Abundance of cosmogenic noble gases as a marker of the organic degradation by cosmic rays in the surface Martian rocks. Implications to MSL and Mars 2020. A. A. Pavlov[1], G. Vasilyev[2], V. M. Ostryakov[2], A. K. Pavlov[2], P. Mahaffy[1]; [1]Planetary Environments Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA (alexander.pavlov@nasa.gov), [2]St. Petersburg State Polytechnical University, Polytechnicheskaya 29, St. Petersburg, Russia.

Introduction: Only recently, long-term exposure to cosmic rays (CRs) has been recognized as a major environmental factor, which can alter and destroy organic molecules in the Martian surface rocks [1,2]. This topic is important because the entire strategy of the Mars Exploration Program's search for the extinct life on Mars is based on the assumption that some original complex organic molecules would be able to survive for hundreds of millions - billions of years in the ancient Martian outcrops. Moreover, current MSL, future Mars2020 will sample only the top few cm of the surface Martian rocks. Organic molecules at those depths are essentially unprotected against cosmic ray radiation. Total degradation of the organic molecules in the surface rocks is a cumulative effect. Therefore, it is critical to determine dosages of radiation which are accumulated in the exposed Martian outcrops over time.

Sample Analysis at Mars (SAM) measured abundance of cosmogenic nuclides (^{3}He, ^{21}Ne, ^{36}Ar) in the mudstone on the floor of the Gale crater, which allowed determination of the cosmic ray exposure ages of the Martian surface rocks at that location [3]. Such analysis will continue throughout MSL mission and might be possible in the future Mars 2020 mission as well. Therefore, it is important to understand how measurements of the cosmogenic nuclides abundance can constrain the cumulative radiaton dosages in the surface rocks and the degree of degradation of the organic molecules on Mars.

Here we conducted a modeling study which links the rates of cosmogenic isotopes production with the radiation accumulatin rates on Mars. Calculations were performed for various incident spectra of galactic cosmic rays (GCRs) and solar cosmic rays (SCRs), various chemical composition of the surface rocks and various atmospheric thickness.

Methods: To calculate the full cascade of nuclear reactions and simultaneous loss of particles' energy due to ionization, we used the standard GEANT4 code (http://geant4.cern.ch).

In our calculations we considered GCR particles in the 20 MeV - 10000 GeV energy range, while SCR particles were assumed to have energies in the range of 1 MeV – 2 GeV. The incident flux and energy distribution of the GCRs at the top of the Martian atmosphere were adopted from [4]. Atmospheric column was varied from 0-500 mbars of CO_2. Surface rock composi-

tion was taken from [3] with varied amounts of Cl and H_2O. The cases of pure SiO_2 and Fe_2O_3 were considered as well.

Results:
1) We found that SCRs produce cosmogenic nuclides (e.g. ^{21}Ne) at a comparable rate to GCRs in the top few cm of the Martian rocks despite 7 mbar CO_2 atmosphere and cannot be neglected in the interpretation of the surface exposure ages.
2) We discovered that the radiation dosage accumulation rates decrease more rapidly with depth than the rate of cosmogenic nuclide production. For example, at 2 meter rock depth (assuming rock density of ~2.5 g/cm^3) the radiation dosage accumulation rate from GCRs decreases by a factor of 20 while the rate of ^{21}Ne production decrease by just a factor of 5.
3) We determined the range of possible Martian atmospheric column masses under which cosmogenic nuclides would accumulate in the surface rocks while organic molecules would be effectively shielded from the cosmic ray destruction.
4) We calculated the effects of shielding from the potential surface ice layer on the production rates of cosmogenic isotopes in rocks underneath the ice and in permafrost soils.
5) We estimate the rate of organic degradation at Cumberland [3] based on the observed abundance of cosmogenic nuclides and new radiolysis constants [2].

References: [1] Pavlov A. A. et al. (2012) GRL doi:10.1029/2012GL052166. [2] Pavlov A. A. et al. (2014) LPSC 2014. [3] Farley et al., (2014) Science doi: 10.1126/science.1247166. [4] Adriani O., et al. (2011), Science, doi:10.1126/science.1199172.