DEGRADATION OF THE ORGANIC MOLECULES IN THE SHALLOW SUBSURFACE OF MARS DUE TO IRRADIATION BY COSMIC RAYS. A. A. Pavlov[1], G. Vasilyev[2], V. M. Ostryakov[2], A. K. Pavlov[2] and P. Mahaffy[1], [1]NASA Goddard Space Flight Center, Code 699, Greenbelt, MD 20771 (alexander.pavlov@nasa.gov), [2]Laboratory of Mass Sectrometry, Ioffe Physico-Technical Institute of Russian Academy of Sciences, St. Petersburg, Russia

Introduction: Detection of the organic matter on Mars is one of the main goals of the future martian landing missions. Yet, degradation of organic molecules by cosmic ray irradiation on Mars is often ignored. We calculated the organic degradation rates due to exposure to solar cosmic rays (SCRs) and galactic cosmic rays (GCRs) at various depths in the shallow Martian subsurface. We demonstrated that the heavy organic molecules would not survive in the shallow subsurface of Mars if the exposure age of a geologic outcrop would exceed 300 Myr. Our results have direct implications to the current Mars Science Laboratory (MSL) mission.

Method: We first calculated the ionization rates using the new version of the standard GEANT4 code (http://geant.cern.ch) - an approach similar to [1]. Then, we used the calculated ionization rates and the radiolysis constants for aminoacids from [2] to calculate the time of exposure necessary to destroy organic molecules of various masses at different depths on Mars.

Results: Fig 1 shows the time of exposure needed to decrease abundance of organic molecules a 1000-fold at 4-5 cm depths which is the max depth of MSL sample drilling. At 4-5 cm depths SCRs produce noticeable but not the dominant contribution towards the degradation of organic molecules. We found that 100 amu organic molecules could be detectable at 4-5 cm depths even after 1 billion years of exposure to both SCRs and GCRs. Given that at least 3 cm of soil would be eroded in this period of time we conclude that 100 amu organic molecules have a decent chance of detection by MSL. In contrast, heavier organic molecules (300 amu and larger) make a 1000 fold drop due to ionizing radiation in less than 300 Myr. Furthermore, the degradation rate due to GCRs at 20 cm depth decreases only by ~10% comparing to the degradation rate at 5 cm. Therefore, assuming even the higher average rates of erosion (1 nm/year), heavier organic molecules were likely to be degraded by ionizing radiation at the depths of MSL's future drilling.

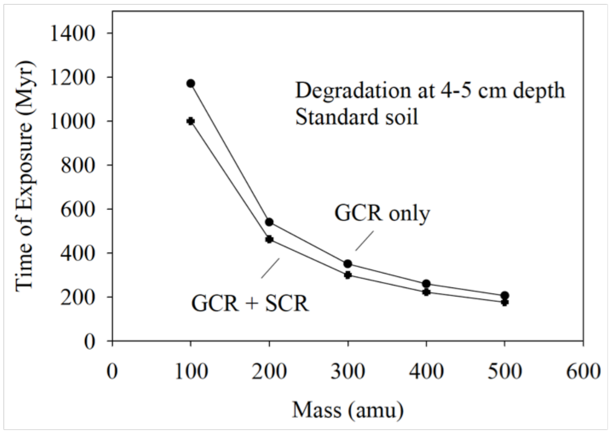

Fig 1 Time of exposure of the Martian rocks at 4-5 cm depth necessary to degrade various organic molecules (100-500 amu) below the MSL detection limits.

Conclusions: Our modeling results suggests that heavy ancient organic molecules (biological or abiotic from meteorites) can be effectively destroyed in the shallow Martian subsurface by cosmic rays. We find that the radiation dose accumulation rates from galactic cosmic ray particles are not very sensitive to the type of rock in the first 20 cm of the Martian regolith. We find that the solar cosmic rays (SCRs) destroy organic compounds effectively in the first 2cm of the martian rock, while below 2 cm organic matter is destroyed primarily by the galactic cosmic rays (GCRs). We show that the preservation of the ancient complex organic molecules in the shallow (~10 cm depth) subsurface could be highly problematic if the exposure age of a geologic outcrop would exceed 300 Myr. We demonstrate that more simple organic molecules with masses ~100 amu should survive in the shallow subsurface of Mars for ~1 billion years and can be detected by MSL.

References:

[1] Dartnell L. R. et al., (2007) *GRL, 34,* doi:10.1029/2006GL027494. [2] Kminek J. L. and Bada J. L. (2006) *EPSL, 245*, 1–5.