PROTECTION OF BIOMOLECULES BY MARTIAN ANALOGUE MINERALS AGAINST THE EFFECTS OF RADIATION

G. Ertem[1], C. P. McKay[2] and R. M. Hazen[3]. [1]University of Maryland, Department of Atmospheric and Oceanic Science, College Park, MD 20742, [2]Space Science Division, NASA Ames Research Center, Moffett Field, CA, 94035, [3]Geophysical Laboratory, Carnegie Institution for Science, Washington, DC 20015 gertem@umd.edu.

Introduction: As analysis of organic compounds in meteorites and interplanetary dust particles (IDP) indicate, organic molecules that can be considered as building blocks of RNA, proteins and fatty acids, form in space and delivered to Earth, Martian surface, and other planets. The fates of organic material on the surface of Mars must be affected by the Martian environment, in particular by ultraviolet (UV) and other ionizing radiation: Exposure to ionizing radiation by charged, energetic particles arriving at the surface through the thin Martian atmosphere suggests that the fate of these organic molecules at or near the Martian surface must be very different than those on Earth . In addition to effects of radiation, these biomolecules may have been subject to effects of asteroid impacts. Accumulation and preservation of organic molecules at or near planetary surfaces is an essential step in life's origins.

We have been studying the effects of UV and gamma radiation, and asteroid impacts on the survivability of biomolecules in the presence and absence of Martian analogue soils and minerals.

Irradiation by UV was performed in a Martian Simulation Chamber, Fig 1, at a temperature range, pressure and atmospheric composition observed on Martian surface by the instruments on board of Mars Science Laboratory (MSL) rover.

Figure 1. Mars Simulation Chamber

Mineral-organic mixtures were placed onto aluminum plates with 3 cm diameter and 1 mm height. Penetration depth of UV radiation into the soil is at the sub-millimeter to millimeter range and depends on the properties of the soil.

The dose of UV radiation received by the samples during 30 h was equivalent to 5 Martian Sol (Sol: Martian day = 24 h 37 min): 0.028 W m^{-2} nm^{-1}.

Following the irradiation, organic compounds were extracted and analyzed by HPLC (High Pressure Liquid Chromatography).

Results demonstrated that purine, pyrimidine and uracil are greatly protected against the effects of UV radiation when they are mixed with Martian analogue minerals, i.e., calcium carbonate, calcium sulfate, kaolinite and Atacama soil. The organic loss was only 1-2%. In the absence of minerals, on the other hand, the same dose of UV radiation has completely degraded these organic compounds.

For comparison, we also studied the effects of gamma radiation on mineral-biomolecule mixtures. Gamma rays have considerably higher energy (> 2 x 10^{-14} Joule), compared to UV radiation (5 x 10^{-19} to 2 x 10^{-17} Joule). Samples were prepared as described for UV irradiation experiments: Organic-mineral mixtures were placed in 2 mL polyethylene tubes. Irradiation was performed at the Uniformed Services University, Bethesda, MD using Gamma Cell 40 from a ^{137}Cs source at 25 ^{0}C. Although Cs-137 itself is a beta emitter with a half life of 30.1 years, its decay product metastable Ba-137 further decays by gamma emission to the stable Ba-137 with a half-life of only 2.6 minutes. In the Gamma Cell 40, electrons are trapped before reaching the target sample. In these experiments, samples received a total dose of 3 Gray corresponding to approximately 15,000 days dosage on the Martian surface.

Irradiation of biomolecule-mineral mixtures by gamma radiation with a dose corresponding to only 15,000 years on Martian surface resulted in 10-12% organic loss.

We are going to present the effects of gamma irradiation from a Co-60 source with a dose corresponding to 1,000,000 years on Martian surface.

A number of missions to Mars and other planets are being planned to search for organic molecules and possible biosignatures. Therefore, it is of the utmost importance to investigate the survivability of organics under plausible surface conditions on the surface of each planet.