Depth distribution of Chlorine at the Gale crater according to DAN and APXS measurements onboard the Curiosity. M. L. Litvak[1], I. G. Mitrofanov[1], R. Gellert[2], M. V. Djachkova[1], D. I. Lisov[1], A. R. Vasavada[3], [1]Institute for Space Research of Russian Academy of Sciences (Moscow, 117997, Russia), [2]University of Guelph, [3]Jet Propulsion Laboratory, California Institute of Technology.

Introduction: Chlorine is considered an important chemical component of the martian surface material. NASA's Curiosity rover carries a sophisticated instrument suite capable of measuring surface elemental composition [1]. It was sent to Gale crater to investigate potential habitability by exploring layered sediments enriched with hydrated mineral phases [1,2]. In this work we used APXS and DAN data to evaluate how chlorine is distributed vertically in the shallow subsurface.

Measurements: Dynamic Albedo of Neutrons (DAN) [3] exploits a pulse neutron generator (PNG) to irradiate the subsurface under the rover with short high energy neutron pulses and detects the induced neutron albedo of the subsurface at thermal and epithermal energy ranges, which strongly depends on the water distribution and the presence of neutron absorbers in the Martian soil [4]. Chlorine is one of the primary elements causing thermal neutron absorption due to its unique combination of relatively high subsurface concentration and elevated neutron absorption cross section [4]. DAN irradiates and then collects neutrons from an area of radius 1.5 m and from a depth as deep as ~50-60 cm [5]. Therefore, DAN accesses a volume up to 5 cubic meters of martian soil/rocks below/around the rover.

The APXS instrument [6] uses particle induced X-ray emission (PIXE) and X-ray fluorescence (XRF) methods to determine the abundance of major, minor and trace elements in rocks and soils starting with sodium. To induce X-ray emission in the samples it is equipped with the radioisotope curium-244 emitting energetic alpha particles and X-rays [6]. The APXS has a field of view of around 17 mm in diameter. The APXS chlorine signal originates from about 15 micrometer depth which can be impacted by airfall dust and other loose surface materials. To examine dust free surface targets the MSL Dust Removal Tool (DRT) is used before APXS measurements.

Drilling is done to acquire powdered material for the sampling instruments (SAM and CheMin). It is also a unique opportunity to compare dust-free surface APXS data with the composition of tailings and the powder from ~ 1.5 to 5-cm depth at the same location/rock. A majority of the drill holes show highly elevated Cl (and Br) in the DRT surface, compared to the powder from deeper in the rock, while the major bulk chemistry is usually comparable.

Results: In our analysis we focused our efforts on the evaluation of the chlorine depth distribution and used APXS and DAN instruments data sets [7]. We compared chlorine measured at drilling locations by APXS before drilling (brushed surface, surficial chlorine), chlorine measured by APXS from drill tailings (1.5 – 5 cm depth) and chlorine measured by DAN around drilling location (tens of cm depth), see Figure 1. DAN is measuring the so-called absorption equivalent Cl (AEC) that account for concentrations of all neutron absorbers in martian subsurface (not only Cl but for example such elements as Fe, Ti, Gd, B). Therefore, DAN AEC values measured around drilling spots were converted to true chlorine mass fractions using APXS elemental compositions of non-Cl elements retrieved from the examination of drill tailings.

These measurements have been acquired from ~ 30 drill holes made by Curiosity along its 30 km drive. Joint analysis of APXS and DAN data has shown that the chlorine distribution at Gale crater could consists of two components (Figure 1).

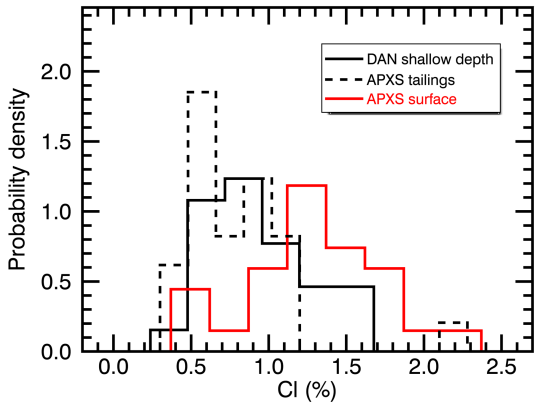

Figure 1. The distributions of surficial (~15 microns depth) Cl measured by APXS at brushed drilling spots (red color), Cl measured by APXS at drill tailings (1.5 – 5 cm depth, see dash line) and shallow depth (50-60 cm depth) Cl derived from DAN observations acquired around the same drilling spots (black curve).

The surficial chlorine (DRT/APXS) with concentration >1% is thought to be primarily controlled by aeolian deposition of Cl-rich dust and following rock surface alteration, and subsurface chlorine (drill powder/APXS and DAN) with concentration <1%, is

likely to be associated with groundwater activity in the past.

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