Chlorine in Gale Crater, Mars: comparing data from DAN and APXS instruments onboard the Curiosity rover

Denis Lisov¹, Maya Djachkova¹, Ralf Gellert², Maxim Litvak¹, Igor Mitrofanov¹, and Sergey Nikiforov¹
¹Space Research Institute, Moscow, Russian Federation (lisov@np.cosmos.ru)
²University of Guelph, Guelph, Canada

The Dynamic Albedo of Neutrons (DAN) experiment onboard the MSL Curiosity rover performs active neutron measurements at the rover’s stops. It produces short pulses of high-energy neutrons and observes the time profile of slowed down neutrons leaking from the subsurface. Due to neutrons’ high penetrating power it is sensitive to the abundance of neutron moderating elements (mostly hydrogen) and neutron capturing elements (most significant are chlorine and iron) in approximately top 60 cm of the subsurface under the rover, a few tons of matter in total. The DAN data processing procedure is based on numerical simulations of neutron propagation, moderation and capture with the MCNPX software package and returns both the model acceptance probability and the best fit estimates for \( H_2O \) mass fraction and equivalent Cl mass fraction. The latter corresponds to the total neutron absorption of the subsurface assuming a fixed Fe content. If external information on Fe content is available from other measurements, the DAN equivalent Cl mass fraction can be transformed into an estimate of the real Cl mass fraction in the subsurface.

We compare the DAN data on neutron absorption in the subsurface to the data on the Cl and Fe mass fractions on the surface as measured by the APXS instrument in different regions along the Curiosity path. Our analysis shows that the DAN and APXS measurements taken at the same location are in many cases not consistent with each other as the neutron absorption corresponding to the surface concentrations of chlorine and iron measured by APXS is too high to be accepted by the DAN data.

We investigate this finding in several regions along the Curiosity path. E.g., for the Glen Torridon region the DAN neutron absorption level for different measurements corresponds to the average chlorine mass fraction of 0.81% with a standard deviation of 0.18% and with typical measurement uncertainty of 0.10% (assuming the Fe mass fraction measured by APXS), while the chlorine mass fraction measured by APXS is 1.19% on average with a standard deviation of 0.43%. These two distributions are significantly different, and only 22% of the DAN measurements in the Glen Torridon region agree with the APXS-based neutron absorption for the same location.

We discuss several possible causes for this inconsistency, including either differences between Cl abundances in the martian dust particles and in rocks, or differences between Cl content in the
very top surface layer and in the subsurface, or possible bias in APXS target selection.