Workshop on Methane on Mars
Current observations, interpretation and future plans
25-27 November 2009, ESRIN, Frascati, Italy

Methane has been detected in the Martian atmosphere by ground-based telescopes and from orbit. This discovery indicates that the planet is either biologically or geologically active. The goal of the workshop is to review the available measurements, the potential reservoirs and release mechanisms of Methane and its circulation in the atmosphere, and to discuss all possible origins of this constituent.

Deadline for abstracts: 1st September 2009
http://www.congres.nl/09c26/

O. Witasse, A. Chicarro, and J. L. Vago

ESA, ESTEC (NL)
Scientific Organising Committee

Nicolas Altobelli (ESA/ESAC, Madrid)
Sushil Atreya (The University of Michigan)
Vincent Chevrier (University of Arkansas)
Agustín Chicarro (ESA/ESTEC, Noordwijk)
Therèse Encrenaz (Observatoire de Paris-Meudon)
Enrico Flamini (ASI, Roma)
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Franck Lefèvre (LATMOS, Paris)
Paul Mahaffy (NASA Goddard Space Flight Center)
Michael Mumma (NASA Goddard Space Flight Center)
Buford Price (University of California, Berkeley)
Olivier Witasse (ESA/ESTEC, Noordwijk)
Richard W. Zurek (NASA Jet Propulsion Laboratory)
Some Numbers

- Almost 100 participants (66% Europe, 20% US, and the rest from other places);
- 3 days;
- 13 hours of talks;
- **4.5 hours of discussion**;
- 1.5 hours for posters;
- 5.5 hours breaks (lunch, coffee);
- 2 social events: welcome drink and dinner.
Joint ESA-ASI Methane Workshop, 27–27 November 2009, Frascati (I)

Excellent talks and motivated speakers

Lively discussions

Tough session chairs

Intense poster sessions
Sessions

1. Observations of methane from Mars orbit;
2. Earth-based observations of Martian methane;
3. Martian surface and subsurface data, and laboratory measurements relevant to the study of methane;
4. Origin of methane;
5. Storage, release, and delivery of methane;
6. Atmospheric circulation and chemistry;
7. Microbial life, metabolism in water ice, and biological experiments under Martian conditions;
Some highlights
Mars Express Observations

Vertical profile of H$_2$O, CO, and CH$_4$ during Spring

Note: No methane correlation with water vapour

Water vapor at 3873 cm$^{-1}$

CO at 4283 cm$^{-1}$

Methane at 3018 cm$^{-1}$

Message: Methane is not found close to the surface.
Earth-based Observations
Mumma & Villanueva

Message: Methane is found mainly over older terrain.
Summary of the observations

• Mars Express/PFS:
  – New CH$_4$ vertical profiles;
  – New maps, characterized by large contrasts on regional scales;
  – Maximum abundances of methane occur near the north pole in mid to late summer;

• Earth-based observations:
  – Confirmation of previous findings;
  – CH$_4$ is found over old terrains;

• MGS/TES observations of methane were also reported, showing an enhancement in methane over Tharsis and Arabia Terra;

• Further work is required to reconcile the spacecraft and ground-based observations.
Geological and Geochemical Context

Methane-rich regions seem to have landforms/mineralogy with possible implications for past methane-related geological processes. Correlating methane to regional geology is a potentially powerful tool that we are just beginning to explore.

Nillie Fossae (Ehlmann et al 2009)

Isidis Planitia Mounds (HIRISE)

Mud volcanoes
Terrestrial analogue
Origin of Martian Methane

• The presence of methane on Mars remains puzzling;

• Origin: biological or geochemical (or both);

• All other potential production mechanisms—exogenic (comets, meteorites), volcanic, and atmospheric—have been ruled out;

• If the production of methane is ongoing, it points to the presence of underground aquifers;

• If the methane was produced when Mars was supposedly warmer and liquid water flowed on the surface, it could have been stored (as clathrates) and is possibly being released from time to time.
New hypothesis (E. Chassefière): Methane release could come from clathrates in the atmosphere. This could explain the (not well established correlation with \( \text{H}_2\text{O} \)).
Conclusions

- The "conventional" atmospheric chemistry does not produce measurable methane variations on Mars, even in the case of a current, episodic, and localized source.

- The condensation/sublimation cycle of CO₂ should generate large-scale methane variations at high latitudes (but they differ from what is observed).

- CSHELL/NIRSPEC: In the most favourable case, an atmospheric CH₄ lifetime of less than 200 days (seasonal release) or ~2 Earth years (single event) is necessary to reproduce the observations.

- PFS: measurements at high latitudes require a lifetime of less than ~3 Earth years. Longitudinal variations at high latitudes and seasonal trends at mid-to-low latitudes cannot be reproduced.

- The CH₄ source: quantitative agreement with the observations requires considerable amounts:
  - ~150 000 tonnes CSHELL/NIRSPEC, seasonal release
  - ~80 000 tonnes CSHELL/NIRSPEC, single event
  - ~50 000 tonnes PFS, polar summer

  Mid-Atlantic Ridge: 50 000-130 000 t yr⁻¹ (Keir et al., 2005)
Conclusions

Solutions?

➢ fast atmospheric loss of methane by chlorine:
  ▪ is not supported by observations of HCl

➢ fast atmospheric loss of methane by electrochemistry:
  ▪ is not supported by current observations of CO, H₂O₂, and O₃

➢ fast loss of methane in the regolith:
  ▪ must be extraordinarily rapid (< 24 h) to satisfy the observations
  ▪ is not supported by current observations of other minor species (CO, H₂O₂, O₃), or must be highly selective
  ▪ is for the moment not supported by laboratory data (Gough et al., this workshop)

→ Observed variations of methane are unexplained by known atmospheric chemistry and physics
A fascinating and very educational series of reports on microbial life, metabolism in water ice, and biological experiments under Martian conditions was presented by many authors.

The presentations considered perchlorate-reducing bacteria, microbes trapped in extreme environments, the mechanism and complexity of terrestrial methanogenesis, the extent to which cryoenvironments could be active microbial ecosystems, terrestrial analogs and methanogen energy sources.
Future Measurements

- Ongoing Mars Express measurements (until at least end of 2012);
- New observations with CRIRES on the Very Large Telescope;
- IRTF, Sofia, Herschel;
- MSL: SAM and TLS experiments (from 2012 onwards);
- ExoMars Trace Gas Orbiter (from 2017 onwards);
- ExoMars Rover: MOMA experiment (from 2019 onwards);
- Discussion raised the novel possibility of a satellite at a Mars Lagrange point to provide global imaging of atmospheric composition with very high spectral resolution.
Presentations

Available on-line at:

http://sci.esa.int/marsmethane2009

Including the book of abstracts and some pictures.
Proceedings

- A special issue is being prepared in *Planetary and Space Science*;
- 25 papers have been submitted;
- To be published after the summer 2010.
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