Catalogization of DAN data for Water Equivalent Hydrogen and Absorption Equivalent Chlorine along the First 27 km Part of Traverse of Curiosity. **S. Y. Nikiforov[1]**, M. V. Djachkova[1], I. G. Mitrofanov[1], M. L. Litvak[1], D. I. Lisov[1], A. B. Sanin[1], A. R. Vasavada[2] [1]Space Research Institute of the Russian Academy of Sciences (IKI), 117997, 84/32 Profsoyuznaya st., Moscow, Russia, [2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA; nikiforov@np.cosmos.ru.

Introduction: The Dynamic Albedo of Neutrons (DAN) is the active neutron spectrometer that measures the content of water, as Water Equivalent Hydrogen (WEH), and neutron absorbing elements, as Absorption Equivalent Chlorine (AEC), in the ground along the traverse of the NASA's Curiosity rover. The instrument operates successfully since August 2012. It consists of pulsing neutron generator and two detectors for epithermal and thermal+epithermal neutrons [1, 2]. The sensing depth of subsurface at ~50-60 cm [6].

Measurements: The instrument provides two types of measurement depending on the neutron source. Measurements taken with pulsing neutron generator are named as *active*, and measurements taken for intrinsic neutron emission of subsurface material are named as *passive*. Active neutron measurements are supported by the pulsing neutron generator (DAN/PNG) that produces 2 microsecond pulses of 14 MeV neutrons at a frequency of 10 Hz. In the active mode of operations, post-pulse neutron emission is measured separately at thermal+epithermal and at epithermal energy ranges. In the passive mode observations, the instrument detects neutrons at the same two energy ranges, but emitted by subsurface due to two different excitations: by charged particles of Galactic Cosmic Rays (GCR) and by high-energy neutrons emitted by the rover's Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) [3].

Data Analysis: The method of WEH and AEC estimation from DAN active data is based on comparing the post-pulse neutron detection time profiles to a numerical model [4]. The model is based on a set of reference profiles generated by simulating neutron transport with the MCNPX software and assumes baseline surface composition based on APXS measurements in the Gale crater. The reference profiles constitute a grid with two parameters: WEH (H2O mass fraction) and AEC (Cl mass fraction). Active measurements are performed at rover stops only, which corresponds up to 1000 individual sites along the 27 km of the traverse.

The assessment of WEH from DAN passive measurements is based on empirically found correspondence between neutron measurements at passive mode and the values for WEH and AEC, as derived from active data [4]. The special "*Method of Referencing by Active Data*" (MRAD) was suggested to derive time profile of WEH content in the shallow subsurface from DAN passive measurements [5]. The instrument records the passive data continuously, so one might derive WEH for entire traverse. According to numerical simulation, a size of an distinctable measured "spot" on the traverse or at a spot is about 3 meters in diameter [4, 6]. To provide such analysis it is required to know the value of AEC in the studied area either from interpolation between sites with DAN active measurements or from another instrument onboard, e.g. APXS [7, 8].

The presentation of DAN data at individual pixels is proposed for the first 27 km of traverse in order to analyze DAN measurements along a complex drive path of the rover in correspondence with the features of local geomorphology [9]. The sides of pixels are selected to be oriented in the latitudinal-longitudinal directions. The values of WEH and AEC for the different spots along the rover traverse, which are located within a single pixel, are averaged and assigned to this pixel. The pixel size was chosen according to the spatial resolution of active measurements, the irradiated area of which has a diameter of 3 m [4, 6]. Thus, a 3x3 m pixel makes it possible to cover an each individual measurement, either active or passive. This choice of pixel size is a compromise between better representation of obtained results and the better coverage of traverse by pixelization.

The results of active and passive DAN measurements along the traverse are assigned to two independent types of pixels: Pixel with Active Data (PAD) includes WEH and AEC content and Pixel of Passive Data (PPD) includes WEH content [14].

The distribution of the WEH results obtained in both types of pixels shows good agreement between them (Fig. 1). On the other hand, the pixel mapping of WEH with passive data allows to perform much better interpretations of local water-rich spots in correspondence with geo-morphological variations of the surface.

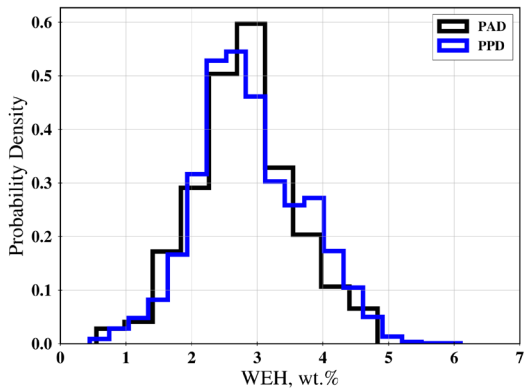

Fig. 1. Distribution of the pixel-averaged values of WEH derived from active (black line) and passive (blue line) DAN measurements. Both distributions areas are normalized to one.

The knowledge of WEH for the sequence of PPD pixels provides the continuous distance profile of WEH variations with the spatial resolution of 3 meters, see Fig. 2 below.

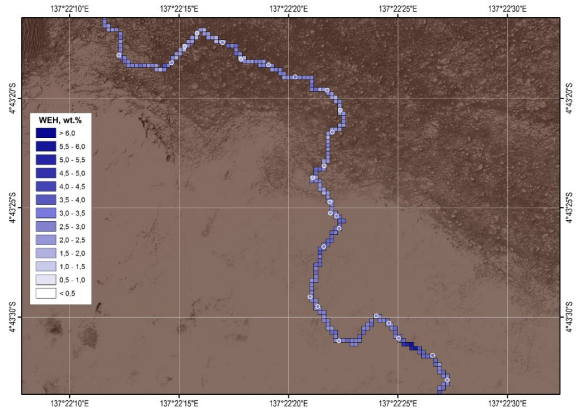

Fig. 2. The sequence of 243 PPD (squares) and 27 PAD (circles) pixels along the Curiosity traverse in period from sol 1781 to sol 1848.

The traverse of the rover crosses several geological regions that have been identified using the data available from Curiosity and other missions. The primary way of organizing the observed geology (primarily lithology), as used by the mission science team, is through the generation of a stratigraphic column. It is divided into informal groups, formations, and members, that logs the lithologies derived from rover observations by elevation [10 - 12].

Each DAN pixel has been assigned to a particular member. When a pixel crosses a member boundary, it is associated with the member that contains the larger fraction of the pixel's area. The association of DAN pixels with the stratigraphic column divisions is presented in [13, 14]. It is also intended for future analyses along new pixalization after the 27 km mark of traverse and for further testing for correlations with other observed surface characteristics and geomorphological features.

Conclusions: This abstract provides profiles of DAN measurements represented as regularly sized pixels along the rover's 27-km traverse as a derived data set. Each pixel contains an estimate of the content of the WEH and AEC derived from DAN data collected from August 2012 (sol 3) to December 2021 (sol 3333). DAN measurements are further associated with distinct geological units along the traverse.

The absolute maximum of WEH so far is (6.1±0.7) wt.%. It is observed in the DAN passive data in Sutton Island member of Murray formation at the 16.3 km mark of the traverse. It is much larger than the maximum of WEH (4.83±0.27) wt.%, as observed at the rover spot at 23.8 km mark of traverse according to active measurements. It is located in Knockfarrill Hill member of Carolyn Shoemaker formation. The content of AEC is found to vary between almost zero and the highest value of AEC (2.56±0.21) wt.% in accordance with active measurements. This maximum is observed in the 6.1 km mark in Bradbury group.

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