Water Estimation in Vera Rubin Ridge and Glen Torridon Based on Measurements of the MSL/DAN Instrument. **S. Y. Nikiforov[1]**, M. V. Djachkova[1] , I. G. Mitrofanov[1], M. L. Litvak[1], D. I. Lisov[1], A. B. Sanin[1], [1]**Space Research Institute of the Russian Academy of Sciences (IKI), 117997, 84/32 Profsoyuznaya st., Moscow, Russia, nikiforov@np.cosmos.ru**.

Introduction: During more than 8 years, NASA MSL Curiosity rover is successfully traversing across Mars surface exploring Gale crater. This work presents results on the assessment of Water Equivalent Hydrogen (WEH) data gathered by the Dynamic Albedo of Neutron (DAN) instrument onboard NASA's Curiosity rover. The main objective of DAN is to study the bound water content in shallow layer of martian subsurface down to 0.6 meters [1,2].

In Sol 2300 the Curiosity rover reached Glen Torridon (GT) region from Vera Rubin ridge (VRR) which was explored started from Sol 1800 [3]. VRR is mostly related to hematite minerals in comparison to GT that is related to clay minerals according to observation by the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [4]. In our work, we will present the latest results on passive observations in VRR and GT regions that are referred to the MSL traverse from ~17 km to ~23 km (see Fig. 1). This analysis shows notable WEH content increase, up to 1 wt.%, in GT.

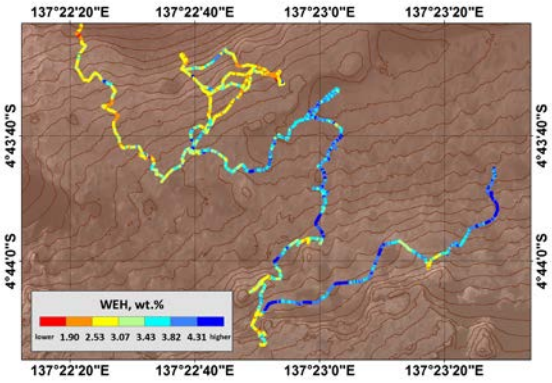

Fig. 1. DAN active measurements for Vera Rubin ridge and Glen Torridon. Data from sol 1800 up to sol 2900.

Instrumentation: The DAN instrument uses a method of active and passive neutron sensing of shallow martian subsurface. Active neutron measurements are provided with the pulsing neutron generator (DAN/PNG) that produces 2 microsecond pulses of 14 MeV neutrons at a frequency of 10 Hz. In passive observations, the instrument detects thermal and epithermal neutrons produced by two different processes: neutrons born in interactions between charged particles of Galactic Cosmic Rays (GCR) and soil nuclei; neutrons moderated from initial high energy neutrons emitted by the rover's Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) [5].

Data Analysis: Method of WEH assessment by passive data is based on empirical correlation between passive and active observations [6]. According to numerical simulation, the size of a measured "spot" during passive observations is equal to 3 meters in diameter [7]. Usage of this technique is providing practically continuous WEH profile during the rover motion and at stops, see Fig. 2.

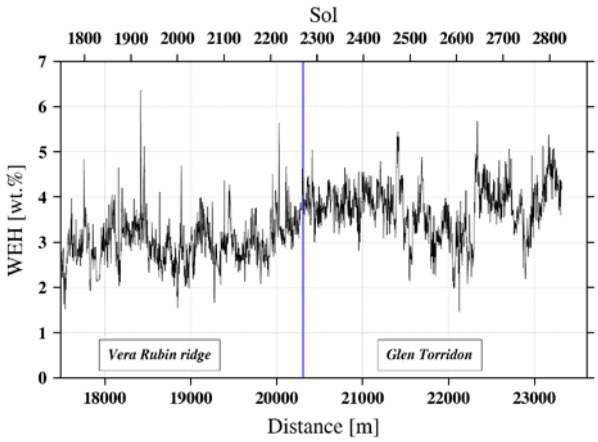

Fig. 2. WEH content profile by passive measurements of DAN. Black line – 3 meter DAN data. Time range from sol 1800 to sol 2900.

Results: DAN measurements in Glen Torridon region by Sol 2900 show notable increase in WEH values in comparison to previous observations with DAN passive and active measurements. DAN passive data show WEH values from 1.4 wt.% up to 6.3 wt.% with the mean 3.0 wt.% in Vera Rubin ridge and from 1.4 wt.% to 5.7 wt.% with the mean 3.7 wt.% in Glen Torridon.

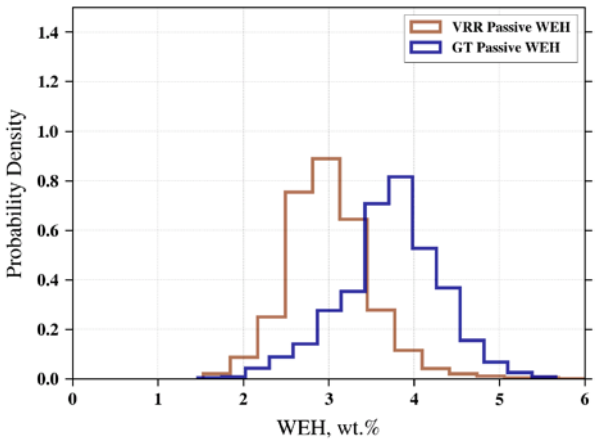

Fig. 3. Distributions of WEH content based on DAN *passive* measurements with a 3-meter scale resolution: brown line – in Vera Rubin ridge, blue line – in Glen Torridon. All distribution areas are normalized to 1.

Discussion: Comparing WEH estimates obtained by two types of measurements, passive and active, it can be noticed a good correlation between them (see Fig. 3 and 5).

Analysis of passive measurements is based on the simplest homogeneous model of subsurface that is described in [8]. This is a two-parameter model: the first parameter is a WEH, the second is an equivalent content of chlorine with an assumption that no other neutron-absorbing elements in subsurface are change and taken as an average along the traverse [8].

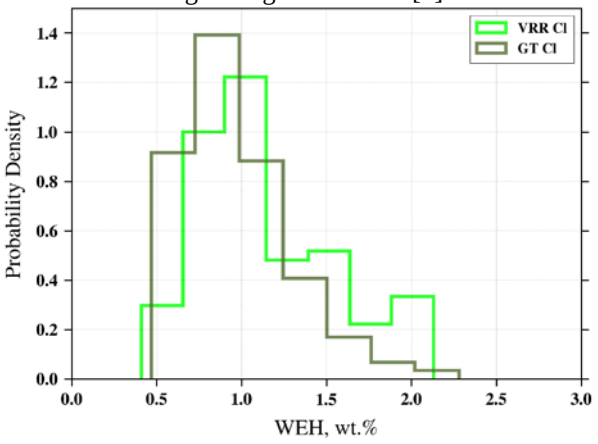

Fig. 4. Distribution of equivalent chlorine content based on DAN active measurements: green line – in Vera Rubin ridge, dark green line – in Glen Torridon. All distribution areas are normalized to 1.

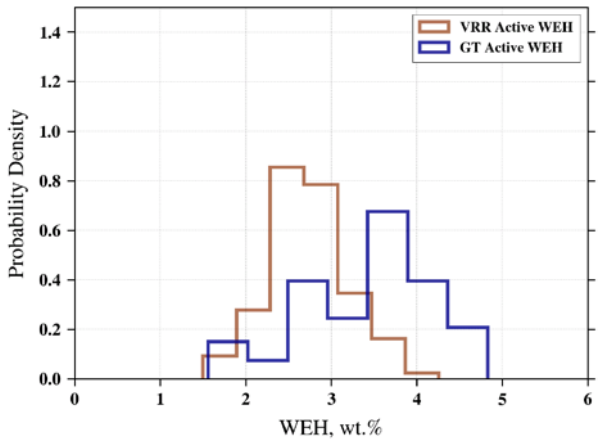

Fig. 5. Distribution of WEH content based on DAN *active* measurements: purple line – in Vera Rubin ridge, red line – in Glen Torridon. All distribution areas are normalized to 1.

It can be assumed, that increase in WEH can be related with increase of hydrogen content in subsurface or with increase of effective chlorine value, based on homogeneous model. However, the distributions of effective chlorine for VRR and GT regions do not show noticeable difference between, see Fig. 4.

Accordingly, it can be assumed that GT region has much larger WEH as it was measured at any areas before. And possibly, it can indicate on the presence of hydrated minerals in GT area, as it was observed by CRISM [4].

References: [1] Mitrofanov, I.G. et al. (2014) *JGRE*, 10.1002/2013JE004553. [2] Livak, M.L. et al. (2014) *JGRE*, 10.1002/2013JE004556. [3] Rampe, E. et al. (2019) *JGR*, 10.1029/2019JE006306. [4] Murchie, S. et al. (2006) *JGR*, 10.1029/2009JE003344. [5] Jun, I. et al. (2013) *JGR*, 10.1002/2013JE004510. [6] Nikiforov, S.Y. et al. (2020). *Icarus*, 10.1016/j.icarus.2020.113818. [7] Sanin, A.B. et al. (2015) *Nucl. Instrum. Methods Phys. Res.*, 10.1016/j.nima.2015.03.085 [8] Lisov, D.I. et al. (2018) *Astron. Lett.*, 10.1134/S1063773718070034