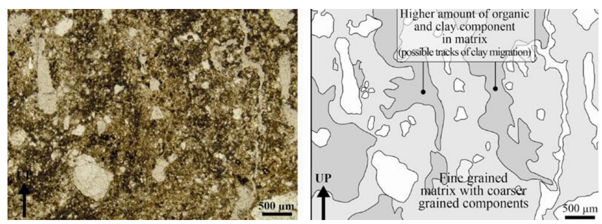

Figure 1. Example of wind deposited loess structure

Particle size and shape analysis: Particle size distributions (PSDs) and grain shapes are indicative of aeolian and fluvial transport mechanisms on Earth [8] provide basis for distinguishing between these two different means of sediment entrainment processes on Mars too. Sediments are mixtures of particle populations that were derived from multiple sources and/or transported by different mechanisms. PSDs include information on these different components/end-members (Fig. 2).

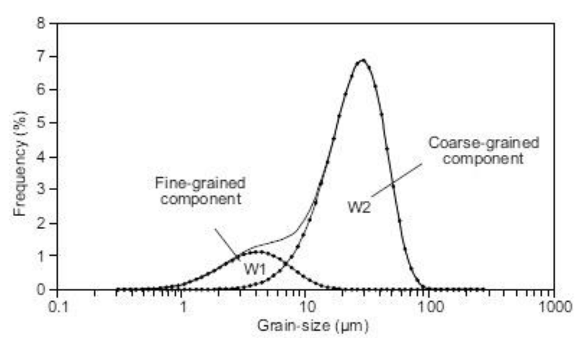

Figure 2. Particle size distributions and modeled end-members of a wind-blown loess sample [8]

Heavy minerals: important to elucidate the source rocks' properies. The main rock type on Mars are various basalts, that are more Fe-rich than those on the Earth in general. Analyzing heavy minerals in Martian meteorites: rutile was found in NWA7034 [9], and expected there with ilmenite [10]; apatite [11], titanite [12], zircon [13] have also been identified. Here the composition might help to roughly characterize the source, including chemistry and the possibly magma's crystallizing depth.

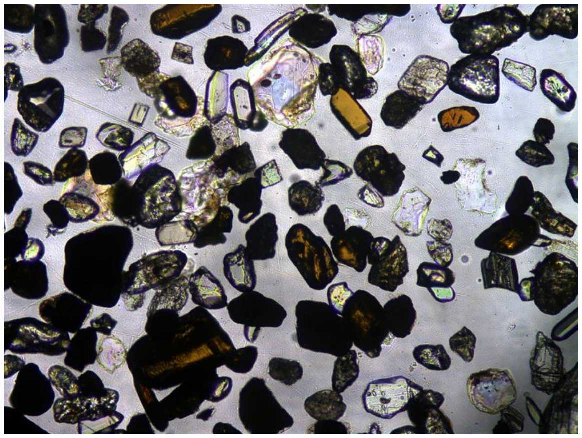

*Figure 1. Image of heavy minerals (rutil, garnet, titanit, apatite) from wind deposited loess sediment in Hungary (image area: 1.28 * 0.88 mm)*

Expected results: EXM will drill at sedimentary terrains in ideal case, meet with mineral grains from basalt (olivine, pyroxene, plagioclase, iron oxides and possibly secondary minerals as weathering products), and devoid of loose dust covered terrain. At the scale of the planned resolution, the features listed in Table 1. could be possibly identified on Mars.

Conclusions: Connecting different types of measurement at different levels (microstratigraphy of borehole wall, particle/aggreagate size, crushed particle size distribution etc.) information could be gained on the source of materials, processes involved in their formation and help to reconstruct paleo-enviromental conditions on Mars. This analysis would be completed with the remote based thermal inertia, extrapolated regional stratigraphy, and spectral mineralogy of the area.

The main parameters that could be estimated with this approach are: 1. ratio and dominance of sediment transport methods including the role of rare great sand storms vs. constant atmospheric fallout of fine dust; 2. change of weathered/unweathered mineral ratio in the vertical column can be connected to climatic changes and occurrence of liquid water; 3. change and occurrence of heavy minerals in the vertical column suggests change in potential source rocks and their rough origin; 4. identification of environment characterized by fluvial sedimentary features points to fluvial activity.

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References: [1] Vago et al. 2006 *ESA Bulletin* 126, 16-23. [2] Kereszturi 2012. *Planet. Space Sci.* 72, 78-80. [3] De Angelis et al. 2013. 44th *LPSC* #1544. [4] Josset J.-L. 2012. *EGU* p. 13616. [5] Baglioni P. 2013 *perconal comm*. [6] Bradak et al. 2011 *Quaternary Intern*. 234, 86-97. [7] Bradak et al. 2014 *Quaternary Intern.* in press [8] Varga et al. 2012 *Netherlands J. of Geosci.* 91(1/2), 159-171. [9] Agee et al. 2013 *Science* 339, 780-785. [10] Papike et al. 2012 43rd *LPSC* #1010. [11] McCubbin et al. 2007 38th *LPSC* 1347. [12] Langehorst, Poirier 2000 *EPSL* 184, 37-55. [13] Moser et al. 2013 *Nature* 499, 454-457.

Table 1. Possible observations of sediments with different origin drilled and analyzed by EXM Rover

observations	**aeolian**	**fluvial**	**impact**	**mass movements**
expected features in general	rounded, sorted, rel. homogeneous composition	rounded, unsorted, rel. homogeneous composition	large size range, angular, unsorted	large size range, angular, unsorted
MaMiss, CLUPI (borehole wall)	climate dependent aggreatates (by water adsorption or sulfate/oxide cemented)	micro-cross lamination, interlamination of fine/coarse garins, soft sediment deformation	sudden change in grain size and composition, nonsorted grains	sharp basal contact in the case of erosion, few small grains between larger ones
MicrOmega, RLS / MARS-XRD (crushed sample)	source's mineral heterogenity, weathering during transport, mechanical strength	water driven mineral alterations	thermal effect of impact event	signs of possibly weathering driven weakening before erosion
information on origin material's	specific source area vs. global homogenization	composition correlation to surrounding fluvial source rerions' remote spectra	nearby bedrock composition	particle size range and composition are connected to nearby source region
extrapolated formation conditions	role of wind, aeolian/fluvial origin, qualitative estimation on the scale of transport length	transported sediment size, hydraulic regime	lithology (fragility, fractured structure) and composition of bedrock	erosinal agent produced dominant clast size, related climatic effect