An Investigation of Martian Methane & Implications for Future Missions
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In July 2005, I attended a seminar at the Lunar and Planetary Institute discussing the recent detection of methane in the Martian atmosphere. Methane requires constant renewal in the Martian atmosphere, so this discovery implies the presence of methane sources on the planet. I am interested in refining the current measurements of methane levels, identifying regions of increased methane concentration, and investigating those regions to understand the source of Martian methane.

Research Justification

Recent spectrographic observations of Mars show evidence for methane in the atmosphere, but results vary widely. Krasnopolsky et al. [1] report detection of methane with a mixing ratio of 10 ± 3 parts per billion (ppb). Formisano et al. [2] detect methane with a mixing ration of 10 ± 5 ppbv, but with fluctuations between 0 and 30 ppbv over the planet. Mumma et al. [3] also detect methane, and suggest that enhanced methane may be correlated to regions with sub-surface hydrogen concentrations detected by Mars Odyssey. They report significantly higher levels of methane (>250 ppbv) than others. It is crucial to obtain an accurate estimate of methane levels in the Martian atmosphere before serious work can be done on potential sources.

Methane has a short photochemical lifetime (~300-600 years) in the Martian atmosphere and must therefore be replenished to exhibit the observed concentrations. A variety of methane sources have been proposed, including biogenic origin [2], hydrothermal activity [2], cometary impacts [2, 4], decomposition of clathrate methane hydrates [5], and serpentinization of basalts [5]. To evaluate these proposed sources, any local enhancements in the Martian atmosphere must be identified. Once identified, spacecraft measurements and images will be used to investigate the sources in greater detail, seeking correlation with geologic features and sub-surface hydrogen concentrations. Although quite short on a geologic time scale, several hundred years is ample time for methane to undergo uniform global mixing. Results suggesting localized concentrations imply that there must be processes actively removing methane from the atmosphere before mixing can occur. Atreya et al. [6] suggest electrochemistry in dust storms may produce hydrogen peroxide, an effective scrubbing agent. The presence of hydrogen peroxide would explain the uneven distribution of methane, as well as the surprisingly low organic content of the Martian surface detected by the Viking landers [7]. This possibility can be addressed by monitoring the seasonal variation of methane concentration, particularly in relation to global dust storms.

Proposed Research

To address the current questions about methane abundance and distribution on Mars, I propose observations with the Phoenix infrared spectrograph at Gemini South Observatory, or with a comparable instrument elsewhere. The very high resolution (R~50000 - 75000) of Phoenix is essential to identify the faint methane traces on Mars. The minimum slit width on Phoenix is 0.17" (2 pixels) allowing for spectra from specific regions of the Martian disk, which ranges in angular extent from ~5" to ~20".

Observations at latitudes from -80^o to 80^o at 10^o intervals will allow detection of any methane abundance gradients. By making multiple observations as Mars rotates, it will be possible to identify variations in abundance with longitude. Observations will be repeated at regular intervals over the Martian year (~2 Earth years) to identify any seasonal variations, particularly those related to global dust storms.

The primary goal of the proposed observations is twofold: to better constrain the global average methane abundance, and identify any geographic variations in that abundance. Additional goals include evaluating hypothetical methane sources and identifying seasonal changes in methane abundance that may give insight into the processes contributing to the Martian methane cycle. These research goals build directly on my experience with spectroscopy and infrared observations.

Results from these observations will give focus to future investigations with Mars-orbiting spacecraft. If geographic regions of localized methane production are identified, they may be primary candidates for future missions, in particular the Mars Science Laboratory (MSL) scheduled for launch in 2009. I am involved in developing an instrument the Mars Analytical Chemistry Experiment (MACE) designed to detect organic molecules on the Martian surface. In-situ investigation of possible methane sources would be ideal for this instrument.

I will use my experience with science writing to present the results of this investigation to the general public. The search for evidence of life on mars and the exploration of the solar system capture the imagination of the public and cultivate an interest in science and engineering that benefits society as a whole.

References

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I attest that this research plan is original and all ideas and proposed observations are my own.