SIMULATIONS OF MARTIAN SURFACE AND SUBSURFACE PROCESSES.

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Introduction: In 1976 the Viking missions landed on Mars with the aim to search for traces of extinct and extant life. Although these spacecraft carried a range of sophisticated instruments they not only did not find any traces of life, they did not even detect any organic compounds in the Martian soil. Early Earth and Mars were probanly seeded with organic material from meteorites and comets which have survived the impact. The current continuous, planet-wide meteoritic mass influx on Mars is estimated between 2700 and 59000 t/yr, which is equivalent with a meteoritic mass accretion rate between $1.8x10^{-5}$ to $4x10^{-4}$ g m^{-2} yr^{-1} [1]. Assuming that this flux has been constant over the last 3 billion years, the total accretion of meteoritic material is $5.4\text{-}12x10^4$ g m^{-2}.

Meteorites. Carbonaceous meteorites are known to contain 3-5% organic carbon by weight. Therefore the total organic carbon from extraterrestrial delivery on the surface of Mars $1.6\text{-}6x10^3$g m^{-2}. These numbers have to be considered as upper limits, due to large uncertainties in the estimate. However it was expected that organic compounds should be detected with a Viking GCMS instrument.

Destruction mechanisms. In the last decades several scenarios have been proposed to explain the absence of organic material in the results of the Viking experiments. Among those scenarios are various destruction mechanisms acting on the planetary surface, including short wave length UV radiation, and oxygen, H_2O_2, metal oxides or other oxidising agents [2]. However there is very little experimental support for these hypotheses.

In summary, the presence of organic compounds resluting from the meteoritic influx was expected to be high enough to be detected by the Viking GC/MS, and its non-detection was eventually explained by the presence of possible oxidizing reagents in the top surface of the planet. As consequence, any organic molecules may have been destroyed, altered or displaced into deeper soil layers (or below rocks), where they are protected from radiation and oxidation.

Mars Simulation Chamber (MSC):

Technical set-up. The Mars Simulation Chamber (MSC) (Figure 1) used for the experiments is a 80 cm long, 60 cm diameter vacuum chamber. It has 17 flanged portholes and a hinged door installed that allow access to the interior of the chamber.

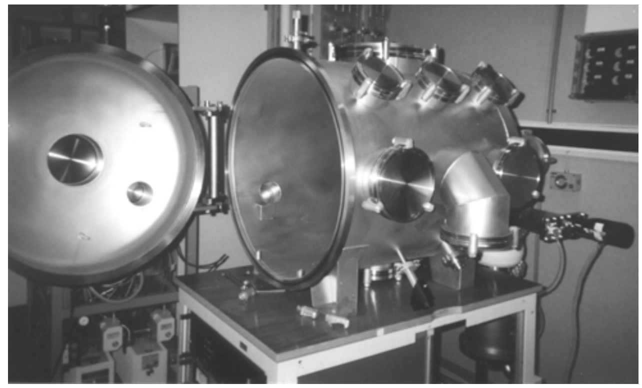

Figure 1 Mars Simulation Chamber

To simulate the current Martian atmosphere we use a mixture of N_2 (2.7 % volume), Ar (1.6 % volume), O_2 (1000 volumetric ppm), CO (500 volumetric ppm), H_2O (100 volumetric ppm) and CO_2 (rest of mixture) at the total pressure of 7 mbar.

Eight samples holders are used to introduce the organic samples in the chamber. These sample holders are 20 cm long stainless steel tubes with a diameter of 1.5 cm, sealed with an o-ringed stopper. They are mounted on a copper ground-plate that can be cooled by flushing liquid nitrogen through it. During the experiments in-situ measurements will be taken at three different depths by means of stainless steel streams connecting three sample holders to a GCMS.

A temperature gradient can be applied to the sample holders by only cooling the ground plate. A constant temperature can be maintained by a liquid nitrogen cooled cold shroud, which is placed around the sample holders. The temperature of the sample holders and the cold shroud can be set between liquid nitrogen temperatures and room temperature.

Experimental set-up. The experimental protocol comprises three parts: (1) preparation of the chamber, (2) setting the experimental parameters, and (3) in situ and post-processing measurements of the samples. In the preparation phase the sample holders are filled with a mixture of Martian soil simulant, JSC-1, organic compounds and at a later stage also oxidising agents. During irradiation, samples are taken from the volatiles inside the sample containers and fed to the GCMS in an automated way. Post-processing analysis of the samples will be conducted by high performance liquid chromatography (HPLC) and various other techniques, such as GCMS.

Organic compounds. The experiments have as a main goal to simulate various processes on organics, such as the effects of UV radiation, diffusion, and temperature, as a function of their depth in the soil. The specific organics will be embedded in either porous or compact Martian soil analogues or quartz beads.

Experimental approach. We are planning to investigate the following parameters in the vacuum chamber:

A. The effects of the changes of the Martian atmosphere over the history of Mars.

B. The effect of UV irradiation on organic molecules embedded in the soil.

C. The effect of oxidation on organic molecules embedded in the soil.

D. The effect of thermal cycling on the surface.

E. A combination of the above mentioned parameters.

Perspectives: The Mars Simulation Chamber (MSC) is used to validate measurements to be made by Beagle 2, and other future spacecraft missions to Mars. Using the MSC we will try to answer a range of questions on the subject of the apparent absence of organic compounds on Mars. Techniques to be used include gas analysis, environmental sensors, HPLC, spectroscopy and other analytical techniques.

We shall also assess the sensitivity of instruments for the detection of minerals and organic compounds of exobiological relevance in Martian analogue soils (mixed under controlled conditions with traces of these organics). The results concerning the simulation of complex organics on Mars, as well as lander instrument chamber simulations will be included in a database to serve for the interpretation of Beagle 2 data and other future Mars missions.

The results of the experiments can also provide constraints for the observations from orbit, such as spectroscopy of minerals, measurements of the water cycle, frost and subsurface water, the CO2 cycle, and the landing site selection.

To provide experimental ground support for the Mars Express mission, ESA established a network of Recognised Cooperating Laboratories, RCLs. In this framework our laboratory was selected in the Exobiology category to provide ground-based research, primarily for the gas analysis package. This research will be carried out using a Mars Simulation Chamber that is part of en experimental programme, developed at the European Space Research and Technology Centre of ESA (ESTEC) and Leiden University [3].

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