Introduction: Polar, non-volatile organic compounds may be found on the surfaces or near surfaces of Solar System objects. Therefore, it would be appropriate to determine their survivability against the effects of irradiation in the presence of minerals identified on Martian surface and most probably on other Solar System bodies.

Effects of UV radiation: We have shown that Mars analog near-surface minerals and soils offer significant protection to biomolecules purine, pyrimidine, and uracil, which may have played a significant role in chemical evolution and in the events leading to the origin of life: In the absence of minerals, these organic compounds are completely degraded when subjected directly to UV photolysis equivalent to only 5 Martian day’s exposure [1]. However, similar UV exposure of the same biomolecules mixed with Martian analogue soils and minerals under the same conditions resulted in only 1-2% of organic lost [1], showing the protective effect of minerals for organics against the radiation effects as was suggested as early as in 1949 by John Bernal [2]. Minerals used was calcium carbonate, calcium sulfate, kaolinite and a soil sample from Atacama Dessert.

The penetration depth of UV radiation into minerals and soils is only about 1 mm depending upon the particle size and wavelength [3, 4]. The 1-2% loss may be the result of the location of organics, which were situated at less than 1 mm from the surface of the mineral-organic mixture exposed to UV light as the total height of our samples was 1 mm.

UV irradiation was performed in a Martian simulation chamber mimicking the conditions on the surface of the Red Planet [5]. These organic compounds completely decomposed upon mixing with iron oxide (Fe₂O₃) before UV irradiation. Likewise, rapid photodecomposition has also been observed for other transition metal oxides: pentose sugars arabinose, lyxose, ribose, and xylose have been shown to decompose in the presence of rutile (TiO₂) under ambient light conditions, but not in darkness [6].

Methods: As polar, non-volatile organic compounds, we used methyl- and ethyl- derivatives of sulfonic acids and phosphonic acids. CaCO₃ and CaSO₄ representing calcite and anhydrite, respectively, were chosen to represent the Martian analogue minerals. Mixtures of mineral and organic compound solution containing 100 ppm organic for each 400 mg mineral were freeze dried, i. e. kept at −85 °C and at 20-25 mbar for 24 hours to remove the water, where water undergoes sublimation, to produce a fine powder. These mixtures were irradiated with UV light from a Xenon lamp in the Martian simulation chamber [1].

Effects of gamma radiation: For comparison, we also investigated the effects of gamma radiation on the survivability of organic compound-Martian analogue mineral mixtures and alkyl-phosphonic and alkyl-sulfonic acid derivatives.

The energy range of gamma rays (> 2 x 10¹⁴ Joule) is significantly higher compared to UV radiation (5 x 10¹⁰-2 x 10¹⁷ Joule): Mineral-organic compound mixtures prepared as described for UV irradiation experiments were irradiated by gamma rays. Irradiation was carried out at the Uniformed Services University, Bethesda, MD using Gamma Cell 40 from a ¹³⁷Cs source at 25 °C: Cs-137 itself is a beta emitter with a half-life of 30.1 years. However, 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.

Mixtures of calcium carbonate and calcium sulfate with purine and uracil were irradiated by gamma radiation. The total gamma dose samples received was only 3 Gy (Gray), corresponding to about only 15,000 days of gamma dose on Martian surface [7]. Organic compound concentration was 25 ppm.

We have also investigated the effect of gamma radiation on the survivability of alkyl-sulfonic acid- and alkyl-phosphonic acid- derivatives mixed with calcium carbonate. The organic concentration was 100 ppm. These compounds are shown to be highly stable against the effects of oxidation, and shock impacts reaching 42 GPa (Giga Pascal) [8].

Organic compounds were extracted from the irradiated mixtures [1] and analyzed by Ion Chromatography (IC) and High Performance Liquid Chromatography (HPLC) [9]. Up to 90% of purine and uracil, and alkyl-phosphonic and alkyl-sulfonic acid derivatives survived the effects of gamma radiation when mixed with minerals.

These experiments demonstrate the possible protective role of minerals for the survival of organic compounds against the harmful effects of radiation on the surfaces or near surfaces of Solar System objects.