EFFECT OF SHOCK IMPACTS ON THE SURVIVABILITY OF RNA AND PROTEIN MONOMERS.

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Introduction: Organic compounds are delivered to Earth, and Martian soil from space via meteorites, comets, and interplanetary dust particles with an estimated amount of 2.4 x 10^8 g of organic carbon/year . A large number of organic compounds that are known as the building blocks of life have been identified in meteorites, such as amino acids [1], pyrimidines [2], purines [3], and sugar acids [4].

We are investigating the survivability and fate of RNA and protein monomers mixed with Martian analogoue soils against the effects of UV and gamma radiation, cosmic rays and particles, and shock pressures mimicking the asteroid impacts. We have demonstrated that purine, pyrimidine and uracil, which may be considered as important biomolecules in the chemical evolution and events leading to the origin of life, completely decompose when subjected to UV radiation corresponding to only 5 Martian days of UV dose on Martian surface. In the presence of Martian analogue soils, however, the same compounds experience only 1-2% percent of loss [5]. Experiments were run in a Martian Simulation Chamber.

In a recent study, amino acids and a peptide embedded in saponite clay were subjected to 12-28.9 GPa shock pressures, which translate into 2.4-5.8 km/s for silicate-silicate impacts on Earth [6]. They demonstrated that at the highest shock pressures, amino acids containing an alkyl side chain were more resistant to the effects of shock pressures than those with side chains carrying a functional group. Furthermore, extent of degradation of amino acids increased with the impact pressures. Cooper et al studied the survivability of sulfonic acid and phosphonic acid derivatives embedded in a meteorite matrix against the increasing shock pressures up to 42.9 GPa [7], which translates into natural silicate-silicate impacts at velocities of approximately 6 km/sec. This velocity range may well represent the impacts that occurred during early solar system evolution as well as asteroid impacts at oblique angles on most planetary surfaces.

Here, we report the results obtained by subjecting the building blocks of RNA (RiboNucleicAcids) and proteins mixed with Martian analogue soils and minerals, namely calcium carbonate, calcium sulfate, kaolinite and Atacama Soil, to increasing shock pressures of 10, 25 and 40 Giga Pascal mimicking the asteroid impacts.

Sample preparation and shock procedure. Mineral-organic mixures, containing the organic compounds at a known concentration were freeze-dried: i. e. kept at –85 ^oC and at 20-25 mbar for 24 hours to remove the water, where water undergoes sublimation, to produce a fine powder and subjected to shock impacts at NASA's Johnson Space Center with a Tungsten target assembly and stainless steel flyer. Organic compound-mineral mixtures have been subjected to increasing shock impacts, i.e., 10.5, 28 and 40 GPa. The impact speed was 1.364-1.379 km/s corresponding to 40.0 GPa (1 Gigapascal = 10 kilobars).

Analysis of organics extracted from minerals: 5'-adenosine monophosphate and 5'-cytidine monophosphate, 5'-AMP and 5'-CMP, respectively, were analyzed by high performance liquid chromatography, HPLC [8]. D,L-alanine was analyzed by gas chromatography-mass spectrometry, GC-MS [9]. Results demonstrated that organics are completely destroyed at shock pressures of 40 GPa. At 10.5 GPa, only about 4% of the organics survived, as opposed to only less than 1% survival at 28 GPa. Nature of the minerals employed did not considerably affect the decomposition ratio of the organics studied.

References:

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