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Testing water in the soil of the Gale crater by DAN active neutron measurements onboard the Curiosity Mars Rover

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Active neutron measurements by DAN [1] are performing onboard the Curiosity Rover [2]. During active measurements, the Pulsing Neutron Generator of DAN is producing pulses of 14 MeV neutrons, which diffuse in a tested substance during a time as large as several milliseconds. Before escaping out from the martian surface, they make a large number of collisions with nuclei of the atoms of the substance encountered. This diffusion of neutrons results in a moderation of the neutron's energy, since particles lose a fraction of energy in each collision. When a substance contains atoms of hydrogen, neutrons lose about half of their energy at each collision with them.

The method of neutron data deconvolution is based on the direct comparison between the measured die-away time profiles of the epithermal and thermal neutrons in the testing spot with the corresponding time profiles predicted by the numerical simulations (see [1]). For the preliminary analysis of DAN data, we used the standard composition of the soil (see [3]).

The simplest model of regolith was one with the same content of hydrogen over each individual tested spot, both in length and in depth (homogeneous model). It has only one fitting parameter, the Water Equivalent Hydrogen (WEH) measured in wt% of water in the soil. It was found that data for only one measurement in the spot of Hottah agrees with this model: the WEH corresponds to about 2 wt% at this stop. The 2-layer model is the next after the homogeneous model in level of complexity: it corresponds to 2 layers with different contents of hydrogen. There are three free parameters of this model: WEH in the top layer, thickness of the top layer and WEH in the bottom layer below the top one. The content of hydrogen in the top layer was found to be practically the same at stops, the value of water in the uplayer was about 1.0 – 1.5 % WEH. The other two parameters of 2-layer model were found to vary from one testing spot to another. For the distance interval of [0 – 100 m] and for the interval of [220 – 500 m] the bottom layer is found to have hydrogen with a vari-able content 2 – 6 wt% WEH at the depth of about 10 – 30 cm. For the distance interval of [100 – 220] hydrogen content is more variable with limits of 4 – 8 wt% WEH, the depth is also somewhat larger, 20 – 40 cm.

References: [1] Mitrofanov I.G. et al. (2012), Space Sci. Rev., 170, 559-582. [2] Grotzinger J. et al. (2012), Space Sci. Rev., 170, 5-56. [3] "The Martian Surface. Composition, Mineralogy and Physical Properties", ed. by J. Bell (2008), Cambridge Univ. Press.