Photodegradation of extra-Martian organics: a source for atmospheric methane and volatiles?

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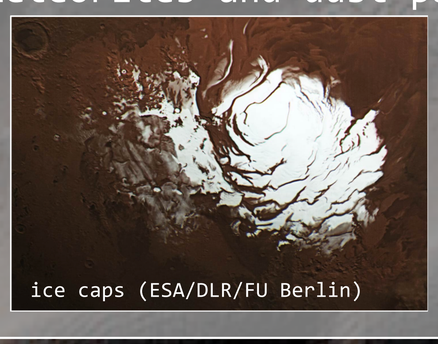
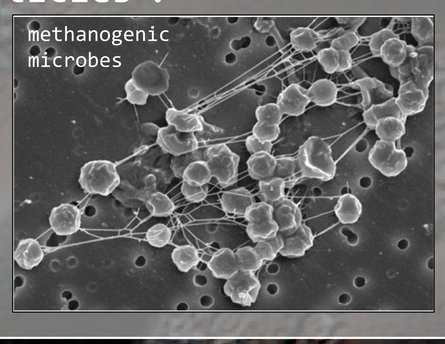
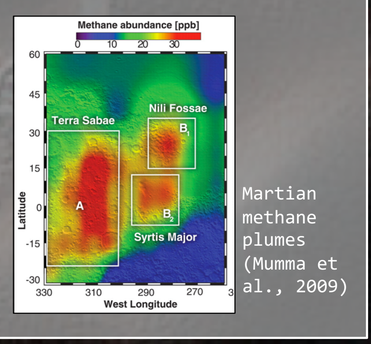
Introduction

The discovery of methane[1] in the atmosphere of Mars in the early 2000s has since posed one of the biggest questions in Martian atmospheric chemistry. This means that a methane source must currently be present on Mars. After all, methane has a short lifetime of only several hundred years[2]. Since the discovery, several sources of methane were hypothesized to be emitting to the Martian atmosphere: **serpentinization** reactions involving water, methanogenic **microorganisms**, release from **methane clathrates** (microscopic ice bubbles), and **photodegradation of organics** delivered to Mars through meteorites and dust-particles[3].



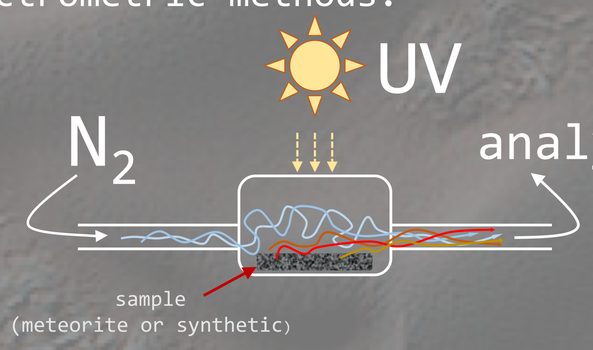




Martian methane plumes (Mumma et al., 2009)

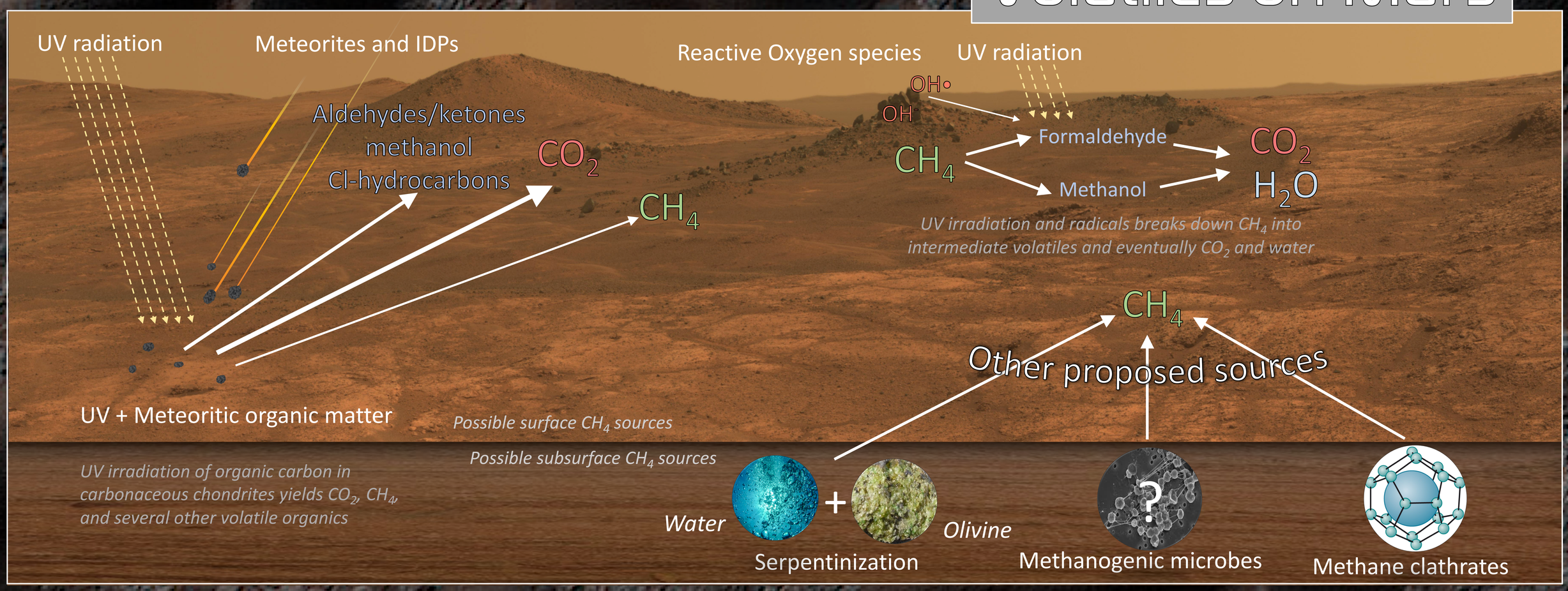
Lab simulations

To test the emission of extra-Martian material when UV-irradiated, samples of the Murchison meteorite or synthetic analogs, are placed in an N_2-flushed reaction chamber and irradiated. Trace gases are analyzed with spectroscopic and mass spectrometric methods.



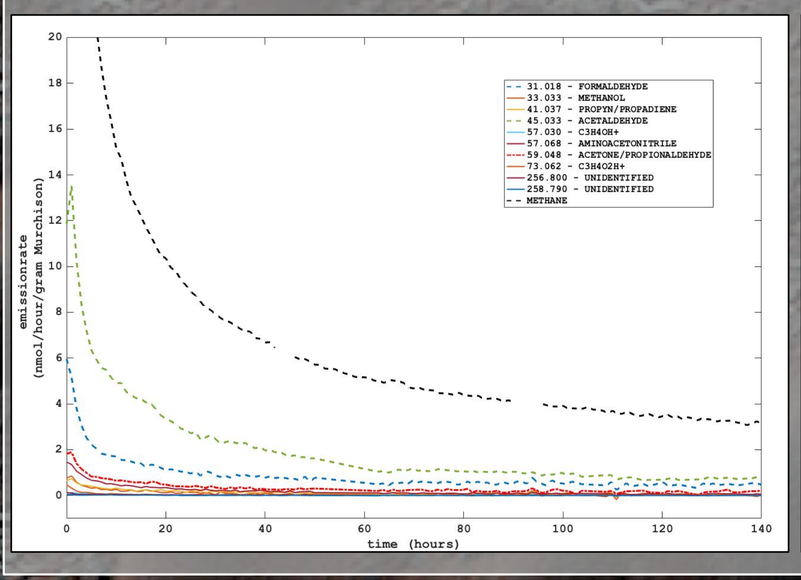
Meteorite material is irradiated in the lab. The reaction products are analyzed.

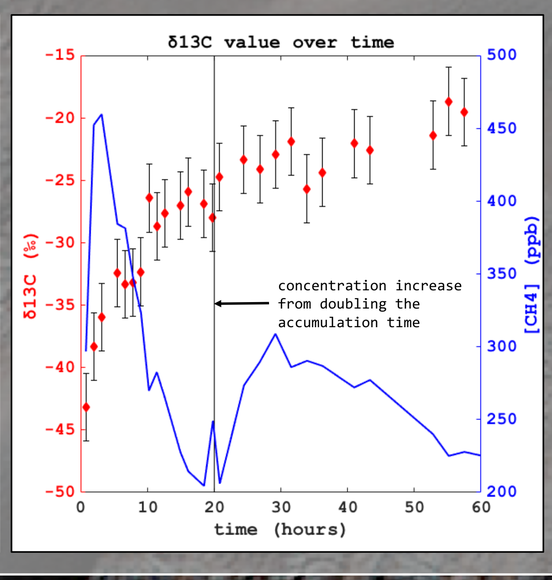
Volatiles on Mars



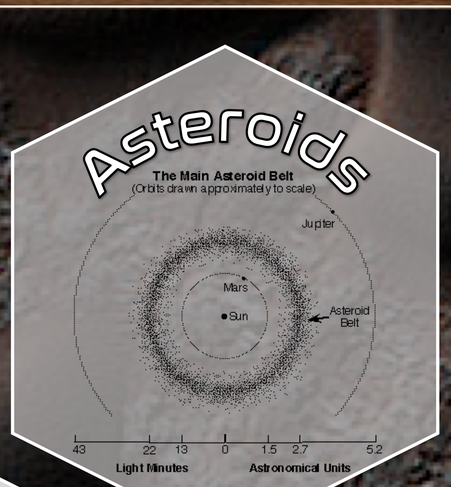
Results & Discussion

Irradiation of powdered Murchison material results in the release of methane, as previously reported and expected[4]. In addition, it is accompanied by several volatiles, of which formaldehyde, methanol, acetaldehyde, and propionaldehyde and/or acetone are the most abundant. Thus if Martian methane is of meteoritic origin, it would be accompanied by short chain (1 to 3 C) aldehydes/ketones. Furthermore, the isotopic data shows that fractionation occurs while methane is emitted from Murchison material. Initial methane emission is isotopically much lighter than after a day of emission in both $\delta^{13}C$ and δD. All methane emitted is isotopically much lighter than organics present in the Murchison meteorite.

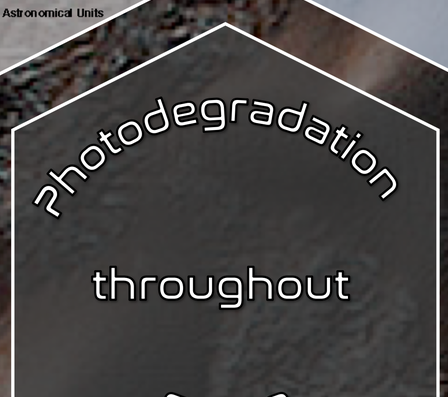


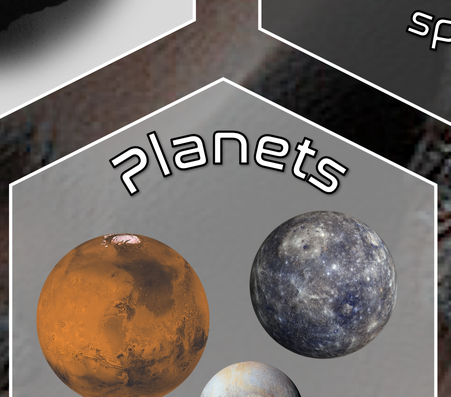


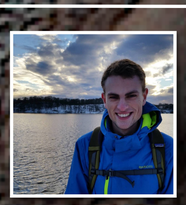
Figures showing the emission of methane and volatiles against time, and the $\delta^{13}C$ isotopic value of methane.



Not only meteorites undergo UV degradation. Many surfaces in the solar system experience strong UV irradiation. These include spacecraft, asteroids, dust, comets, and planets!







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Picture references: nasa.gov (planets, comets), solarviews.com(asteroid belt), oneworldoneocean.com (methanogens), ESA/DLR/FU Berlin (ice cap Martian north pole)

References: **1.** Mumma, M. J. *et al.* Strong Release of Methane on Mars in Northern Summer 2003. *Science (80-.).* 323, 1041–1045 (2009). **2.** Lefèvre, F. & Forget, F. Observed variations of methane on Mars unexplained by known atmospheric chemistry and physics. *Nature* 460, 720–723 (2009). **3.** Flynn, G. J. & Mckay, D. S. An Assessment of the Meteoritic Contribution to the Martian Soil. *J. Geophys. Res.* 95509, 497–14 (1990). **4.** Keppler, F. *et al.* Ultraviolet-radiation-induced methane emissions from meteorites and the Martian atmosphere. *Nature* 486, (2012).