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АКТУАЛЬНЫЕ ВОПРОСЫ НАУК О ЗЕМЛЕ В КОНЦЕПЦИИ УСТОЙЧИВОГО РАЗВИТИЯ БЕЛАРУСИ И СОПРЕДЕЛЬНЫХ ГОСУДАРСТВ

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PRELIMINARY DATA ANALYSIS TO CREATE A MODEL OF MARTIAN EOLIAN DEPOSITS

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Information about Martian surface materials can be used for compared planetology and spacecraft landing calculations. One of the major processes that influenced on Mars exterior is the eolian process represented by dust storms and dust devils. Modeling of the eolian process is necessary to research surface processes on Mars, insofar it changes relief of the planet and mixes soils entirely for several years. Also, the eolian process should be considered to establish the correct operating mode of descent vehicles.

Major compositions elements were SiO_2 and Fe_2O_3 (FeO), from 42 to 45 wt% and 15 to 23 wt% respectively. Al_2O_3, MgO, CaO, SO_3 are also found in amounts of more than 5 wt% (Table 1). Therefore, it can be argued that the crucial minerals in the Martian regolith are olivine, pyroxene, plagioclase, ilmenite, and magnetite or hematite (Shekhovsova, Korolev, 2019).. The dust is represented by secondary weathering products of mafic igneous rocks (Martian basalts), as well as iron-containing smectite clay.

The shape of the particles is tabular, angular, rounded, which of course is explained by the rolling of particles in the eolian stream (Fig. 1). On the surface we can see individual particles up to 2 mm diameter 1-40 mm diameter agglomerates, accordingly, sand size (> 100 μm) basalt particles are quickly comminuted to silt and clay size particles by Mars eolian processes. Particles with a size of 0.1-10 μm are always in the air, dust with a size of 5-100 μm are transferred by dust storms and dust devils, also 20-60 μm diameter particles lacking on Earth, may be rare on Mars as well. The study of the particle size distribution of sediments was carried out during different missions, so during the Viking 1,2 missions the particle size distribution of deposits from 0.001 mm to 10 mm in size was obtained (Fig. 2).

Physical and mechanical properties of Martian eolian materials were observed by various spacecraft missions, for example, by Spirit Rover, Pathfinder, Viking Lander 1. Undoubtedly physical properties explore should be started from information about density and porosity, insofar as it exposes a real state of drift deposits. Density data were obtained in the range from 1.1 to 1.3 g/cm^3 with an error corresponding to the test methods. It will not be correct to talk about such a concept as the porosity of eolian sediments, however, during the tests, values from 35 to 65% were received. Also, data were retrieved on the density of the solid phase deposits equal to 2.6-3.1 g/cm^3 for individual particles.

Table 1 – Major element composition of Martian soil (wt%) (Zeng et al, 2015)

	Viking 1	Viking 2	Pathfinder	Spirit	Opportunity	Curiosity
SiO_2	43.00	43.00	42.00	45.80	43.80	42.88
TiO_2	0.66	0.56	0.80	0.81	1.08	1.19
Al_2O_3	7.30	-	10.30	10.00	8.55	9.43
Cr_2O_3	-	-	0.30	0.35	0.46	0.49
Fe_2O_3	18.50	17.80	21.70			
FeO				15.80	22.33	19.19
MnO	-	-	0.30	0.31	0.36	0.41
MgO	6.00	-	7.30	9.30	7.05	8.69
CaO	5.90	5.70	6.10	6.10	6.67	7.28
Na_2O	-	-	2.80	3.30	1.60	2.72
K_2O	<0.15	<0.15	0.60	0.41	0.44	0.49
P_2O_5	-	-	0.70	0.84	0.83	0.94
SO_3	6.60	8.10	6.00	5.82	5.57	5.45
Cl	0.70	0.50	0.90	0.53	0.44	0.69
Total	88.81	75.81	99.80	99.37	99.18	99.85

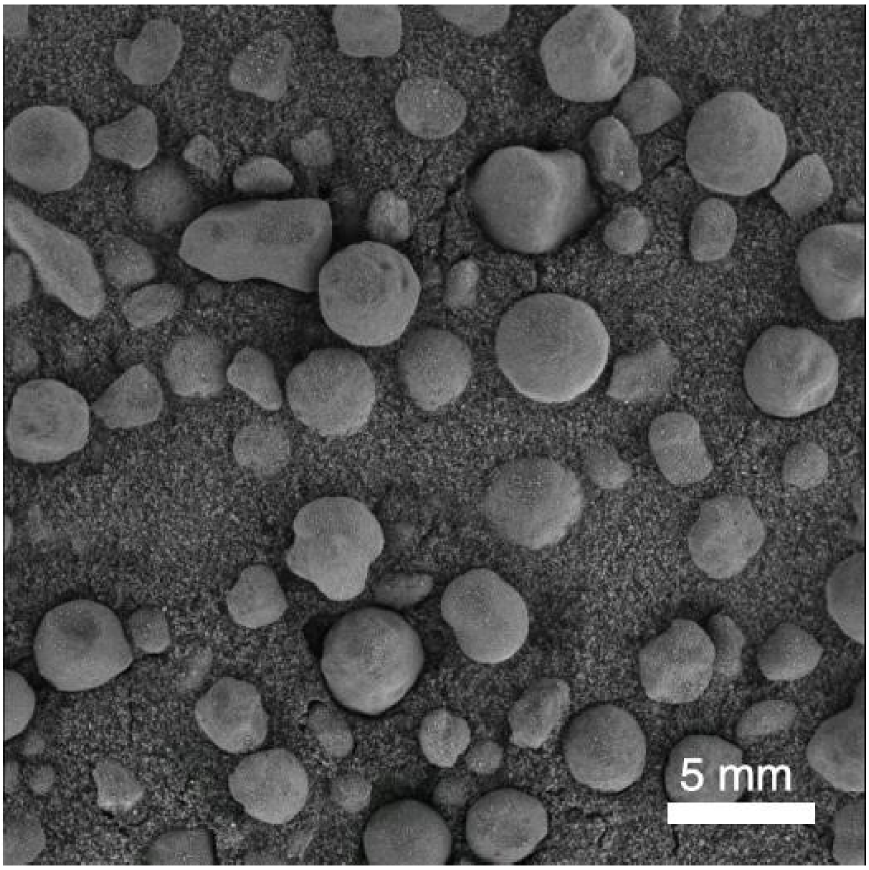

Fig. 1. Typical example of the Meridiani Plains soil (Fergason et al, 2006)

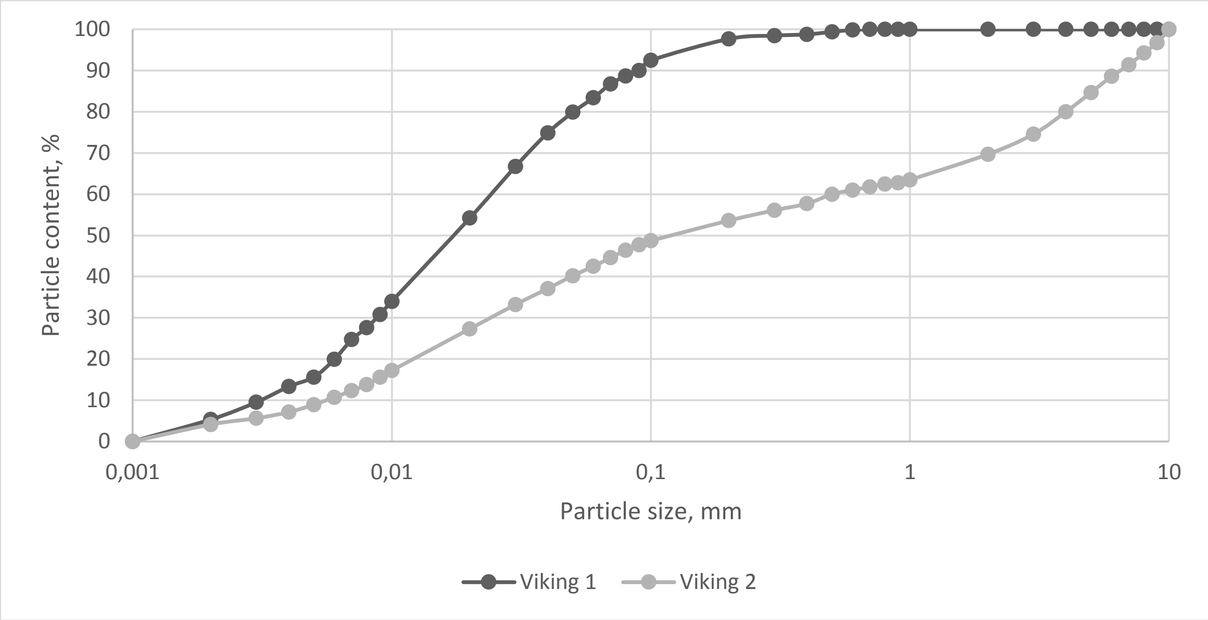

Fig. 2. Grain size distribution of the Martian regolith according to Viking 1,2 (Zimmer et al, 1977)

Also, the instruments, which participate in the missions, are described above researched several mechanical properties associated with the strength characteristics of eolian deposits, allowing them to be considered as soils. The values of the angle of internal friction angle were obtained in the range from 18^0 to 34.3^0, however, the predominant number of indicators was about 20^0. Additionally, cohesion was also reviewed, which results from 0.042 to 1.6 kPa were received (Table 2).

Table 2. Mechanical properties of Martian regolith at different Mars langing sites (Zeng et al, 2015)

Missions	Soil type	Bulk density (kg/m^3)	Cohesion (kPa)	Internal friction angle (°)
Spirit Rover	Drift material	1200-1500	1-15	~20
Pathfinder	Drift material	1285-1518	0.042	34.3
Viking Lander 1	Drift material	1150±150	1.6±1.2	18.0±2.4

For modeling, it is necessary to choose the most suitable soil for mixing, so the array of minerals must be defined to determine the rocks composing of the surface materials of Mars. Thus, to model a sample of Martian eolian deposits, it is recommended to use Kamchatka basalts and smectite clays to create the closest mineral composition. Viking 1,2 data should be taken as a reference particle size distribution, but use information only about drift materials with particle size from 0.001 mm to 0.1 mm. Also, during the study the model, its density should be measured in loose and dense addition, and calculate the porosity of the sample using the density of the solid phase. Strength tests should be carried out to compare them with the data of real Martian deposits. It is proposed to conduct a compression test of the model of eolian deposits to create a prediction of the deformability of real drift materials on Mars.

Also, an analogy criterion should be developed that takes into account all the properties of the resulting model and the coherence of the corresponding parameters to real Martian eolian materials. Speaking about the analogy criteria, it is necessary to introduce auxiliary criteria for assessing the similarity of each selected category. Separately, it is necessary to evaluate the similarity in composition, shape, density, and porosity, as well as strength characteristics. For each of them, the scale of values should be divided into 5 categories: Very strong analogy, Strong analogy, Average analogy, Weak analogy, Very weak analogy. The same scale can be used for the general analogy criterion.

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