Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.33726

Survival of organic molecules exposed to UV radiation on planetary surfaces: the importance of mineral matrices.

SIMON GOUZY[1,2,3], FABIEN STALPORT[4], BENJAMIN RONDEAU[2], VASSILISSA VINOGRADOFF[3], ELISABETH LAPP[2], FLORIAN MASSUYEAU[5], MAXIME PINEAU[6,7], RACHEL GONTHIER[8], HERVÉ COTTIN[8] AND JOHN CARTER[9,10]

[1]Gemological Institute of America (GIA)
[2]Laboratoire de Planétologie et Géosciences (LPG), UMR 6112
[3]Physique des Interactions Ioniques et Moléculaires (PIIM), UMR 7345
[4]Laboratoire Interuniversitaire des Systèmes Atmosphériques (LISA), UMR 7583
[5]Univ Nantes, CNRS, Jean Rouxel Institute of Materials, IMN, F-44000 Nantes, France
[6]Laboratoire de Géologie de Lyon Earth - Planets - Environment (LGL TPE), UMR 5276
[7]Laboratoire d'Astrophysique de Marseille (LAM), UMR 7326
[8]Laboratoire Interuniversitaire des Systèmes Atmosphériques, UMR 7583
[9]Laboratoire d'Astrophysique de Marseille (LAM)
[10]Institut d'Astrophysique Spatiale (IAS)

On Earth, alteration minerals, from phyllosilicates to sulfates and amorphous silica, have proved to interact with organic molecules through multiple processes, as well as being catalysts of various biochemical reactions. Moreover, some of them, such as opal, have shown to be capable of preserving ancient traces of life, as demonstrated by the 3.48-billion-year-old fossils found in the Pilbara Craton, Australia. Over the last decade, alteration minerals have been found across the surface of Mars in relation to liquid water-induced sedimentary morphologies, in environments where prebiotic & biotic chemistry leading to life could have developed. However, while terrestrial rocks that host these organics are protected from most of the Sun's radiation by the Earth's atmosphere, this has not been the case for billions of years on Mars. These radiations penetrate the surface of the rocks by a few microns to several meters and UV radiation may induce significant damage to organic molecules. Furthermore, the process of aeolian erosion on Mars permanently exposes fresh materials, thereby accentuating the destructive impact of radiation on any potential organic molecules that may be present in outcrops. While the UV photoprotection offered by clay minerals such as montmorillonite or vermiculite has been extensively studied, the UV photostability of organics associated with silica-rich phases and silicification events has not previously been examined experimentally.

For this purpose, we exposed natural organo-mineral complexes to UV radiation: opal, chalcedony, sepiolite, and silicified sepiolite, naturally colored in pink by chromophoric polycyclic aromatic hydrocarbons known to be photodegradable. We monitored the evolution of the intensity of the pink color throughout the UV exposure using UV–visible spectroscopy as a proxy of the degradation of the organic molecules.

Our results show that each mineral host possesses a distinct capacity for the preservation of their organic molecules against UV radiation. Among them, opal proved to be the most efficient, far ahead of chalcedony and sepiolite. Furthermore, our results underline that silicification events of preexistent organic-containing minerals favor the long-term preservation of organics and therefore represent key targets for the search for traces of life on Mars and other planetary bodies.