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# Turnover of Methane in the Martian Atmosphere

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## Abstract

The processes which release methane in the martian atmosphere and the processes which remove it are unknown. The present data on methane concentrations in the martian atmosphere are considered in the light of possible biological and abiological processes governing the turnover of methane.

## 1. Introduction

The detection of methane in the martian atmosphere [1] at a global average level of 10 ppbv and the resulting chemical nonequilibrium condition has led to speculation whether methane has to be regarded as a biomarker. The lack of $SO_2$ in the atmosphere is a sign against a volcanic source of the methane [2].

## 2. The Viking Biology Experiments

A re-interpretation of the results of the Viking Biology Experiments [3] suggests that organisms employing a hydrogen peroxide-water mixture in their intracellular fluid exist in the martian soil at the landing sites of the Viking Landers. The evolutionary advantages of $H_2O_2$-$H_2O$ mixtures are a freezing point below 220K, an implied source of oxygen and energy and hygroscopicity to attract water vapor from the atmosphere. The metabolism of these putative organisms, which produce $H_2O_2$ from atmospheric constituents, might well produce methane as a metabolite [3], see eq.(1):

$$CO_2 + 6\ H_2O + hv \rightarrow CH_4 + 4\ H_2O_2 \qquad (1)$$

As a source of energy, these surface-dwelling organisms have a sunlight at a wide spectral range available. Unlike on Earth, where methanogens decompose organic matter, on Mars the "methanogens" need sunlight in an assimilation process to produce hydrogen peroxide and methane or possibly other reducing compounds such as $H_2CO$ and CO.

## 3. Mapping the methane

Mapping the variations of the methane concentration in the martian atmosphere, both by observation from the ground [4] and with the PFS aboard Mars Express [5] have led to a picture of "plumes" of enhanced methane concentration, suggesting localized sources of methane. The photochemical removal of methane molecules from the martian atmosphere has been modelled, resulting in a half-life of a methane molecule of 100s of years. This would mean that even with very localized sources, the concentration of methane would even out over the whole atmosphere. Therefore, other processes have been suggested such as heterogeneous chemical processes driven by oxidants at the surface [6]. Moreover, such processes would only be effective if these occur over a widespread area.

## 4. Measurements by Curiosity

The latest measurements of the methane concentration in the martian atmosphere have been carried out by the SAM-TLS instrument on the Curiosity rover [7]. At variance with the earlier remote measurements, these localized measurements have resulted in a relative absence of methane, with an upper limit of 3 ppbv. For these measurements the atmosphere was sampled at sols 79, 81 and 106 after landing in August 2012. Sampling occurred during the night because of power budget constraints. If we suppose that methane is produced by photo-autotrophs, the lack of methane as measured in Gale crater can be explained by the lack of production during the nighttime, while the destruction of methane, especially close to the surface, removes the methane produced during the daytime.

### 4.1. Moisture at Gale crater

Another factor which may play a role is the lack of moisture in the atmosphere at these measurements [8]. For reaction (1) to proceed, the putative organisms have to use water extracted from the atmosphere. Seasonal variations of the methane concentration [9] also may point to a biological origin of methane.

## 5. Conclusions

The conclusion is that the methane concentration in the martian atmosphere may well reveal a diurnal cycle, as well as a depency on moisture. Therefore, daytime measurements of $CH_4$ by MSL are called for, and if still the lack of methane is repeated, the measurements had better be repeated at a season when there is more moisture in the atmosphere at Gale crater.

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