**WATER EQUIVALENT HYDROGEN ABUNDANCES FROM BRADBURY LANDING TO AMARGOSA VALLEY (SOLS 0 – 753) USING PASSIVE DATA FROM THE MSL DYNAMIC ALBEDO OF NEUTRONS EXPERIMENT.** **C. G. Tate[1]**, J. Moersch[1,2], B. Ehresmann[3], I. Jun[4], C. Hardgrove[2], M. Mischna[4], M. Litvak[5], I. Mitrofanov[5], W.V. Boynton[6], F. Fedosov[5], D. Golovin[5], K. Harshman[6], D. Hassler[3], A.S. Kozyrev[5], A. Malakhov[5], R. Milliken[7], M. Mokrousov[5], S. Nikiforov[5], A.B. Sanin[5], and A. Vostrukhin[5]. **[1]Dept. of Physics and Astronomy, University of Tennessee, Knoxville, TN, USA, ctate10@utk.edu**, [2]Dept. of Earth and Planetary Sciences, University of Tennessee, Knoxville, TN, USA, [3]Southwest Research Institute, Boulder, CO, USA, [4]Jet Propulsion Laboratory/California Institute of Technology, Pasadena, CA, USA, [5]Space Research Institute, RAS, Moscow, Russia, [6]University of Arizona, Tucson, AZ, USA, [7]Brown University, Providence, RI, USA.

**Introduction:** The Dynamic Albedo of Neutrons experiment (DAN) on the Mars Science Laboratory (MSL) rover *Curiosity* is designed to detect neutrons for the purpose of determining hydrogen abundance within the shallow subsurface of Mars [1,2]. DAN is capable of detecting neutrons through the use of two $^3$He proportional counters. One of these detects neutrons of energy up to 100 keV, while the other is shielded with cadmium and thus detects neutrons of energy above the Cd cutoff of ~0.4 eV [2]. DAN has two modes of operation [1,2]: an active mode that makes use of a pulsed neutron generator (PNG), and a passive mode, in which there are multiple sources of neutrons for DAN to detect. One source is derived from galactic cosmic rays (GCR). As these energetic particles propagate through the tenuous Martian atmosphere, some will interact with nuclei in the atmosphere, producing secondary free neutrons along with other particles [3]. The majority of GCRs, however, reach the surface of the planet and penetrate the subsurface up to a depth of ~1 meter, where they produce neutrons through spallation [3]. A separate source is the Multi-Mission Radioisotope Thermoelectric Generator (MMRTG), which produces energetic neutrons as a product of the decay of plutonium-238. These neutrons, along with the GCR-induced neutrons (both from the atmosphere and the subsurface), move throughout the subsurface and interact with the constituents of the soil through both elastic and inelastic scattering, which has the effect of moderating the energies of these neutrons [3]. Some neutrons escape from the surface, providing a leakage flux that the DAN counters can measure. The energy spectrum of these neutrons is dependent on the amount of hydrogen in the subsurface. A higher hydrogen content will lead to more moderation and thus a higher proportion of low energy (thermalized) neutrons. High thermal neutron absorption cross section elements (most prominently, chlorine and iron), however, have the confounding effect of removing thermal neutrons from the leakage flux [4].

**Methods:** Numerical simulations of the DAN detectors and the martian neutron leakage flux are necessary for understanding the measurements made by DAN in its passive mode. We use Monte Carlo modeling, specifically the Monte Carlo Neutral Particle-Extended (MCNPX) software package [5], which models the transport and interactions of neutrons and other particles within a user-defined geometry and compositional distribution. A single full scale simulation of the neutron environment on the surface of Mars is not computationally feasible because the volume of the DAN detectors is negligible compared to the volume of the atmosphere of Mars and its near-surface regolith. Thus, our model consists of 3 steps that decouple the individual neutron sources contributing to the signal and improve simulation uncertainties [6]. In one step, GCR interactions are simulated from the top of the atmosphere down to 3 m above the surface. The results from this simulation as inputs into the next step, a local-scale simulation from 3 m above the surface to 10 m below it that contains a model of the rover and DAN detectors [6]. In a third step, the interactions of MMRTG-sourced neutrons with an appropriate initial energy spectrum [6,7] are also simulated at a local scale. Results from these simulations are normalized by taking into account the number of source particles per second from the MMRTG [7], and by calibrating the instrument with results from both the MSL Radiation Assessment Detector (RAD) penetrating counter and DAN active mode to estimate the GCR neutron contribution to the count rates [6].

**Results**: DAN passive thermal neutron count rates show substantial variation from Bradbury Landing to Amargosa Valley. In driving from Bradbury Landing to Amargosa Valley, beyond which are the Mount Sharp basal units of Pahrump Hills, the *Curiosity* rover covered slightly less than 9.5 kilometers along the floor of Gale crater, crossing a variety of geological units and terrain types. Preliminary values reported here are hydrogen in the form of water equivalent hydrogen (WEH). WEH estimates have been made by using absorption equivalent chlorine (AEC) results from DAN active-mode measurements for each fixed location to uniquely infer the WEH for a given location. The term "fixed location" refers to locations where the rover stopped and investigated for any period of time (usually overnight). This is in contrast to continuously acquired traverse data from passive DAN measurements, which are taken while the rover is driving. For these measurements, no other surface or subsurface data are available to help constrain the AEC abundance.

WEH estimates from analyses of DAN passive measurements from fixed locations along the rover's route (Fig. 1) range from 0.3 ± 0.1 wt. % to 8.5 ± 1.3 wt. %. The average WEH value is 3.7 wt. %, and the standard deviation of WEH values is 1.7 wt. %.

DAN also acquired passive data continuously (Fig. 2) while the rover was traversing between fixed locations. These data produce WEH estimates that range from 0 ± 0.2 to 11.7 ± 2.0 wt. %. In this analysis, an AEC value of 1.05 wt. % has been used for all points, following previous assumptions [6].

There are, however, a handful of data points containing both extremely low and extremely high thermal neutron count rates that are not fit by the current models. Further investigation into these specific points will be required in order to better understand the data at these locations. This will include anomalous regolith composition simulations and further constraints on the environment at the time of data acquisition. As stated, however, there are no measurements from other instruments to give insight into the AEC abundance at the times of acquisition of these data, *i.e.*, when the rover is driving.

Reasonable point-to-point (~2-3-m-scale) correlation between WEH estimates is observed, however, no correlations with surface textures or rock abundances in image data have been found. This is not particularly surprising, though, given that bulk subsurface composition is the largest contributor to variations in DAN passive measurements.

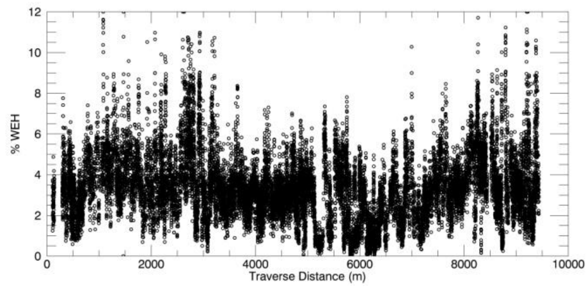


**Fig. 2.** WEH estimations from DAN passive data acquired during rover traverse segments from Bradbury Landing to Amargosa Valley.


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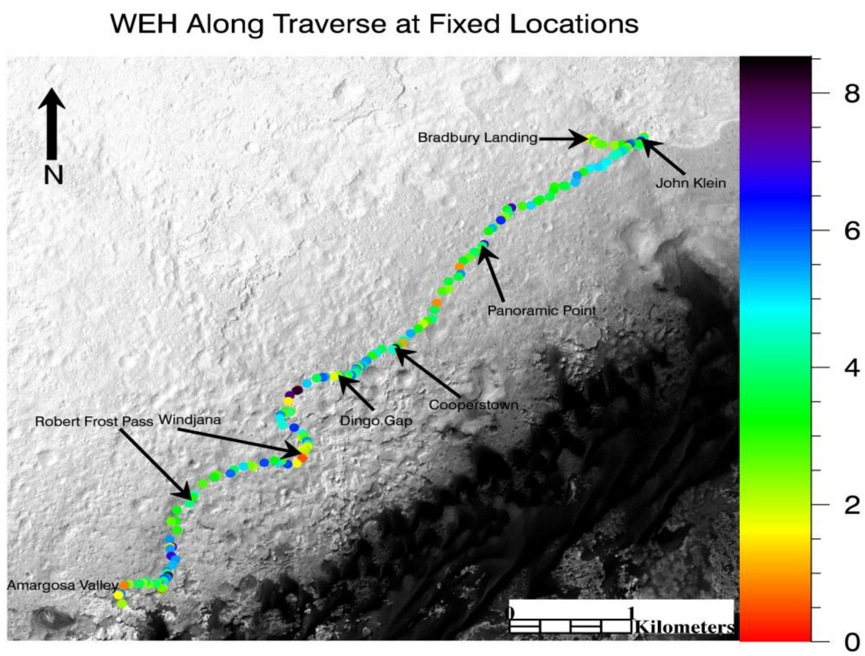


**Fig. 1.** WEH estimates from DAN passive data at fixed locations from Bradbury Landing to Amargosa Valley.