WATER DISTRIBUTION IN MARTIAN SUBSURFACE BASED ON THE PASSIVE MEASUREMENTS OF THE DAN INSTRUMENT ONBOARD NASA/MSL

Water Distribution in Martian Subsurface Based on the Passive Measurements of the DAN Instrument onboard NASA/MSL

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Introduction: During more than 5 years MSL Curiosity is successfully traversing across Mars surface exploring Gale crater. In our study we have used data gathered from Dynamic Albedo of Neutron (DAN) instrument installed onboard Curiosity rover. The main objective of the DAN instrument onboard Curiosity rover is to study the bound water in shallow layer of Martian subsurface (up to 0.5 – 1 m) [1, 2]. We paid our major attention to the DAN passive observations to suggest new technique and to reconstruct continuous profile of subsurface water along the traversed distance in Gale crater. We have also compared our results with previous analyses [5, 6].

Instrumentation: The DAN instrument uses a method of active and passive neutron sensing of the shallow subsurface. Active neutron measurements are provided with the pulsing neutron generator (PNG), which produces 2 microsecond pulses of 14 MeV neutrons at a frequency of 10 Hz. In passive observations the instrument detects neutrons that are produced by two different sources: 1) the neutrons born in the interactions between charge particles of galactic cosmic rays (GCR) and soil nuclei; 2) the neutrons produced with rover's Multi-Mission Radioisotope Thermoelectric Generator (MMRTG).

Neutrons from the both sources are initially produced with high energies and then moderated down to epithermal and thermal ranges in the subsurface under the rover. The efficiency of the moderation process is known to depend on the presence of hydrogen in the soil because during a neutron-hydrogen collision, the light nucleus of hydrogen atom takes about the same recoil energy, as the scattered neutron. It means that elevated content of hydrogen is detected by DAN through the variations of low energy neutron flux leaking from the subsurface.

Data Analysis: In our analysis we processed of DAN passive observations over the period of 1600 Sols in the Gale crater.

The estimation of water component is based on the comparison and the calibration of passive data using active ones at the rover stops. This method uses two parameters: the ratio between count rates of thermal and epithermal detectors and the content of neutron absorbers. The last one is described by chlorine concentration as most important (taking into account many factors) neutron absorber in the Martian subsurface [1, 3]. For the simplicity we implemented homogeneous model of the subsurface. This regolith structure is prevailing according to the active measurements (see for details [4]).

Results. The analysis of DAN passive data shows that WEH (water equivalent hydrogen) varies from 0.5% up to 6% along the rover traverse over the period of 1600 Sols and distance up 16 km (see Figure 1). The implemented method shows good correlation with active measurements (up to 89% degree of correlation for ~600 individual spots) and could be used for the continuous monitoring of the average content of subsurface water.

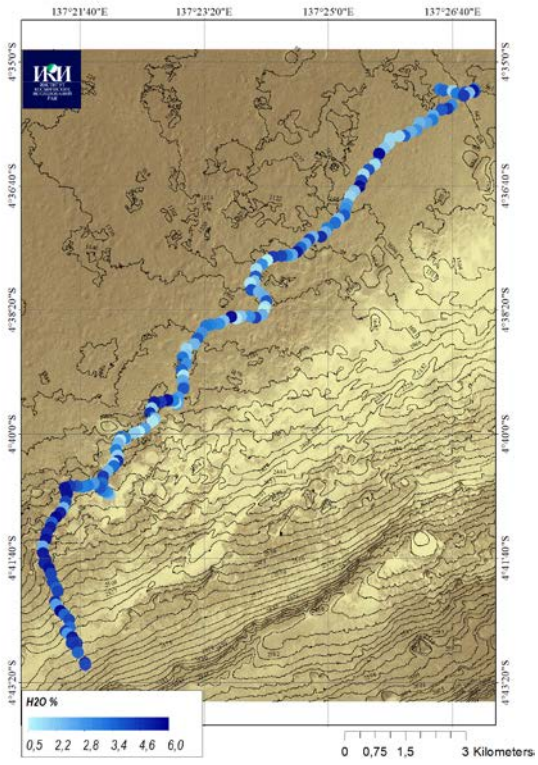

Fig. 1. Water content based on passive measurements of the DAN instrument. Each spot equal to 100m smoothing of the instrument data.

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