Methane on Mars ?

Loïc Trompet, Ann Carine Vandaele, Muriel Lepère

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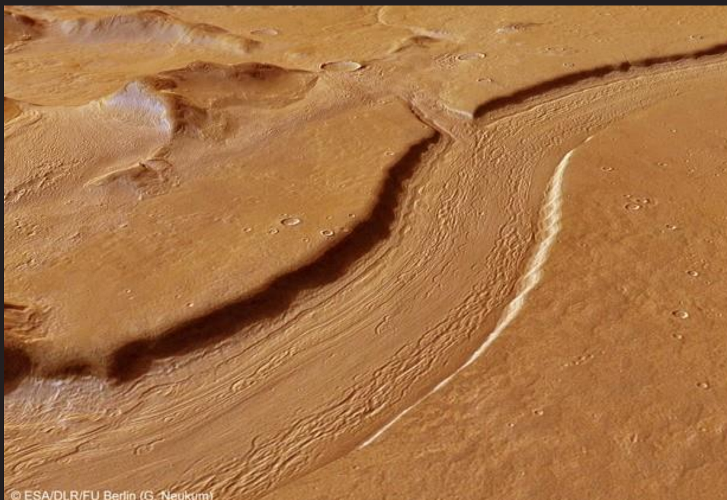
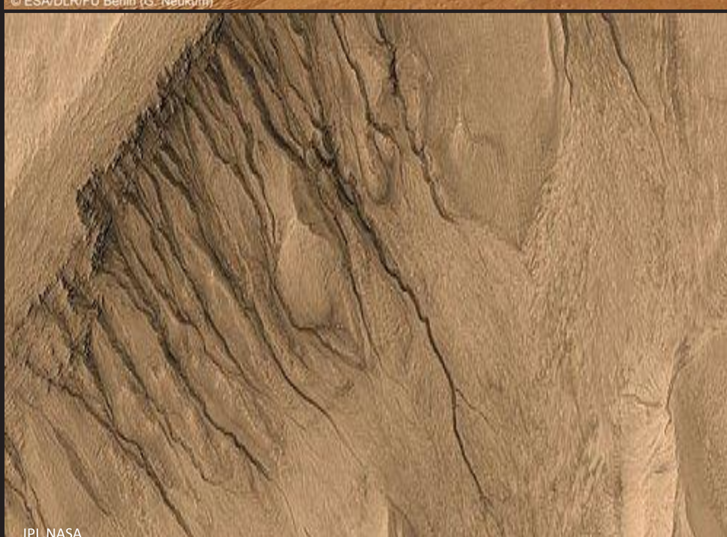
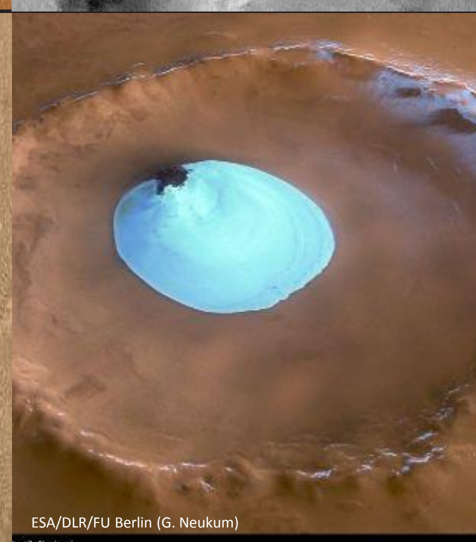
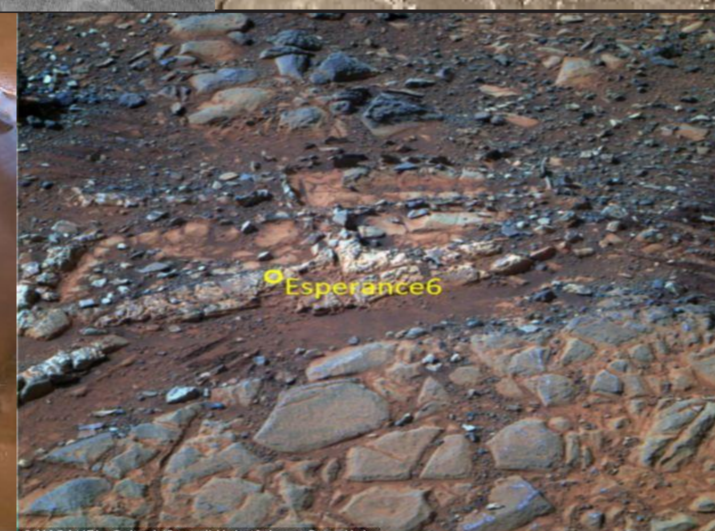
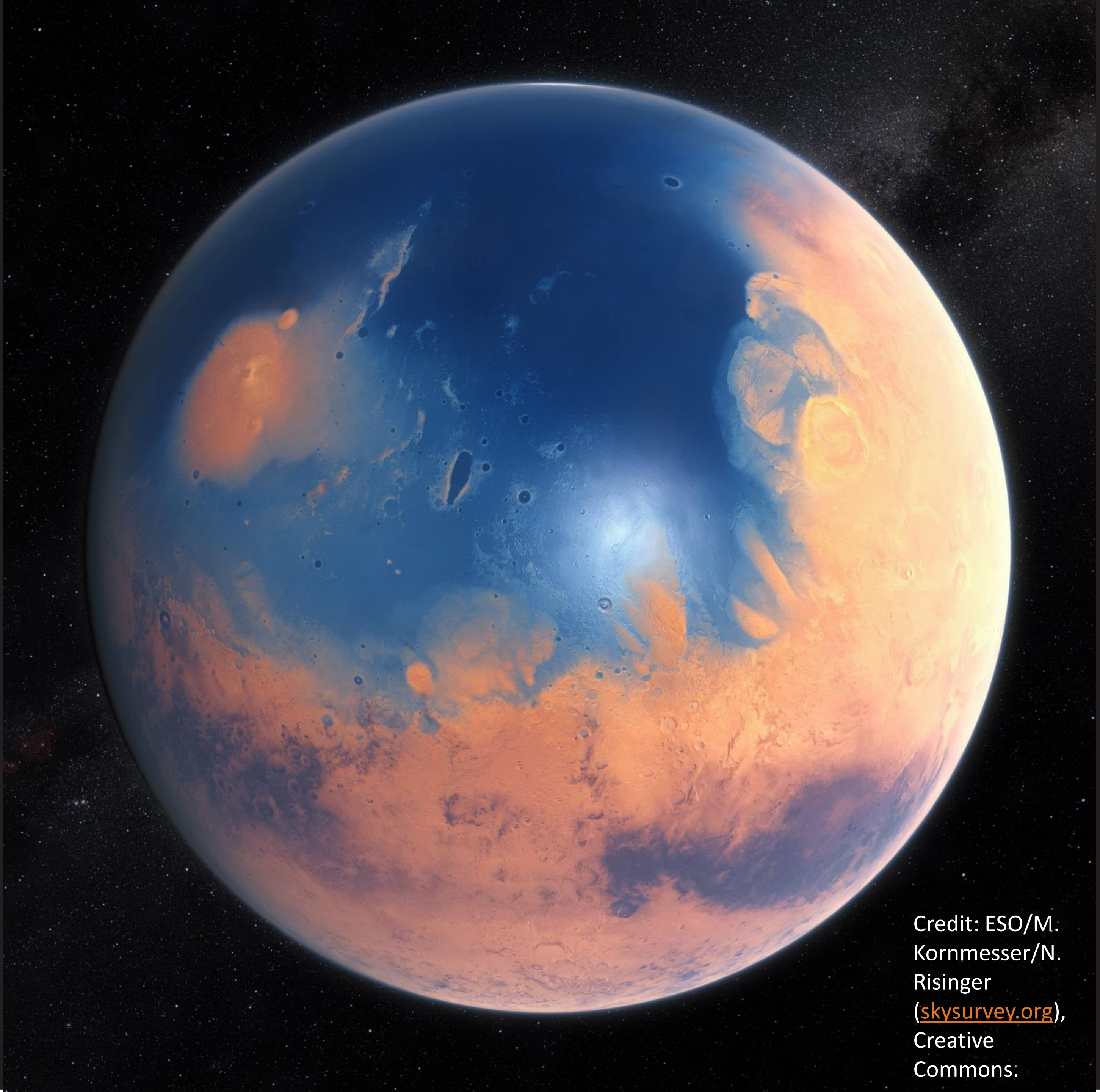
Water on Mars ?











REPORTS

Science, 2003

Detection of Methane in the Atmosphere of Mars

Vittorio Formisano,[1*] Sushil Atreya,[2] Thérèse Encrenaz,[3]
Nikolai Ignatiev,[4,1] Marco Giuranna[1]

We report a detection of methane in the martian atmosphere by the Planetary Fourier Spectrometer onboard the Mars Express spacecraft. The global average methane mixing ratio is found to be 10 ± 5 parts per billion by volume (ppbv). However, the mixing ratio varies between 0 and 30 ppbv over the planet. The source of methane could be either biogenic or nonbiogenic, including past or present subsurface microorganisms, hydrothermal activity, or cometary impacts.

ELSEVIER

Icarus 172 (2004) 537–547

www.elsevier.com/locate/icarus

Icarus, 2004

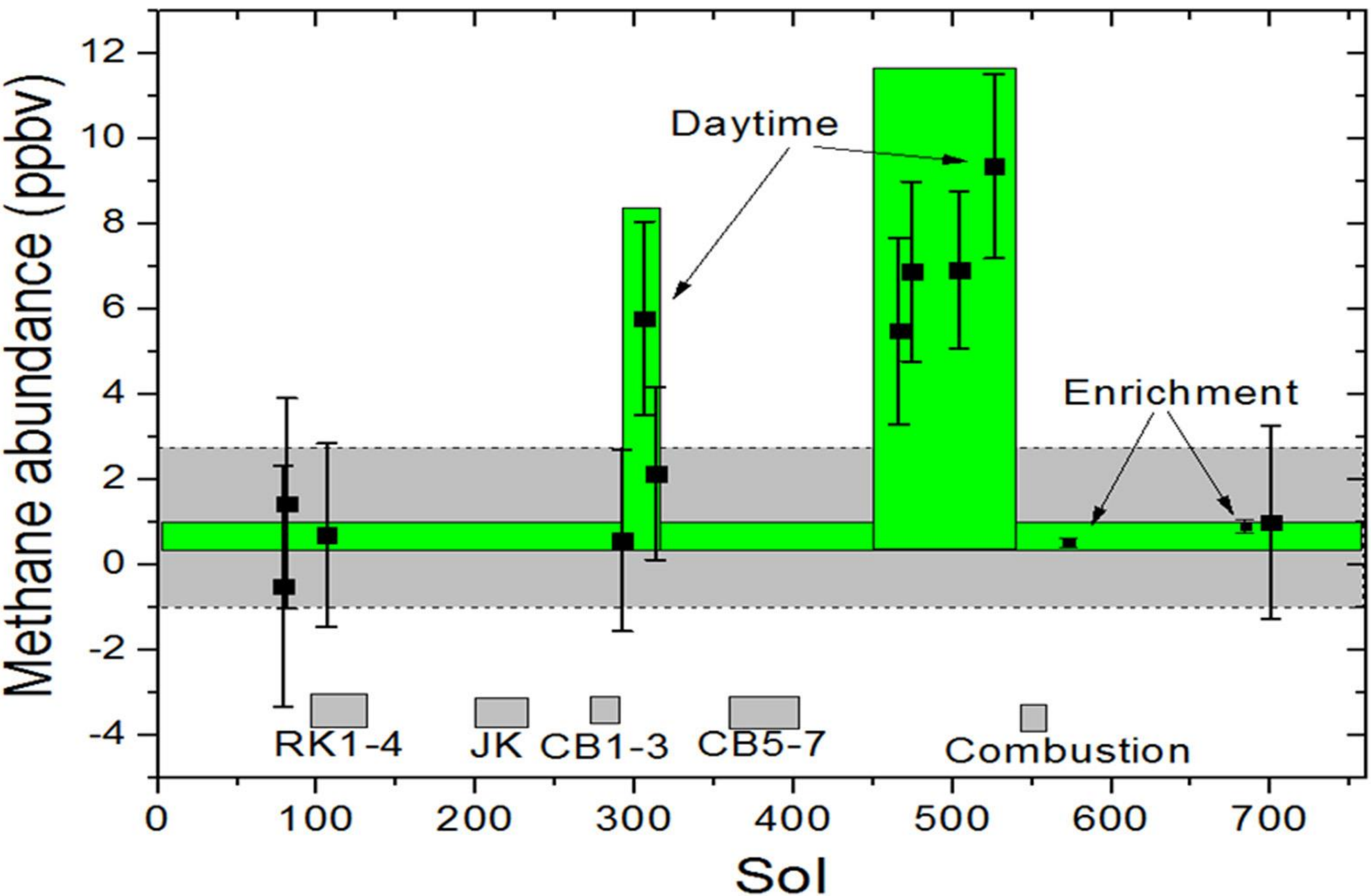
Detection of methane in the martian atmosphere: evidence for life?

Vladimir A. Krasnopolsky[a,*], Jean Pierre Maillard[b], Tobias C. Owen[c]

Science, 2009

Strong Release of Methane on Mars in Northern Summer 2003

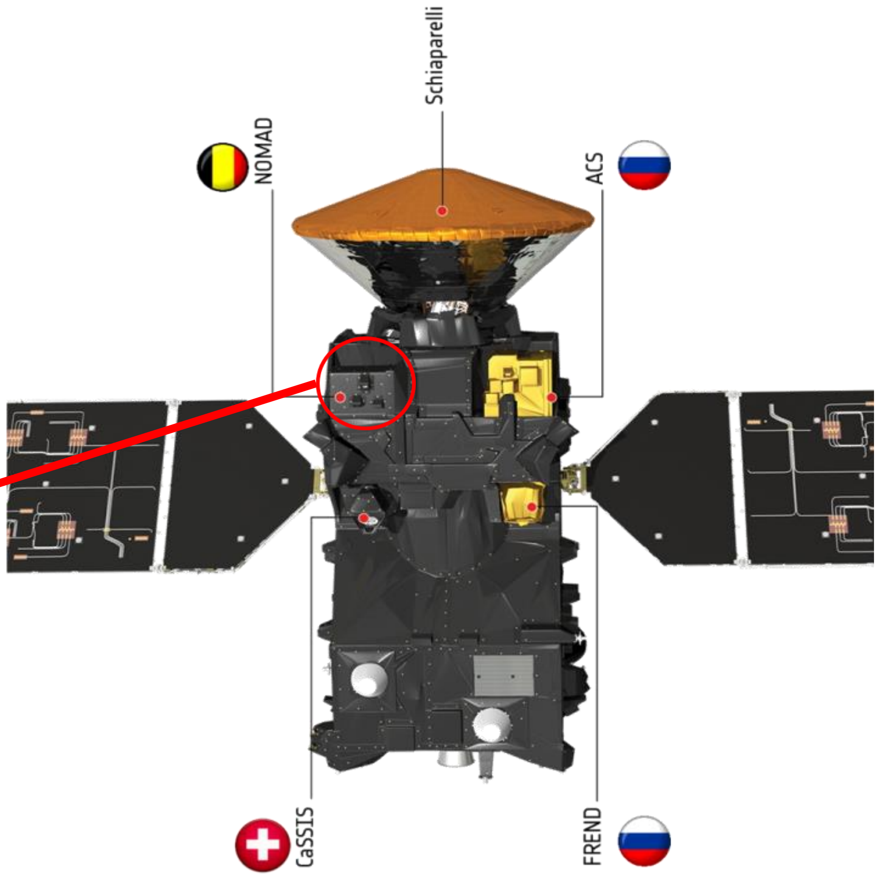
Michael J. Mumma,[1*] Geronimo L. Villanueva,[2,3] Robert E. Novak,[4] Tilak Hewagama,[3,5]
Boncho P. Bonev,[2,3] Michael A. DiSanti,[3] Avi M. Mandell,[3] Michael D. Smith[3]



Credit: C. R. Webster et al., Science, 347, 415-417 (2015)

ExoMars Trace Gas Orbiter

РОСКОСМОС

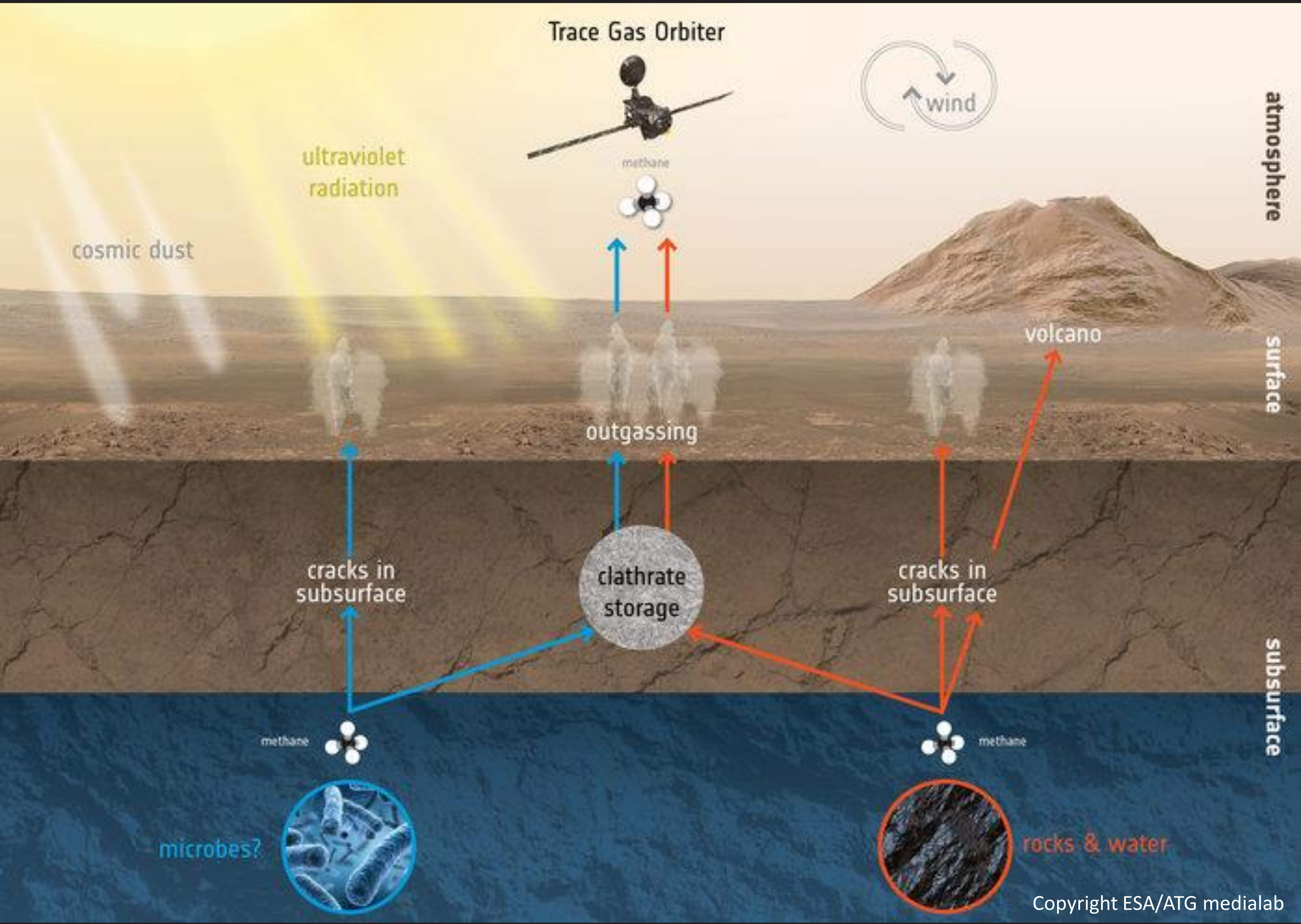


NOMAD

Spectrometer

Lead: A. C. Vandaele (IASB)

UVIS (0.20 – 0.65 μm) λ/Δλ ~ 250	SO Limb Nadir	
IR (2.3 – 3.8 μm) λ/Δλ ~ 10,000	SO Limb Nadir	
IR (2.3 – 4.3 μm) λ/Δλ ~ 20,000	SO	


Trace Gas Orbiter
wind
atmosphere
ultraviolet radiation
methane
cosmic dust
volcano
surface
outgassing
cracks in subsurface
clathrate storage
cracks in subsurface
subsurface
methane
methane
microbes?
rocks & water

The NOMAD instrument on-board ExoMars Trace Gas Orbiter (TGO)

L. Trompet (1,2), A. C. Vandaele (1), Fr. Daerden (1), I. R. Thomas (1), M. Lepère (2), S. Aoki (1), C. Depiesse (1), J. Erwin (1), L. Neary (1), A. Piccialli (1), B. Ristic (1), S. Robert (1), S. Viscardy (1), Y. Willame (1), V. Wilquet (1), G. Bellucci (3), J.-J. Lopez-Moreno (4), M. R. Patel (5), and the NOMAD Team

(1) The Royal Belgian Institute for Space Aeronomy (IASB-BIRA) (2) Research Unit Lasers and Spectroscopies (LLS), ILEE, UNamur (3) Instituto de Astrofisica de Andalucia (IAA), Spain, (4) Istituto Nazionale di Astrofisica (INAF), Italy(5) Open University (OU), UK.

The NOMAD spectrometer suite maps the composition and distribution of the atmosphere of Mars in unprecedent details, fullfilling many of the scientific objectives of the joint ESA – Roscosmos ExoMars mission.

NOMAD

NOMAD (Nadir and Occultation for MArs Discovery) is one of the four instruments on-board the TGO. It consists of a suite of three high-resolution spectrometers covering the UV-visible and infrared ranges, operating in solar occultation, limb and nadir-viewing modes. It actually generates a huge dataset of Martian atmospheric observations across a wide spectral range.

Figure 1: Diagram of the 3 channels of NOMAD

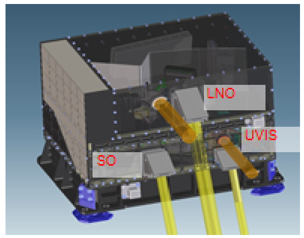


Table 1: Description of the 3 channels of NOMAD

Channel	Spectral Range	Observation Modes	Spectral resolution	Vertical resolution	IFOV in nadir
SO	2.3-4.3µm	SO	0,15 cm-1	0,18 - 1 km	/
LNO	2.3-3.8µm	SO, Limb, Nadir	0,3 cm-1	0,18 – 1 km	0,5x17 km
UVIS	0.2-0.65µm	SO, Limb, Nadir	1,2nm	0,3 – 5 km	5x60 km

Observation modes

Solar occultation measurement

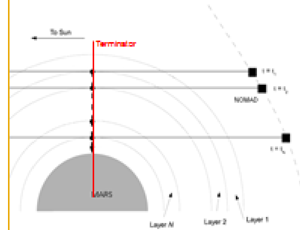


Figure 2: Geometry in solar occultation

Nadir measurement

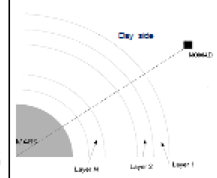


Figure 3: Geometry in nadir

TGO calendar

- 14/03/2016: Launch on a Proton rocket from Baikonur (Kazakhstan)
- 19/10/2016: TGO inserted into Mars orbit
- 04/11/2016: Start aerobraking phase to settle on an orbit at 400 km of altitude (12 orbits/day)
- 21/04/2018: Start of the scientific phase

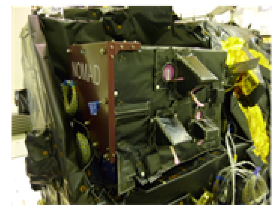


Figure 4: NOMAD on the spacecraft

SO spectra

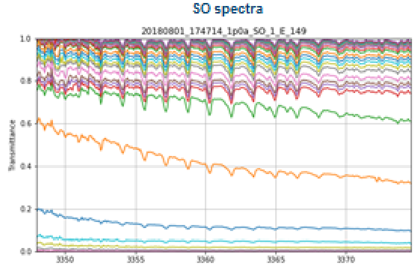


Figure 5 (left): Example of transmittance calibrated spectra of SO

Profile

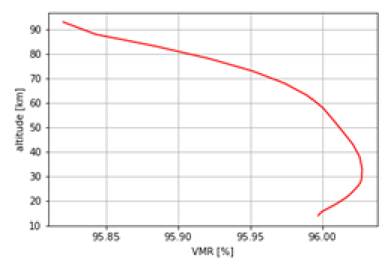


Figure 6 (right): Example of CO2 profile. Profiles or columns of densities are retrieved from the spectra.

Scientific Objectives

- Detection and mapping of the key constituents of the Martian atmosphere
- Order-of-magnitude increase in spectral resolution allows measurement of previously unresolvable gas species, e.g. isotopologues.
- Characterisation of the spatial and temporal variability of gases through extended mapping, to further constrain atmospheric dynamics.
- Detection of sources and sinks of trace gases, such as regions of surface volcanism/ outgassing and atmospheric production. [8]
- Simultaneous infrared and UV-Visible observations together can distinguish dust from ice aerosols [3], [4].

Species	Detection Limit in Solar Occultation Mode
CH_4, $^{13}CH_4$, CH_3D	20-25ppt [1], 20ppt, 70ppt [2]
H_2O, HDO, HO_2	150-200ppt, 700ppt, 1ppb [1]
CO	4-5ppb [1]
HCl, HCN	25-30ppt, 30ppt [1]
H_2CO	30-40ppt [1]
H_2S	3-4ppb [1]
C_2H_2, C_2H_4, C_2H_6	30-40ppt, 150-200ppt, 20-30ppt [1]
NO_2	100-140ppt [1]
OCS	300ppt [1]
O_3	1.5-2.5ppb (IR) [1], 50ppt (UVIS) [2]
SO_2	50ppb (IR) [2], 500ppt (UVIS) [1]

Table 2: Detection limits of NOMAD during nominal operation [1,2]

References: [1] Robert, S. (2015) EGU Poster 2015-10125; [2] Drummond, R. (2011) Planetary and Space Science, 59, pg. 292–298; [3] Wilquet, V. et al. (2009) J. Geophys . Res., 114 ; [4] Drummond, R. et al. (2013), EPSC Poster 2013-175; [5] Vandaele, A.C. et al. (2008), J. Geophys. Res., 113; [6] Mahieux, A. et al., (2009) Optics Express, 17, pg. 2005-2014 ; [7] Patel, M. R. (2014) Fifth International workshop on the Mars atmosphere, [8] A. C. Vandaele,(2015) Planetary and Space Science, 119, pg. 233-249