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Microscale investigation of ultra-violet alteration of meteorite surfaces

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Abstract

Ultra-violet (UV) irradiation of organic-rich surfaces is common on many solar system bodies, including asteroids, comets, meteoroids, interplanetary dust, and the surfaces of some planets and moons. The photodegradation of organic matter at these surfaces is a complex process, as many different organic compound classes are present on these surfaces [1], [2]. UV irradiation of the Murchison meteorite yields methane and CO_2 [3], [4]. Furthermore, in UV (200-400 nm) irradiation experiments of the Murchison meteorite, using cavity ring-down spectroscopy and proton transfer reaction mass spectrometry we detected additional volatiles, e.g. alcohols, aldehydes, and ketones. Emission of methane and CO_2 continued for more than 400 hours. Many parameters in the photodegradation process remain unclear.

Using numerical models in R we simulated the penetration and attenuation of UV light into the meteorite surface, the kinetics of the photodegradation reactions, and the diffusion of methane outwards. Our results suggest a slow, kinetics- and organic matter-limited process is responsible for the long time-scale emissions.

To determine the attenuation depth of UV, and hence photodegradation, in meteorite material and to quantify the amount of organic carbon that can be photodegraded, we are now in the process of using focused ion beam (FIB) milling in combination with nanoscale secondary ion mass spectrometry (NanoSIMS) to investigate the top layers of the irradiated surfaces. We will present the results of the reaction and diffusion models and preliminary results from our NanoSIMS investigation of irradiated meteorite surfaces.

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