RAPID DEGRADATION OF THE AMINO ACIDS IN MARTIAN SUBSURFACE ROCKS AND REGOLITH DUE TO EXPOSURE TO COSMIC RAYS.

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Introduction: Until recently, long-term exposure to cosmic rays (CRs) has not been recognized as a major environmental factor, which can alter and destroy organic molecules in the Martian surface rocks and regolith. This topic is critical 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 and soils. Organic molecules at those depths are essentially unprotected against cosmic ray radiation.

Recent modeling studies [e.g. 1] suggested that amino acids with masses >100 amu would be effectively destroyed in less than 1 billion years in the top 5 cm of the Martian rocks. However, Pavlov et al (2012) calculated the fraction of the survived organic molecules using conservative radiolysis constants derived from the gamma irradiation experiments on pure dry amino acid mixtures [2]. Cosmic rays can produce oxidative radicals in the immediate vicinity of the organic molecules within the rocks and increase the rate of organic degradation.

Methods: To evaluate the rate of amino acids degradation by cosmic rays in Martian rocks we exposed amino acids (AAs) mixed with SiO_2 and graphite powders to gamma ray ionizing radiation (an analogue of CRs) at room and -50 C temperatures. For the analysis of AAs abundance and distribution in SiO_2 powder we used the extraction procedure and liquid chromatography time of flight mass spectrometry techniques from [3]. The effects of accumulated dosage of up to 2 MGy were investigated by comparing the amount of AAs compounds in control (nonirradiated) samples relative to irradiated materials.

New radiolysis constants for aminoacids were derived. Radiation accumulation rates in the Martian rocks were derived with the state of-the-art GEANT4 code. Newly derived radiolysis constants were then combined with the radiation accumulation rates to determine the rate of organic destruction and alteration by Galactic Cosmic Rays (GCRs) and Solar Cosmic Rays (SCRs) on Mars.

Results: 1) The destruction rate of amino acids in silicate powder mixtures is dramatically higher than in pure dry amino acid mixtures. Therefore, all amino acid molecules, which were either produced (by biosphere) or deposited (by meteorites) on Mars earlier than 50-100 million years ago would have very little chance of survival in the surface Martian rocks.

2) The destruction rate of all amino acids increases dramatically even further if several percents of H_2O are added to the SiO_2. Therefore, hydrated minerals are the worst place to look for the intact ancient organic molecules on Mars.

3) Cold temperatures (-50 C) slow down the rate of amino acid degradation slightly. However, even under cold temperatures amino acids would be mostly destroyed in just 50-100 million years of cosmic ray exposure in the top meter of Martian rocks.

References: [1] Pavlov A. A. et al. (2012) GRL doi:10.1029/2012GL052166. [2] Kminek, G., and J. Bada (2006), Earth Planet. Sci. Lett. 245, 1-5. [3] Glavin D & Dworkin J (2009) P Natl Acad Sci USA 106(14):5487-5492.