life on mars

what to know before we go

david a. weintraub

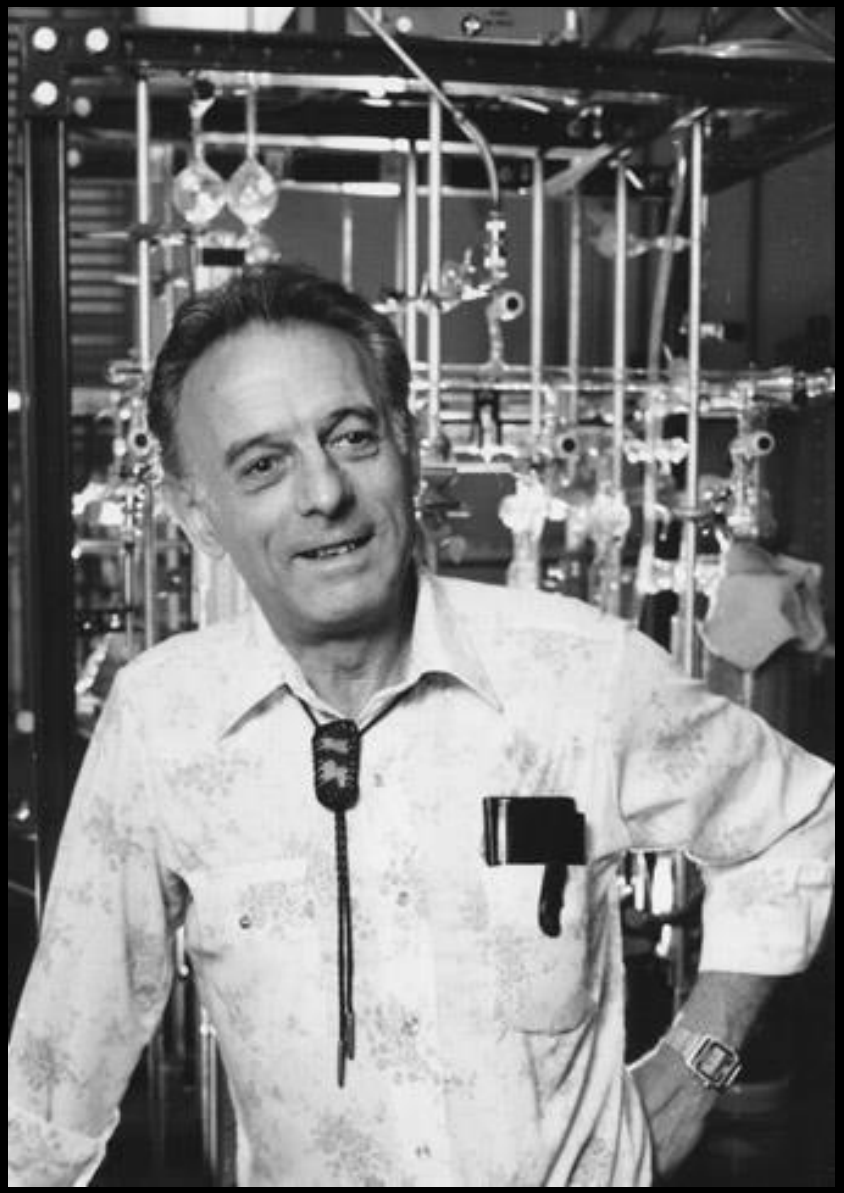
1969: DAWN OF THE MARS METHANE ERA

Launched
March 27, 1969

Mars fly-by:
August 5, 1969
Results:
126 images of Mars

NASA Press Conference: August 7, 1969

"We are confident that we have detected gaseous methane and gaseous ammonia between approximately 61 degrees and 76 degrees south latitudes on Mars." -- George Pimentel



George Pimentel, PI, Infrared Spectrometer team

2 Gases Associated With Life Found on Mars Near Polar Cap

By WALTER SULLIVAN

Special to The New York Times

August 9, 1969

Mariner Hints Life on [redacted]

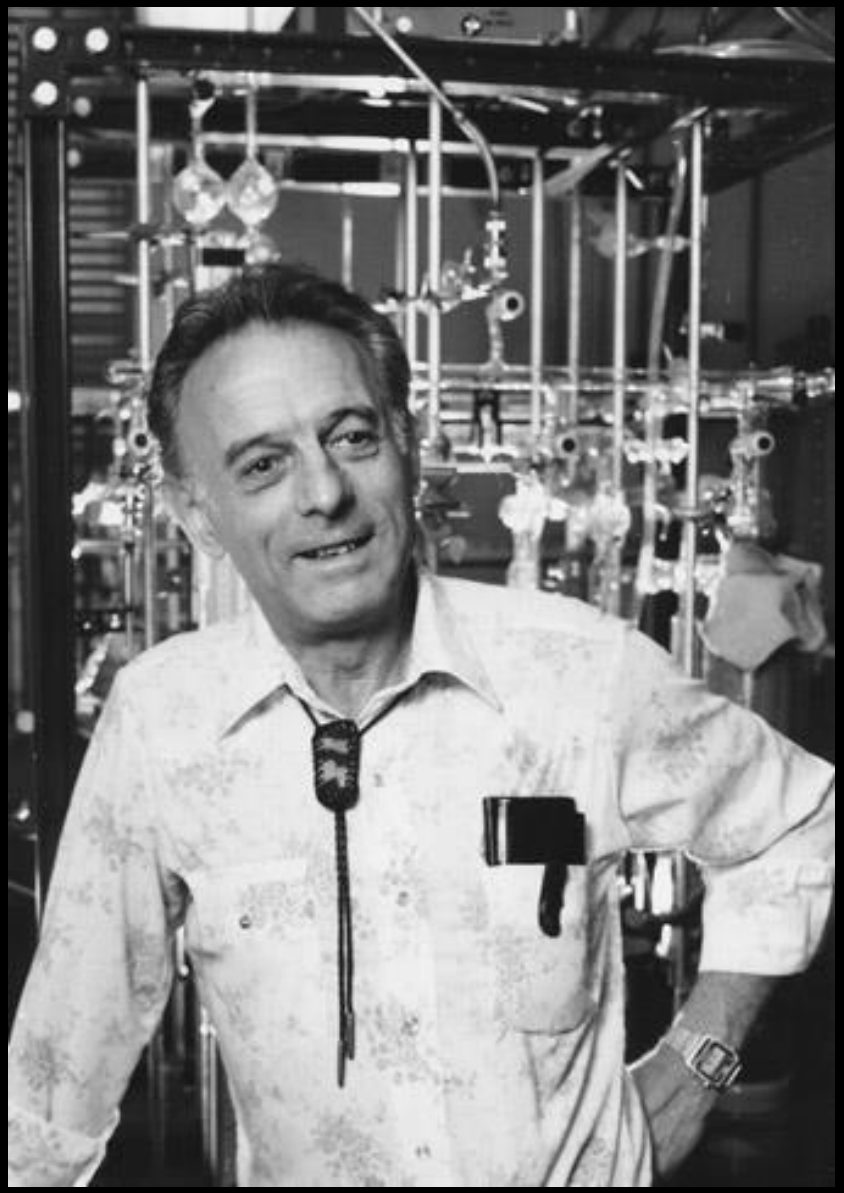
By RALPH DIGHTON

PASADENA, Calif. (AP)—An indication that a crude form of life might exist on [redacted] was reported Thursday by a scientist studying information radioed from Mariner 7 in its sweep past the planet early Tuesday.

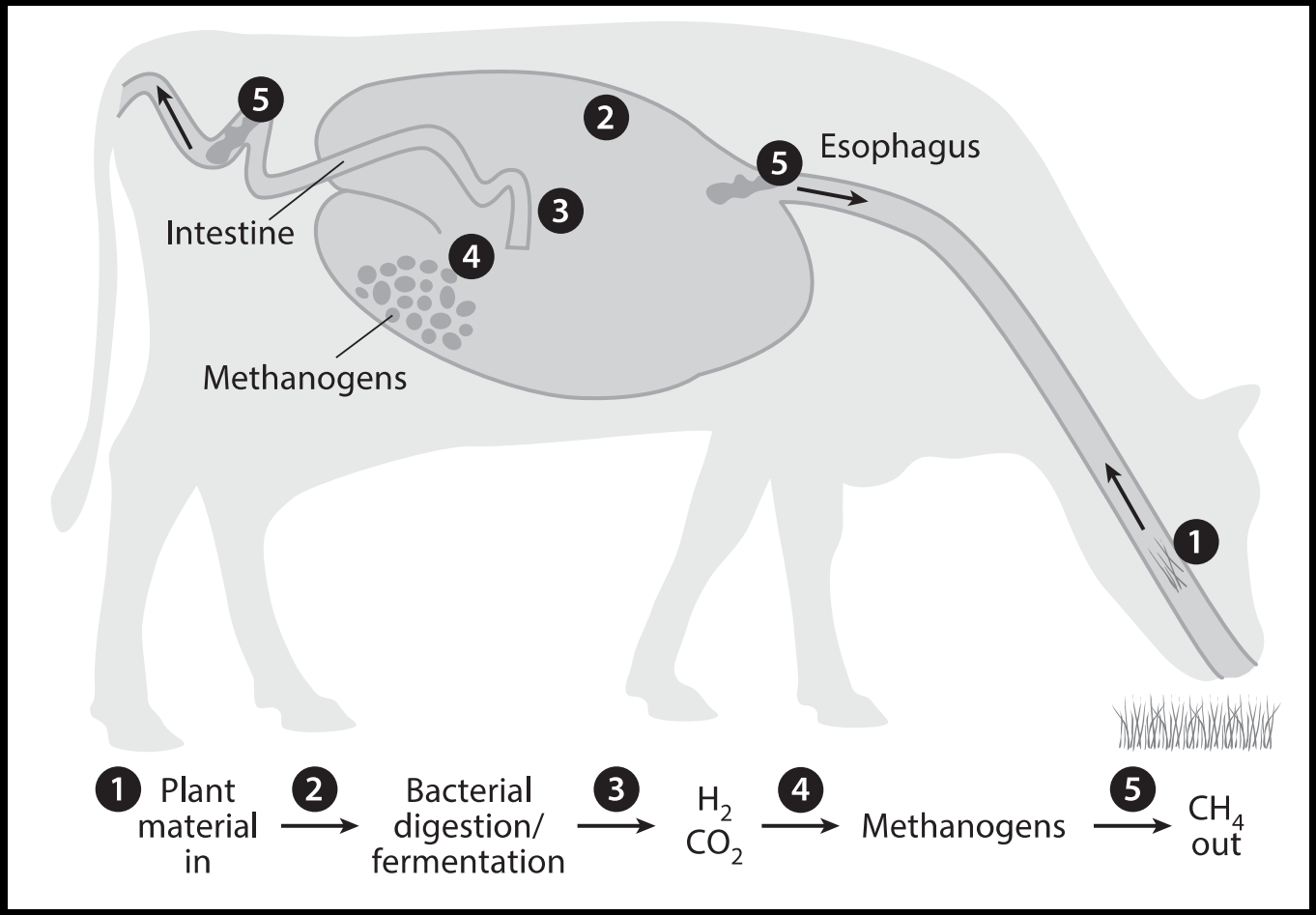
NASA Press Conference: August 7, 1969

"We are confident that we have detected gaseous methane and gaseous ammonia between approximately 61 degrees and 76 degrees south latitudes on Mars."
-- George Pimentel

"I have no clue as to the origin of these gases, but if the readings are true — and I believe they are — we have to face the possibility they could be of biological origin." -- Kenneth Kerr, IRS team member

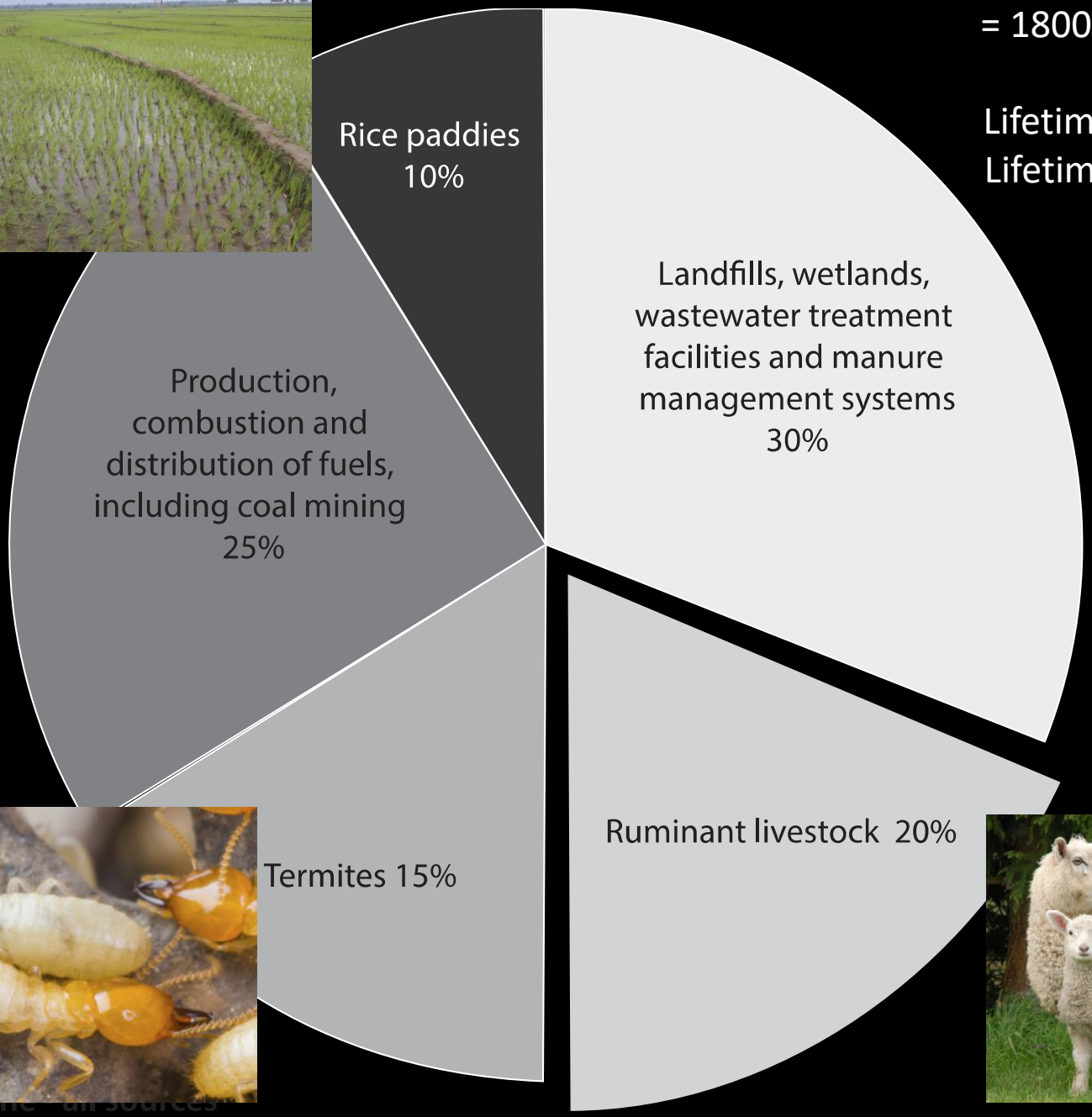


George Pimentel, PI, Infrared Spectrometer team


5
2
5
Esophagus
3
Intestine
4
Methanogens
1
1 Plant material in
2 Bacterial digestion/ fermentation
3 H_2 CO_2
4 Methanogens
5 CH_4 out

Methane in Earth's atmosphere
= 1800 parts per billion

Lifetime / Earth = 12 years
Lifetime / Mars = 300 years



Methane – all sources

news conference: September 11, 1969

"the spectral features previously attributed to methane and ammonia were, in fact, caused by frozen carbon dioxide (dry ice)."

"The new discovery "remove[d] one of the final hopes scientists held of finding life on the planet."

"the fact that carbon dioxide can mimic the behavior of methane and ammonia was "just a cruel coincidence."

-- George Pimentel

WSJ: "a perfect example of the hazards of quick conclusions"

Final Mariner 7 result (1972): "less than 3.7 parts per million"
(or, less than 5,600 parts per billion at 99.7% confidence)

1969: Infrared Interferometer

Mariner 9

Launched
May 30, 1971

Mars orbit insert:
November 13, 1971

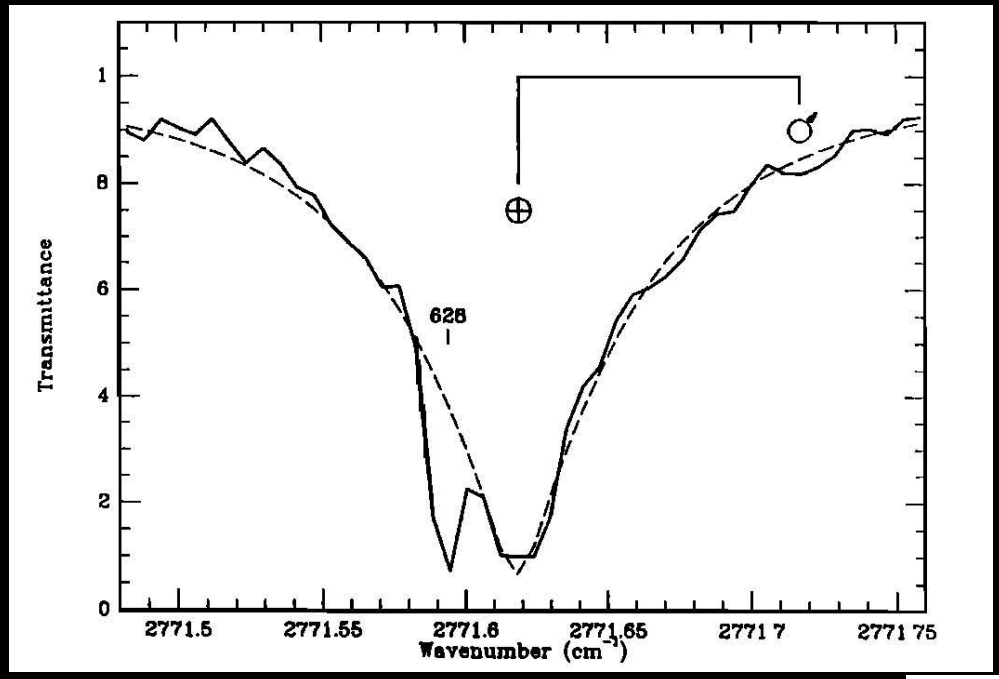
No press conference about methane

Methane results not published until 1977

Results: undetected at “less than 30 parts per billion”

KITT PEAK NATIONAL OBSERVATORY

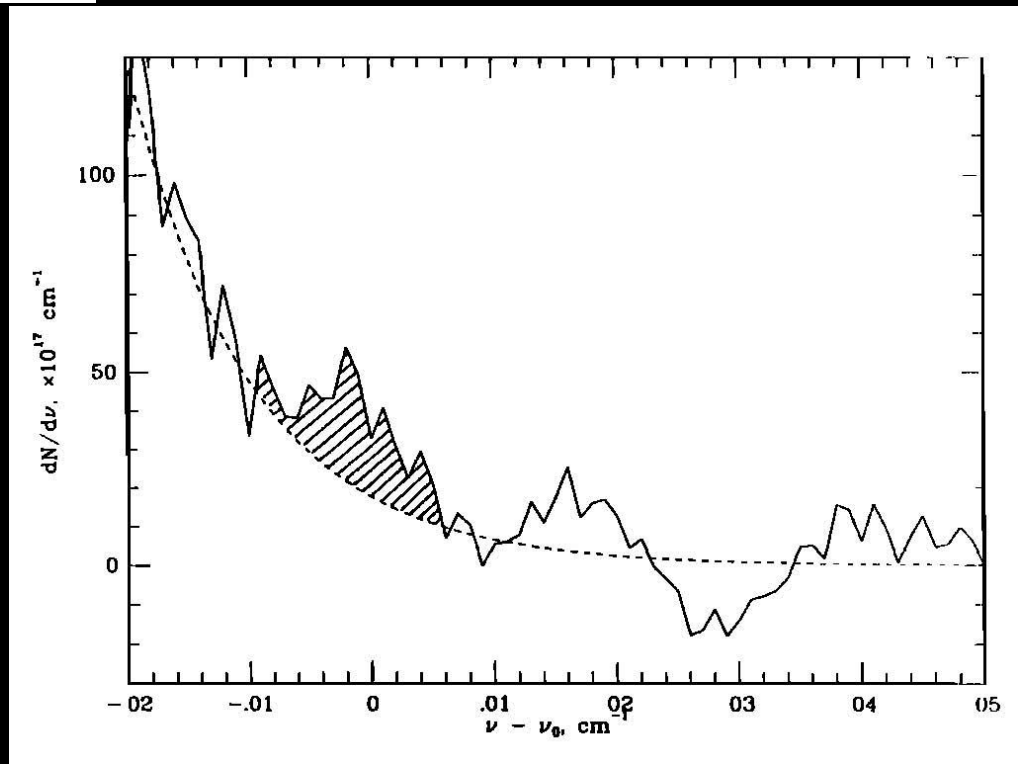
1988/1997: Vladimir Krasnopolsky, Mike Mumma, Gordon Bjoraker, Donald Jennings



Motion of Mars (away from Earth) ‘redshifts’ methane line

Methane above telescope in Earth’s atmosphere: 2000 ± 1000 ppb

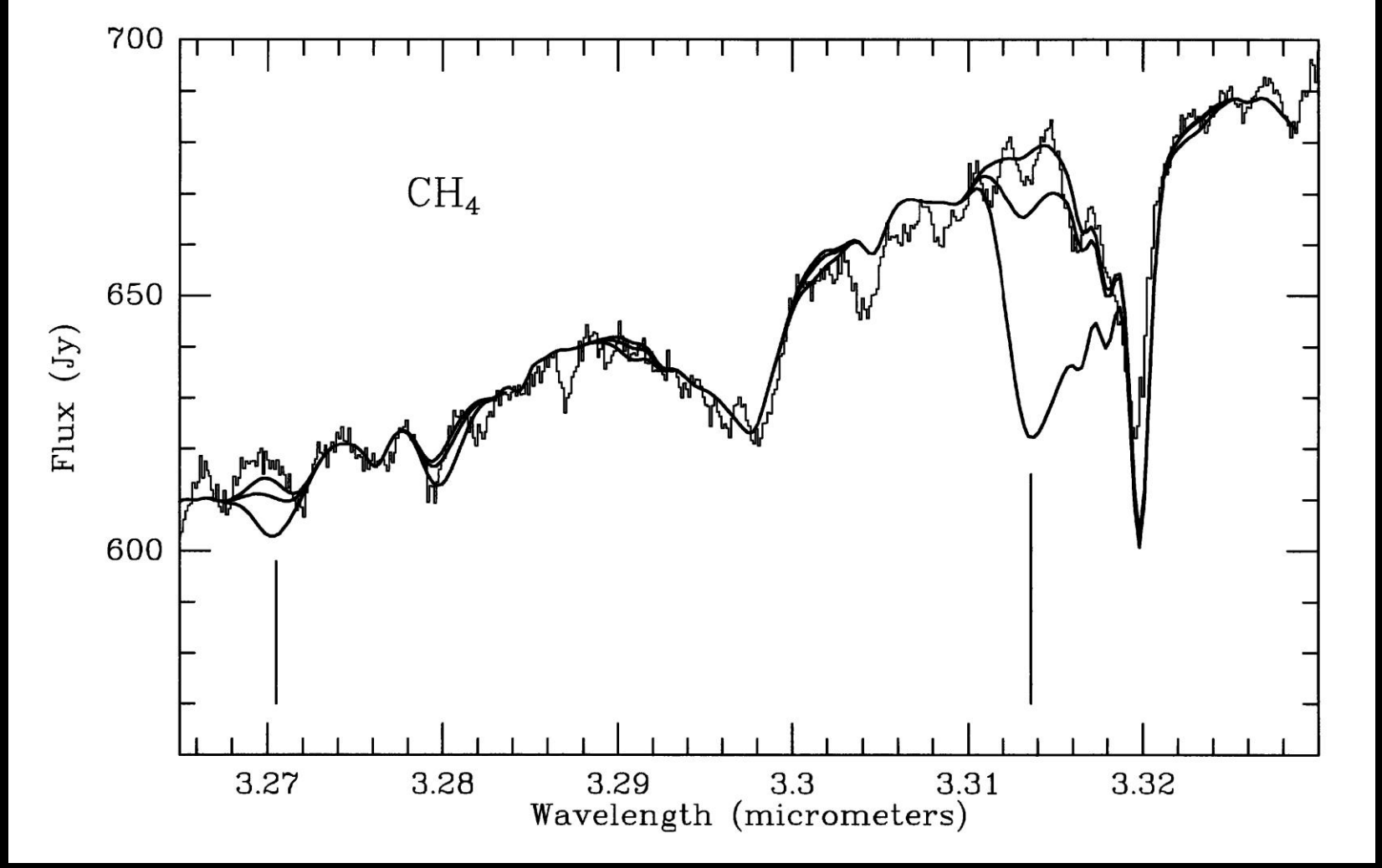
Martian methane: 70 ± 50 ppb



Bottom: close up (inverted) of region centered at 2.771.72 in top figure

Infrared Space Observatory (ESA):

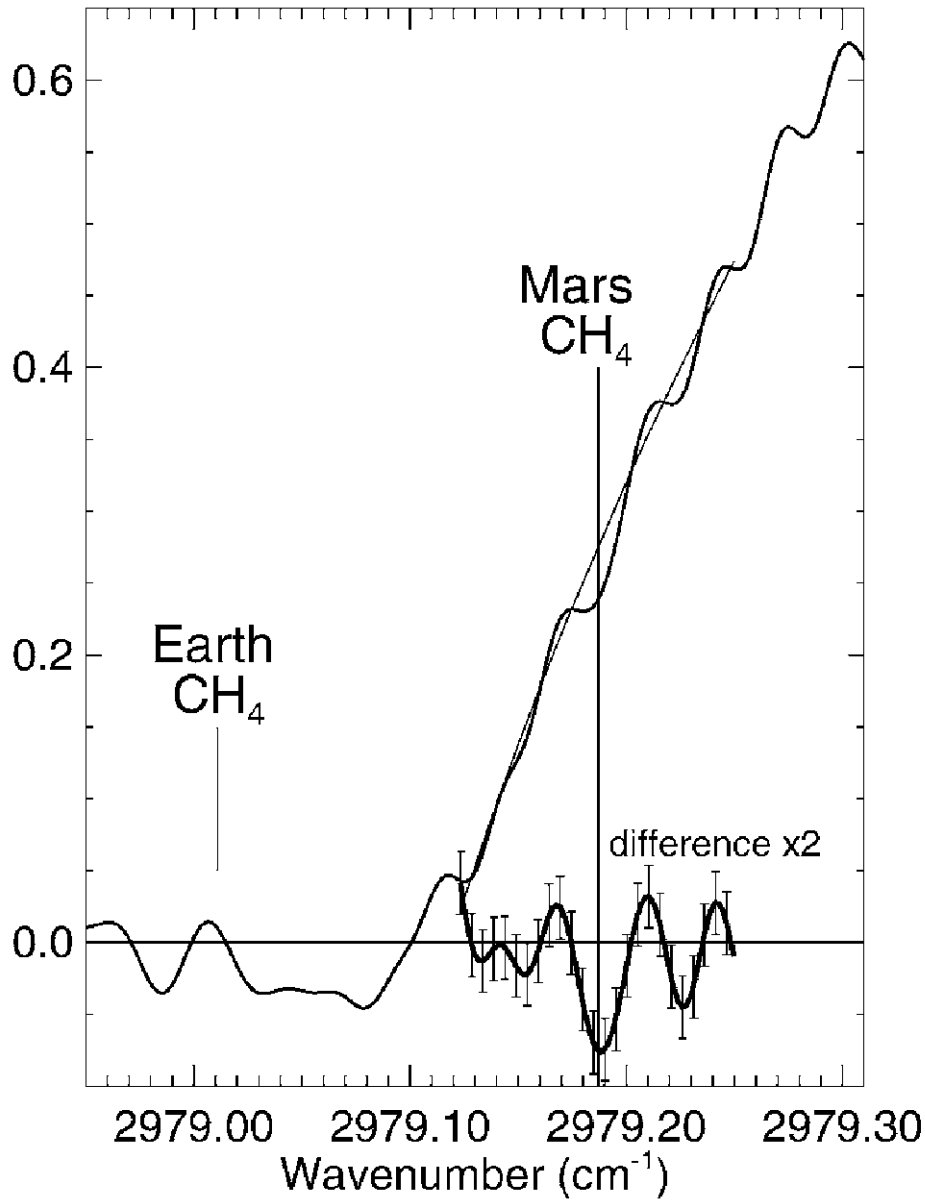
- launched 1995
- Methane project 1997



Smooth curves: model atmosphere fits to data

- Top: no methane. Middle: 50 ppb methane. Bottom 500 ppb methane
- Result: less than 50 ppb methane
- "the tentative detection of methane reported by Krasnopolsky et al. … is indeed marginal at best"

Canada-France-Hawaii Telescope, Mauna Kea, Hawaii
-- Krasnopolsky, Jean Pierre Maillard, Tobias Owen
-- January 1999 (results published in 2004)



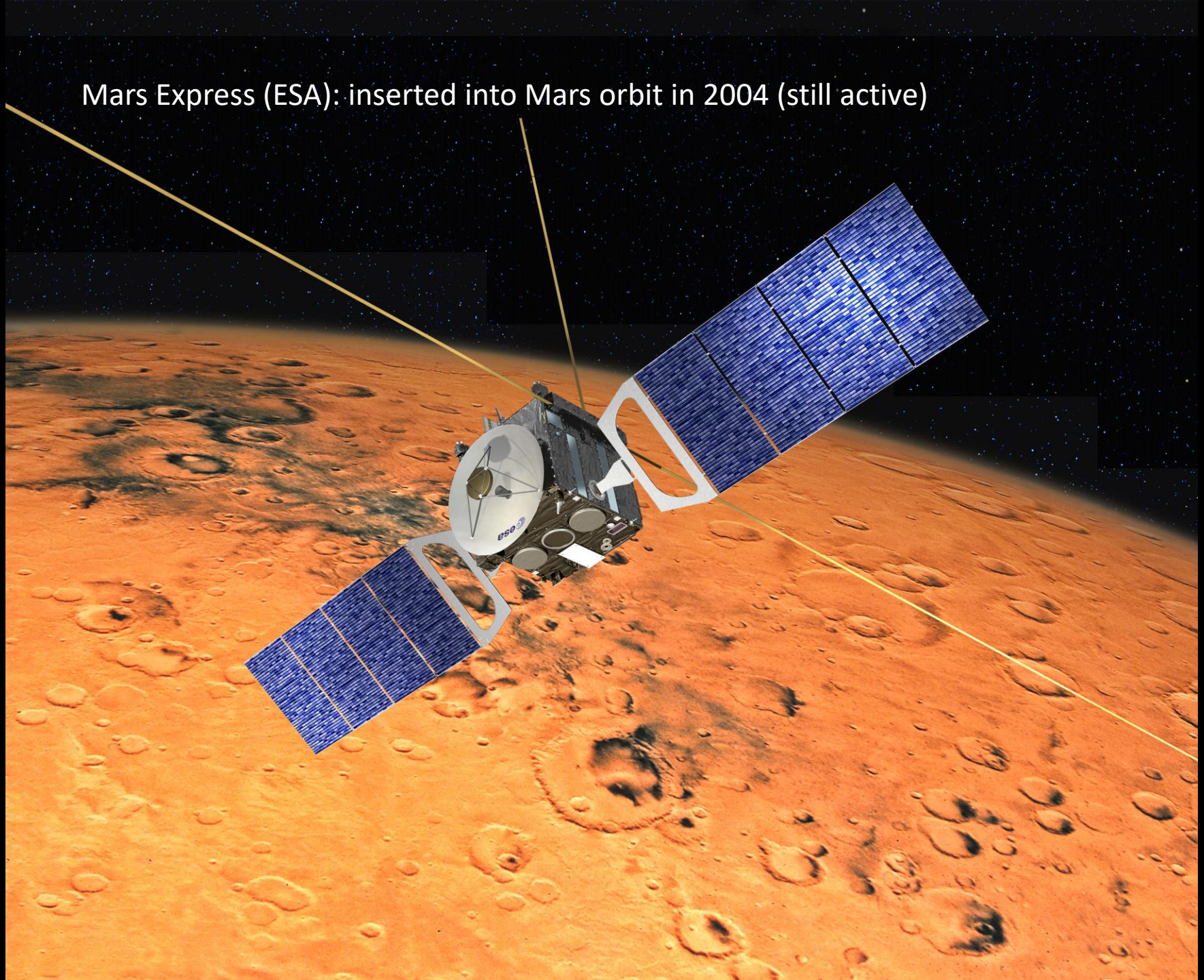
Earth moving 11.05 miles per second faster than Mars, toward Mars

Mars' methane line 'blueshifted' away from Earth's methane line

Result: 10 ± 3 parts per billion

Claim: "we have not found any significant abiogenic source of methane and methanogenesis by living subterranean organisms is a plausible explanation for this discovery"

Mars Express (ESA): inserted into Mars orbit in 2004 (still active)



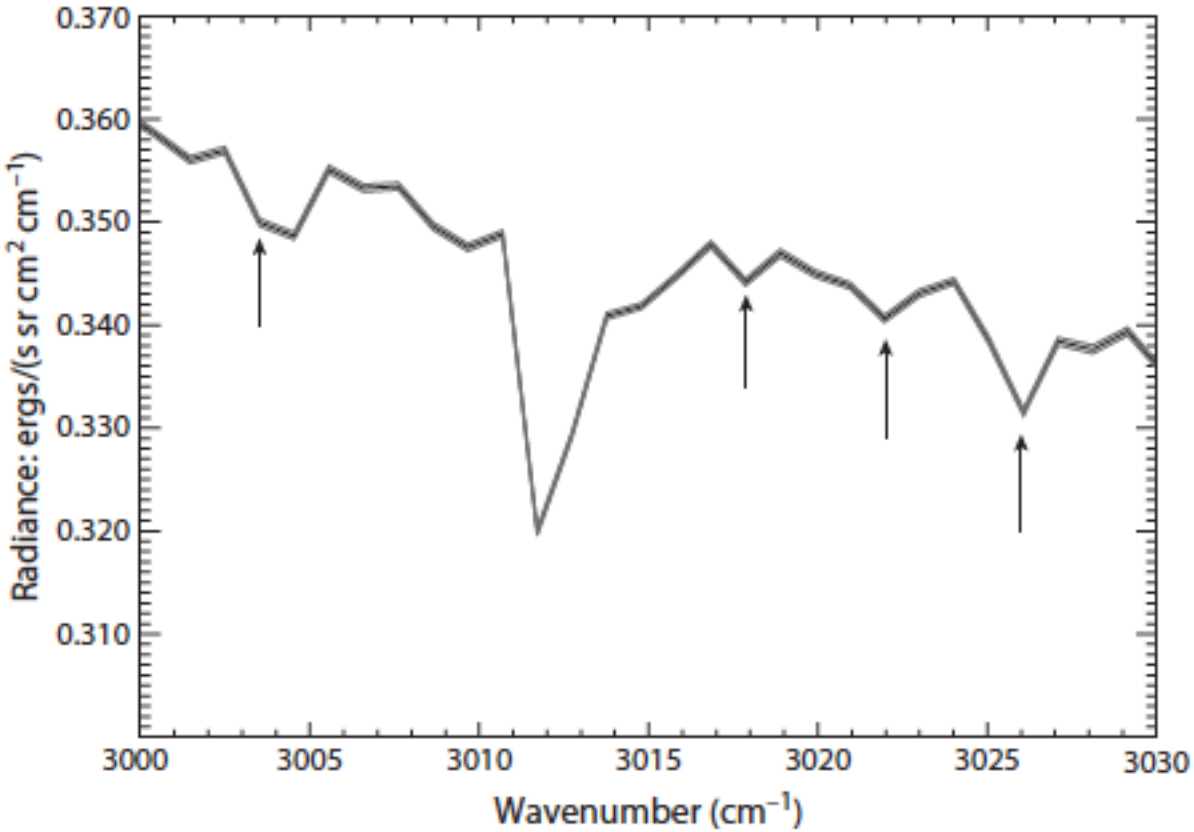


Figure 13.4. Infrared spectrum of Mars obtained by Planetary Fourier Spectrometer on the Mars Express spacecraft in January–February 2004. The apparent detection of methane in the atmosphere of Mars shows up in the small drop in the spectrum at 3018 inverse centimeters (i.e., a wavelength of 3.313 microns). Three strong, known water vapor lines appear in absorption at 3003.5, 3022, and 3026 inverse centimeters. The deep line at 3012 inverse centimeters is due to the Sun. The middle line is the data. The upper and lower lines indicate the noise level in the data. Image based on Formisano et al., *Science*, 2004.

Results: 10 ± 5 parts per billion
Max = 30 ppb
Min = 0 ppb

"We want to stress that the detection of methane does not imply the presence of life on Mars, now or in the past. It is one possibility, but … other sources are equally plausible."

NASA's IRTF, Mauna Kea, Hawaii

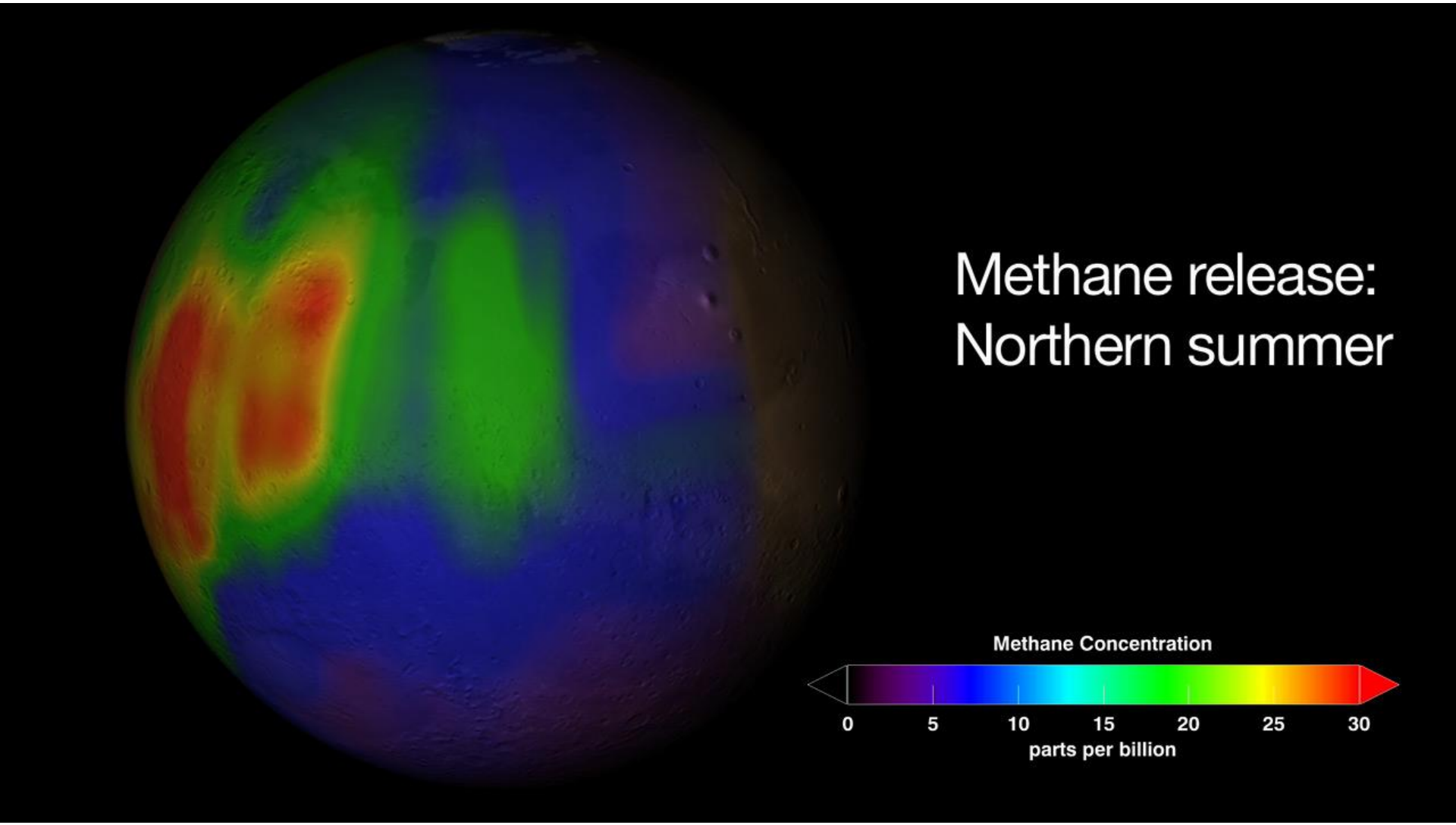
-- Mike Mumma, team leader

2006: "It's 20 to 60 ppb in the north, even lower in the south. But it was more than 250 ppb at the equator."

-- claims:

- methane varies with latitude
- abundance is HIGH
- "significant methane releases"
- "localized release" of methane
- "cannot be waved away as a measurement error"

Mumma, 2009 (same data as before)



Variously: 4 ± 3.5 ppb, 8.5 ± 3.5 ppb, 27 ± 7 ppb
Strongest signal: 29 ± 9 ppb (not 250)

Two local source regions
-- plumes rise, disperse, become undetectable

Krasnopolsky: Feb 2006

- Undetectable (as reported in 2007); Less than 14 ppb
- Revised (2012): DETECTED 10-20 ppb

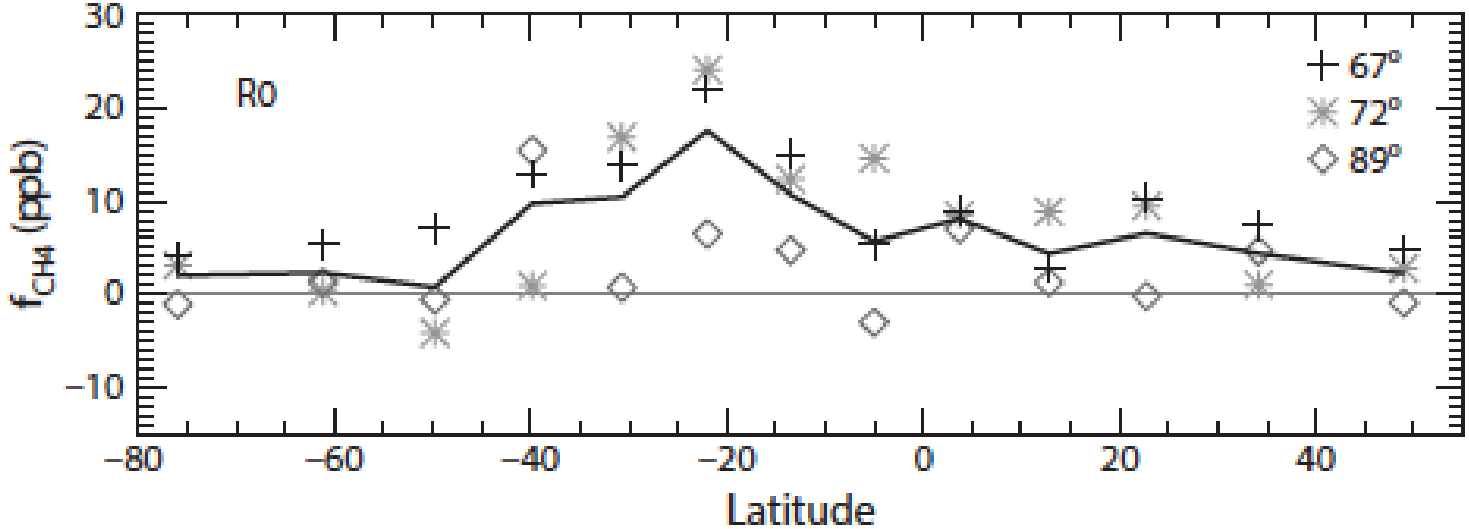


Figure 14.2. February 2006 measurements, showing the abundance of methane in the atmosphere (in parts per billion) as a function of Martian latitude, from –80 degrees (south) to +60 degrees (north). Measurements were made at three different longitudes on Mars (67W, 72W, 89W), as indicated by the three different symbols, and were made at the particular methane absorption line known as the R0 line (at 3028.752 inverse centimeters). The data appear to show a detectable amount of methane at a level of 10–20 ppb) at mid-southern latitudes and lower amounts of methane, or no methane, further north and south. Image based on Krasnopolsky et al., *Icarus*, 2012.

Krasnopolsky: December 2009

- NOT DETECTED

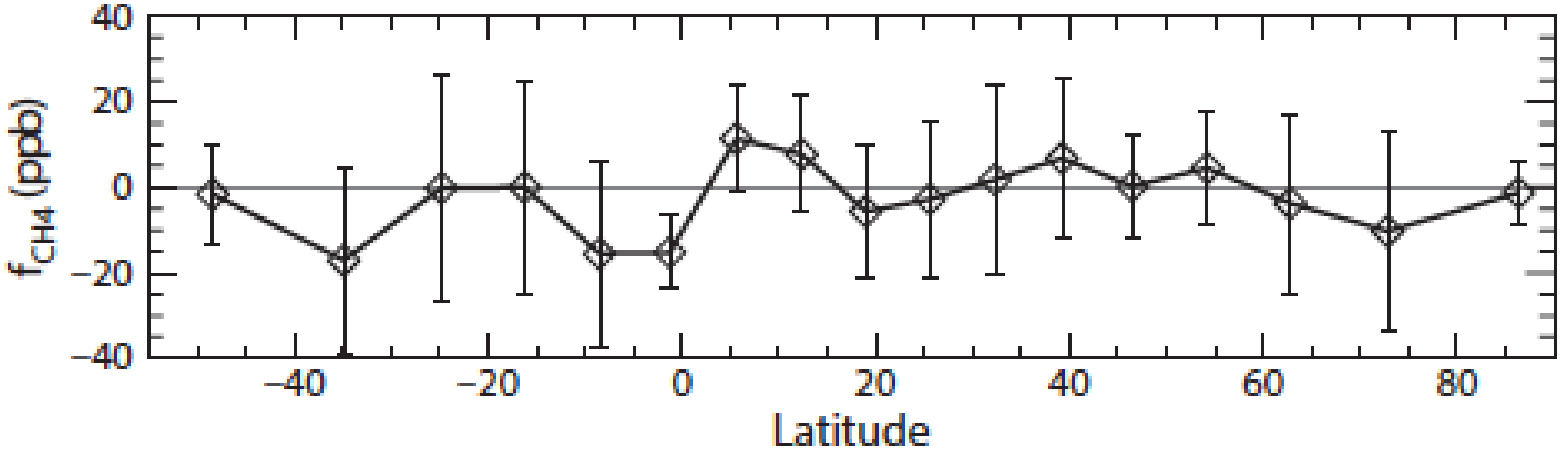
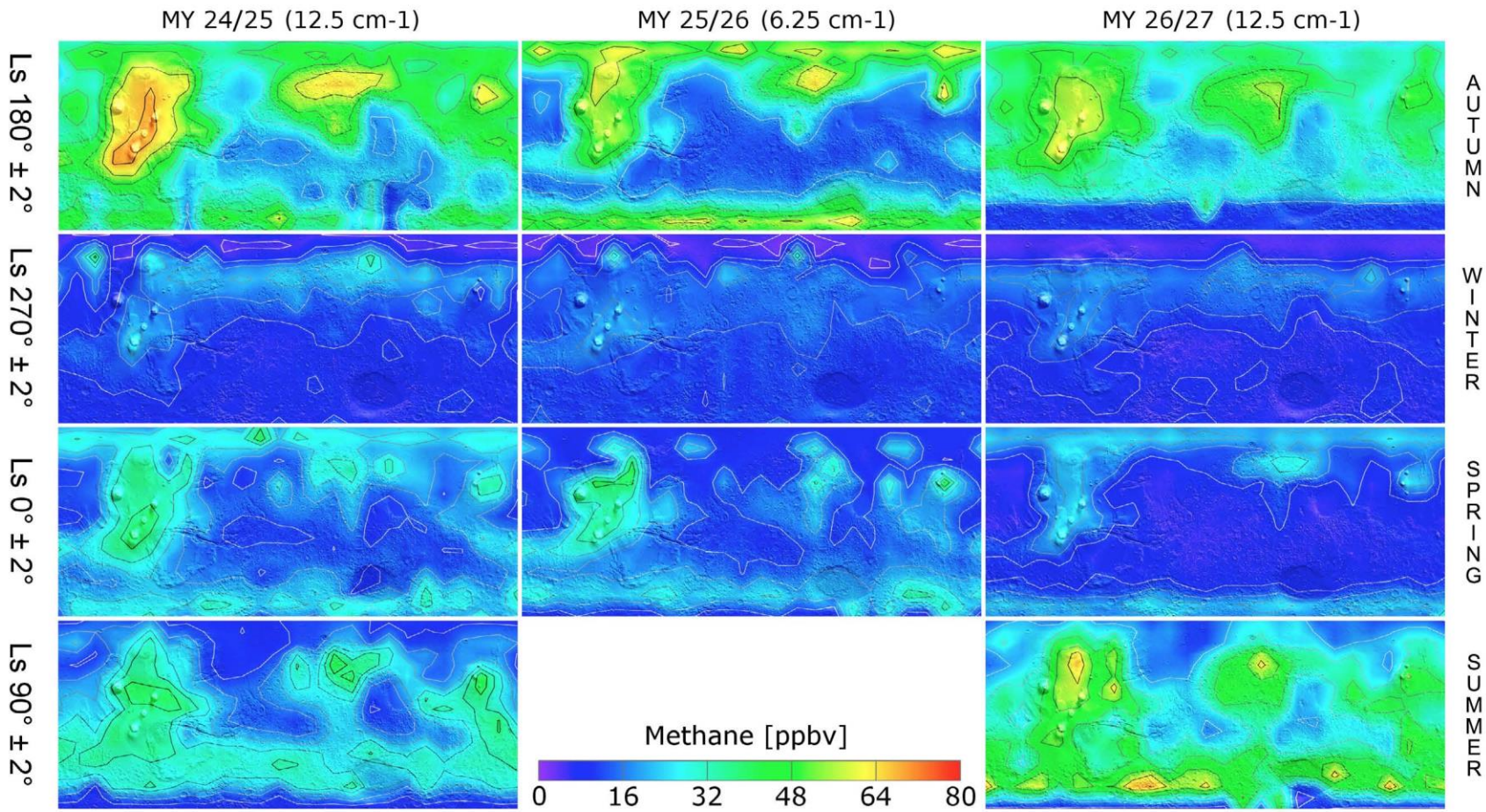


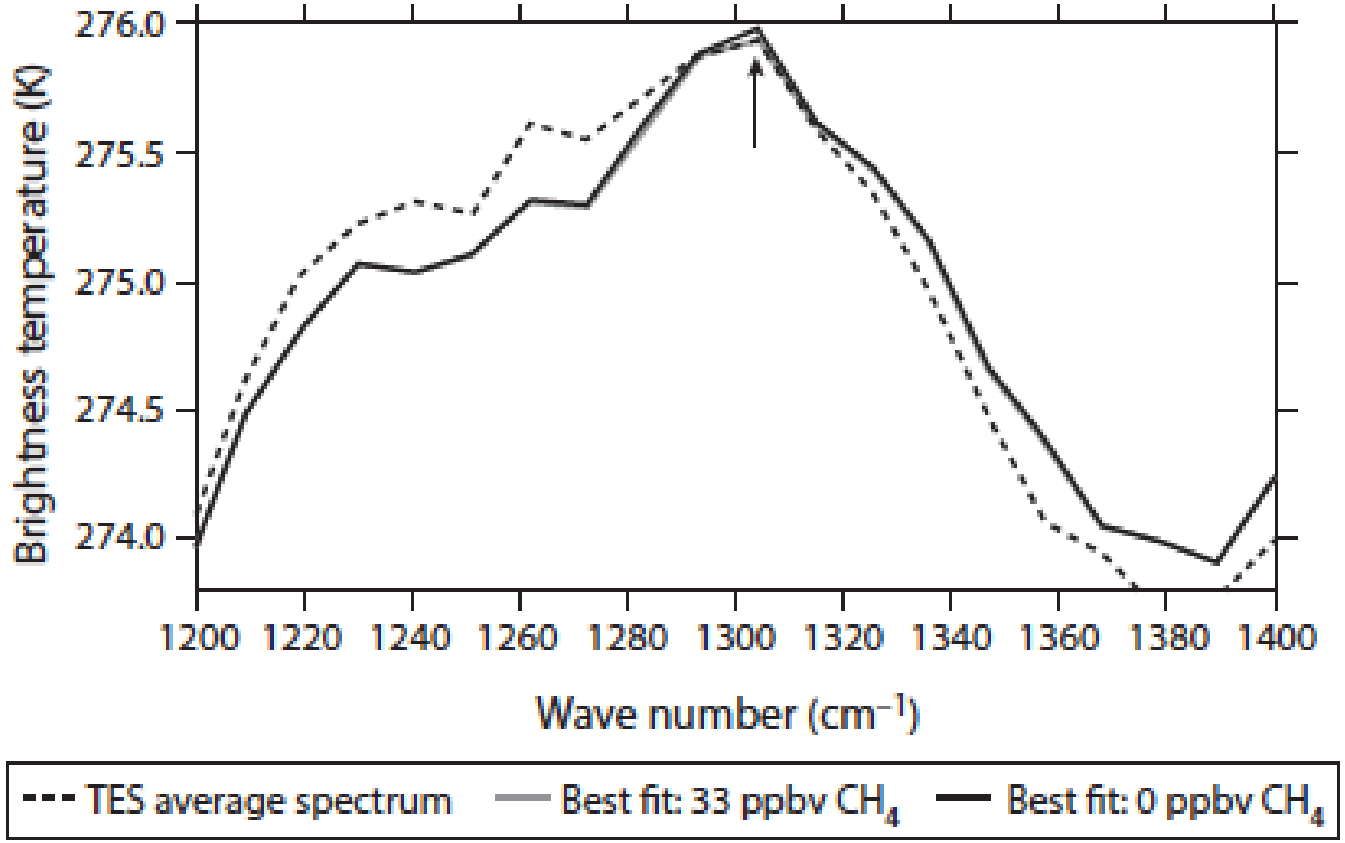
Figure 14.3. December 2009 measurements, showing the abundance of methane in the atmosphere (in parts per billion) as a function of Martian latitude, from −60 degrees (south) to +90 degrees (north). No methane is seen (solid horizontal line indicate mean value of zero; solid vertical lines indicate standard deviations on the measured values). Image based on Krasnopolsky et al., *Icarus*, 2012.

Mars Global Surveyor

- Launched 1996



- Data (from 1998-2004) carefully culled, bad measurements removed
- Results:
  - high in three consecutive autumns: 33 ± 9 ppb, 18 ± 7, 30 ± 8 ppb
  - Low in winters: 6 ± 2, 5 ± 2, 5 ± 1 ppb
- Methane systematically higher in high elevation regions and volcanic regions



Reanalysis of same data by same team in 2015:

- Dashed line = data
- ‘black’ line = no methane; ‘grey’ line = 33 ppb methane
- Methane undetectable
- “the precision needed to definitely identify the presence of methane … is extremely hard to reach, if even impossible, at present.”

Geronimo Villanueva team: 2006-2010 (VLT, Keck, IRTF

VLT (run by ESA): Very Large Telescope (Cerro Paranal, Chile): four 8-m telescopes

Twin Keck 10-m telescopes, Mauna Kea, Hawaii

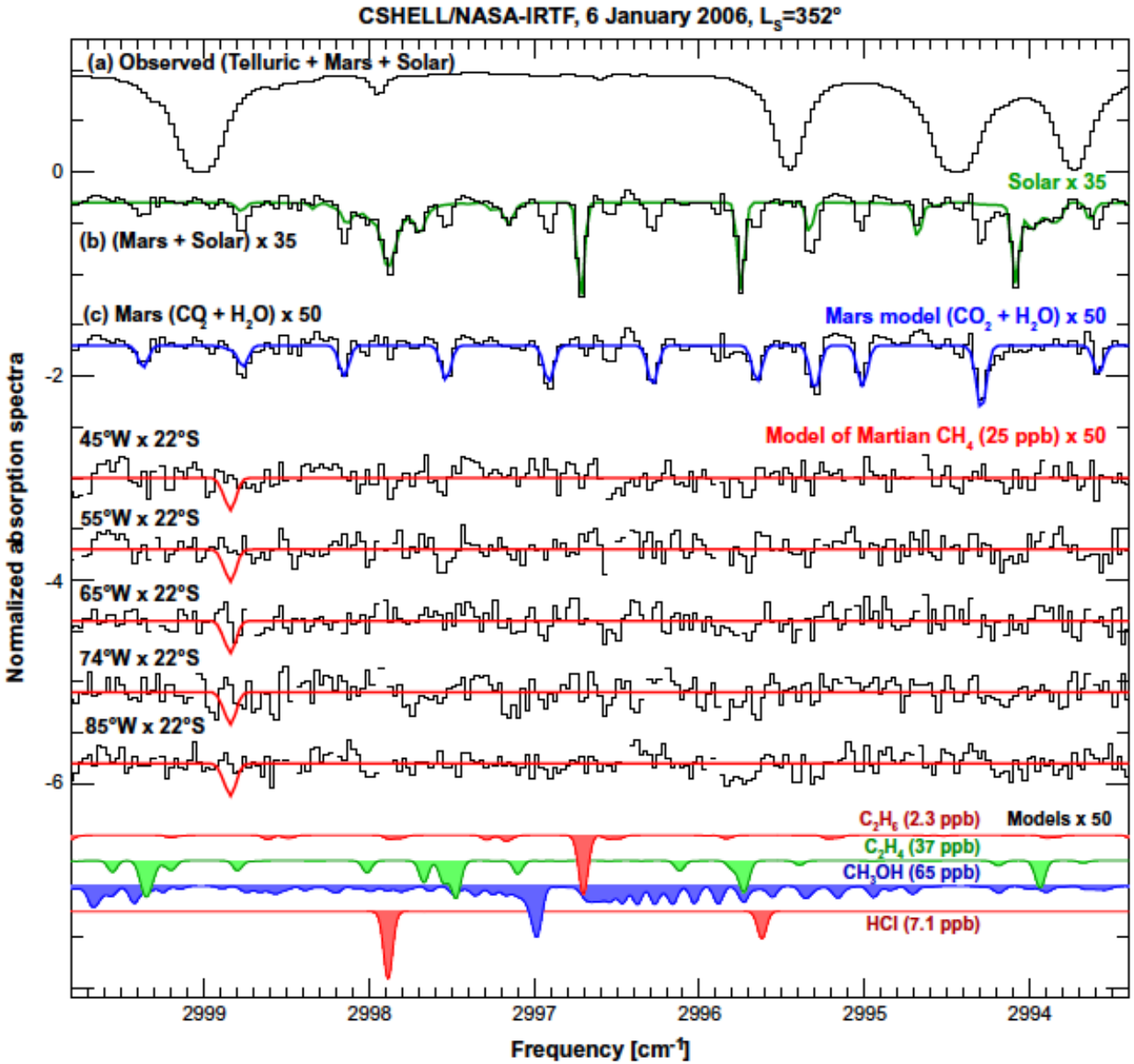


Fig. 5. Sensitive search for methane on Mars over Valles Marineris on January 6th 2006, 1 month prior to the observations by Krasnopolsky (2012) reported up to 25 ppb abundance ratios for methane. Trace 'a' shows the calibrated Mars continuum affected by terrestrial transmittance, and trace 'b' shows the Mars residual spectrum after removing a terrestrial model. Trace 'c' shows the residual spectrum after removing the solar Fraunhofer lines, while the blue trace is a synthetic martian model of CO_2 and H_2O. Our measurements at 22°S latitude in the 45–85°W longitude range reveals no signal of martian methane. Synthetic models for ethane (C_2H_6), ethylene (C_2H_4), methanol (CH_3OH) and hydrogen chloride (HCl) are shown at the 10-sigma detection limit.

Table 2
Abundance limits (3-σ) of trace species on Mars in parts-per-billion (ppb, 10^{-9}).

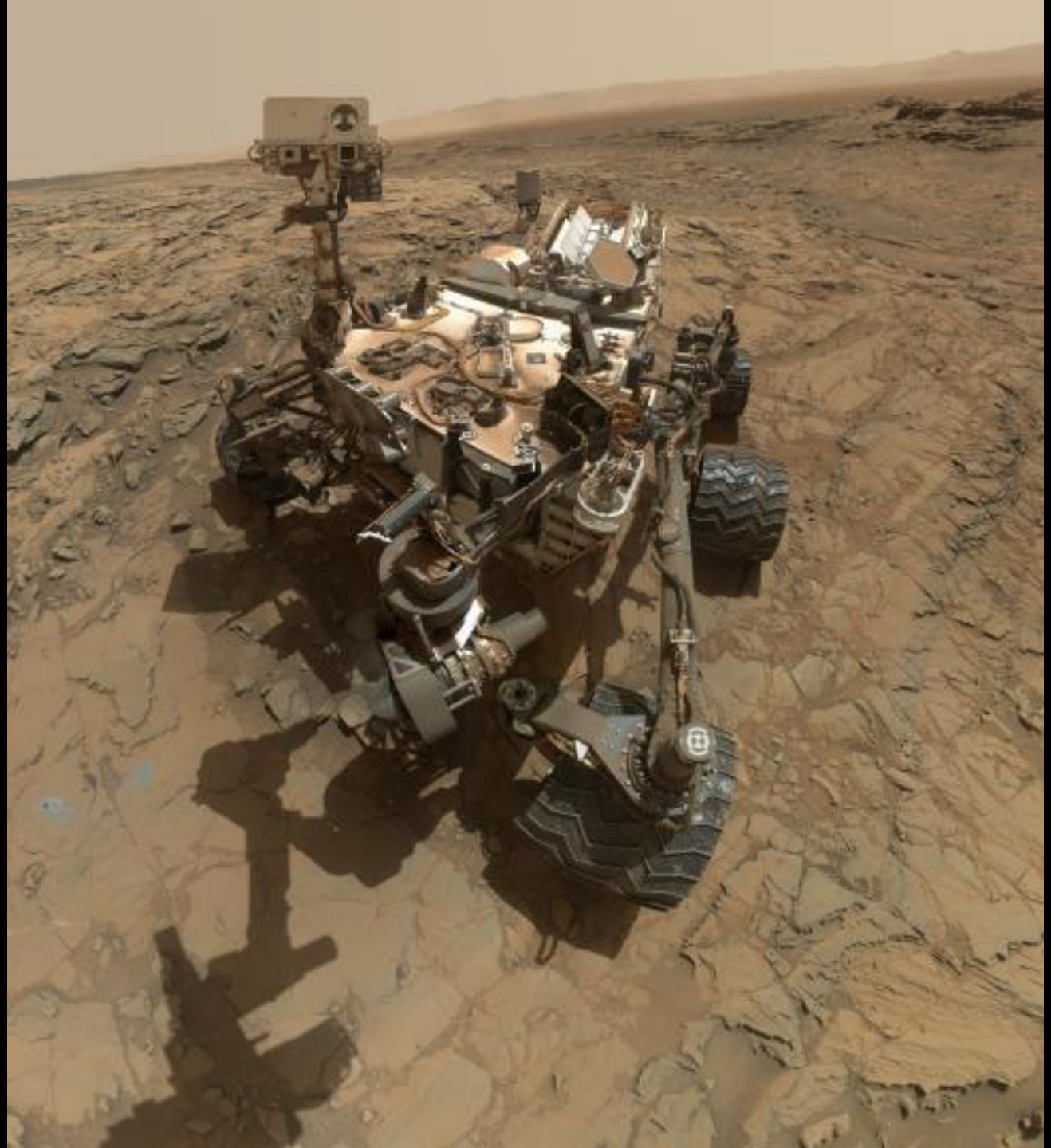
Molecule	Previous (3-σ, ppb)	06 January 2006 L_S 352° MY27	19 August 2009 L_S 324° MY29	20 November 2009 L_S 12° MY30	28 April 2010 L_S 83° MY30
Methane (CH_4)	3–50[a]	<7.8	–	<6.6	<7.2

Results:

- "Considering the complexities associated with measuring methane at the low spectral resolutions [by all previous observers], those measurements may be affected by instrumental effects and unrecognized solar/water signatures that dominate the spectral regions used by these teams to search for methane."

- "If methane is being released into the atmosphere this process is probably sporadic and not continuous."

Mars Curiosity
Rover
Landed 2012



Self portrait

Dec. 2013: No methane
(less than 0.2 parts per billion)

Dec. 2015:
Methane detected
during 2 month period in 2014
level: 7 parts per billion

Curiosity rover's discovery of methane ‘spikes’ fuels speculation of life on Mars --- *The Guardian*

Methane gas clue to 'life on Mars’ --- *BBC*

‘A Great Moment’: Rover Finds Methane, a Clue That Mars May Harbor Life --- *New York Times*

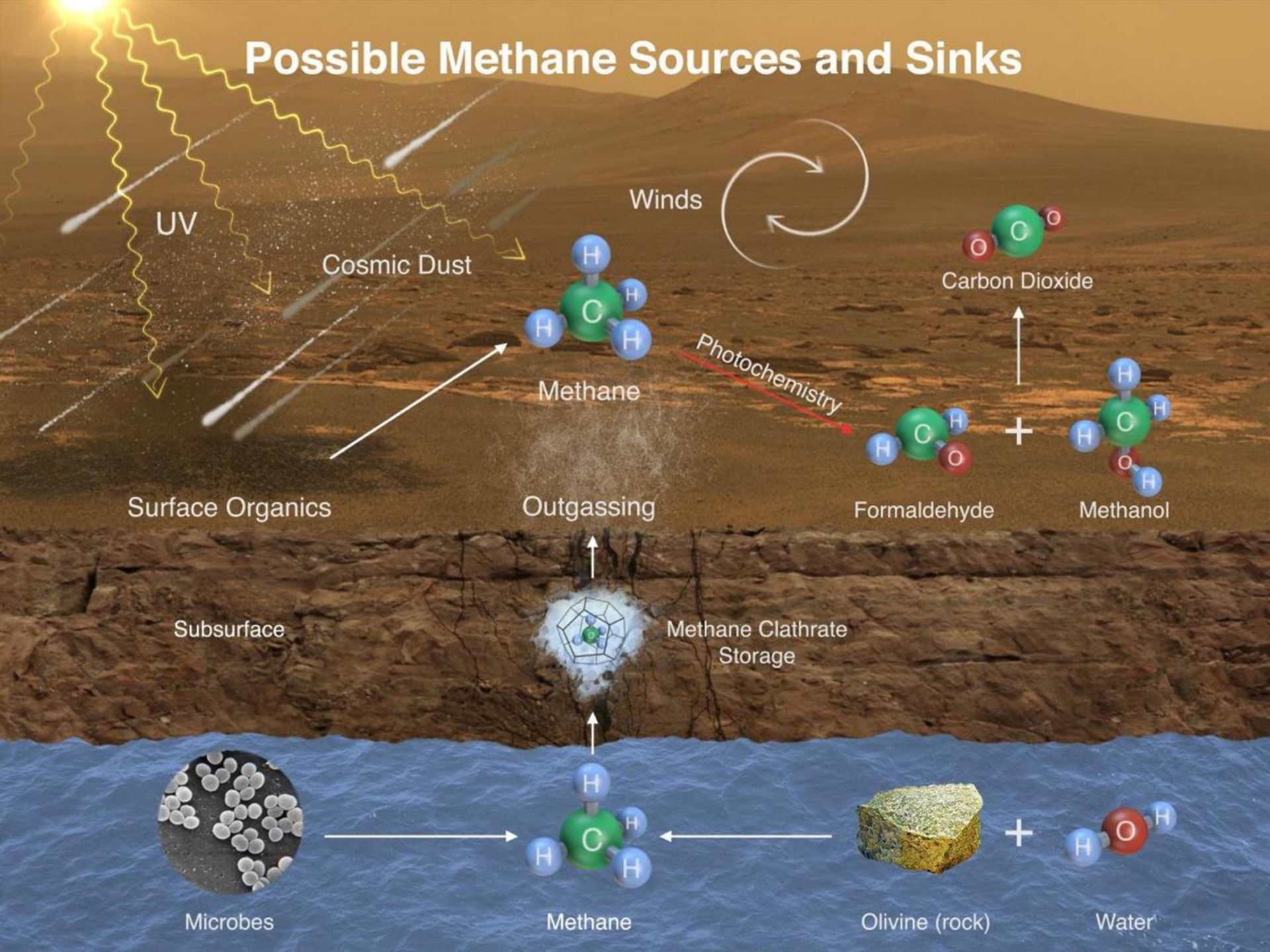
Theory Of Life On Mars Get An Impetus With Discovery Of Methane --- *NY Daily News*

Alien Life on Mars? NASA Rover Spots Methane, a Possible Sign of Microbes --- *National Geographic*

Extraordinary claims require extraordinary evidence”

--- Carl Sagan

Possible Methane Sources and Sinks



Extraordinary claims require extraordinary evidence”
--- Carl Sagan

A cometary origin for martian atmospheric methane --- *Geochemical Perspectives Letters*

Have olivine, will gas: Serpentinization and the abiogenic production of methane on Mars --- *Geophysical Research Letters*

Did Curiosity detect methane on Mars, or just its own exhaust? --- *Inhabit.com*

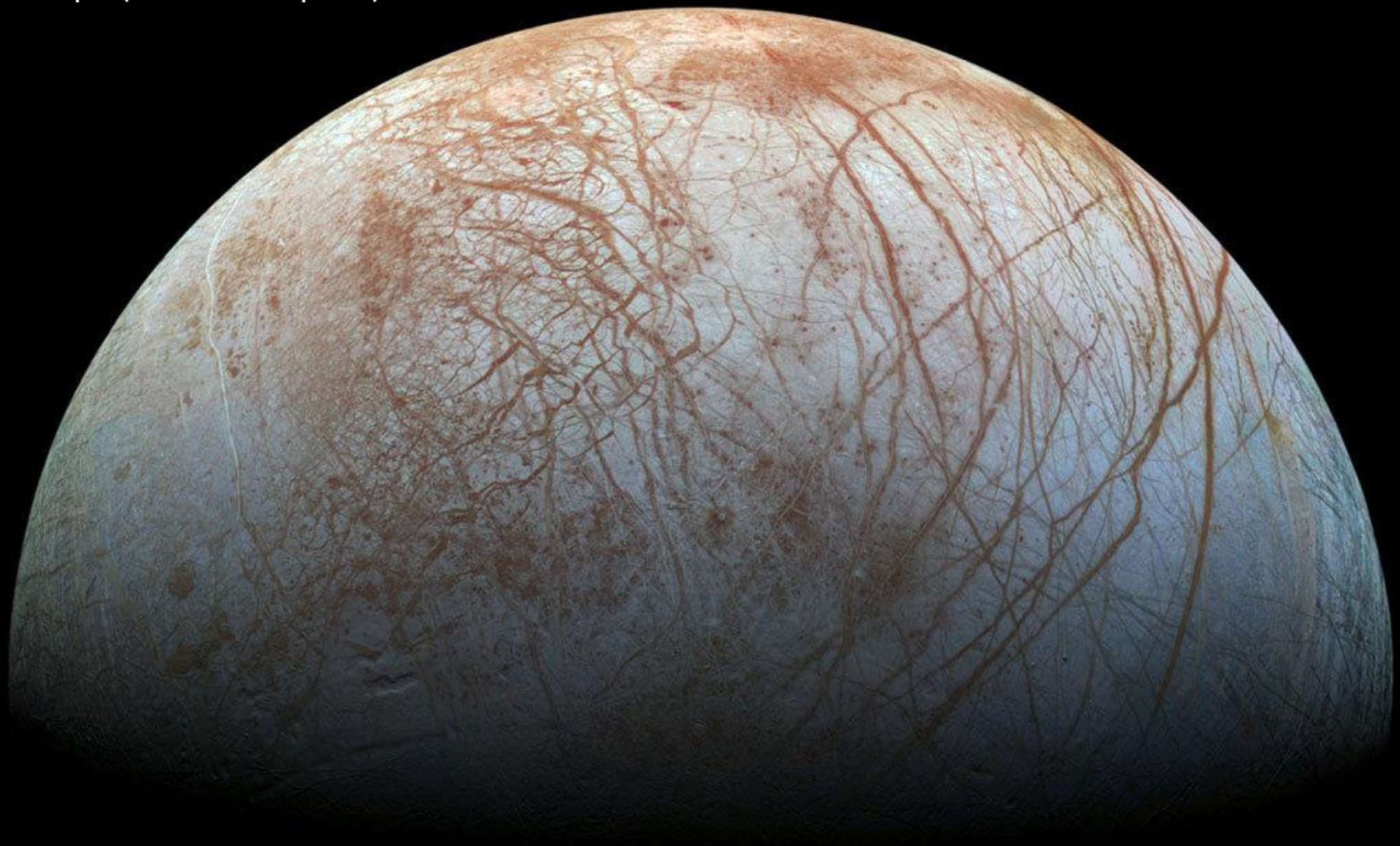
"I am convinced that they really are seeing methane, but I'm thinking that it has to be coming from the rover.”
--- Kevin Zahnle, planetary scientist, NASA Ames Researcher Center

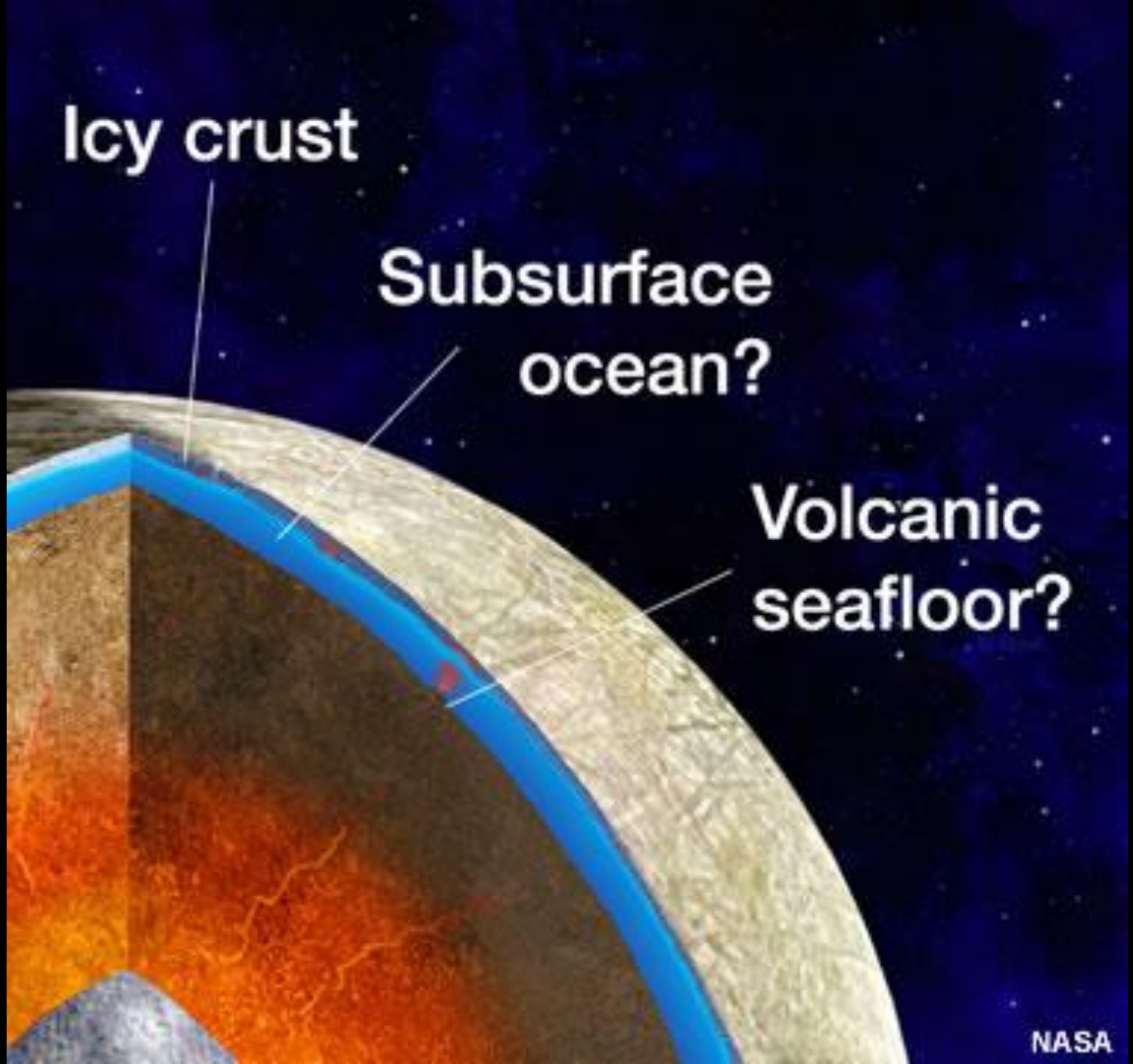
Martian methane

- background level: 0.4 ppb
- Seasonal variations: lows of 0.3 ppb to highs of 0.7 ppb over two martian years

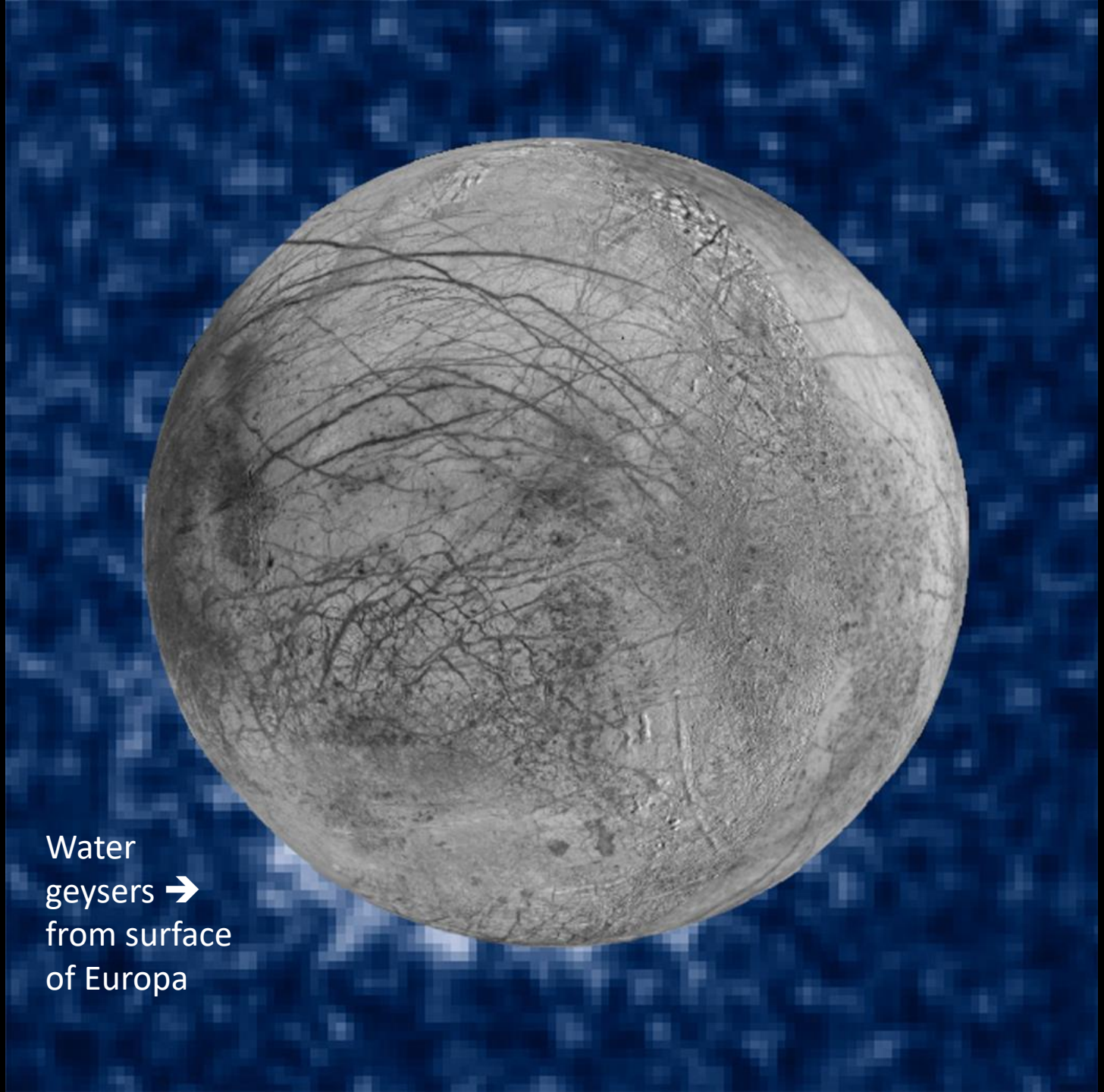
Why? Deep underground source? Meteorite showers? Biology?

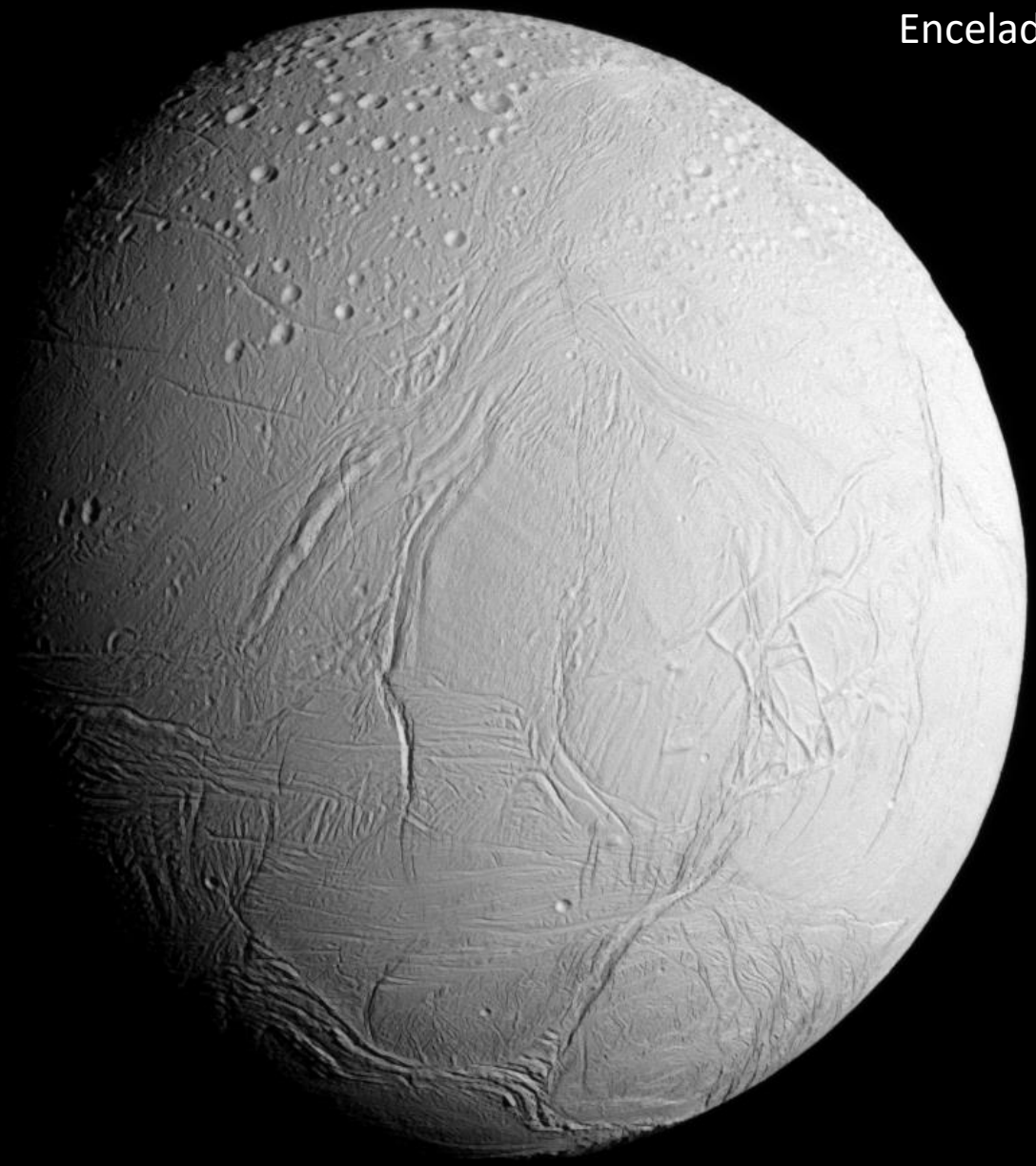
Europa (moon of Jupiter)



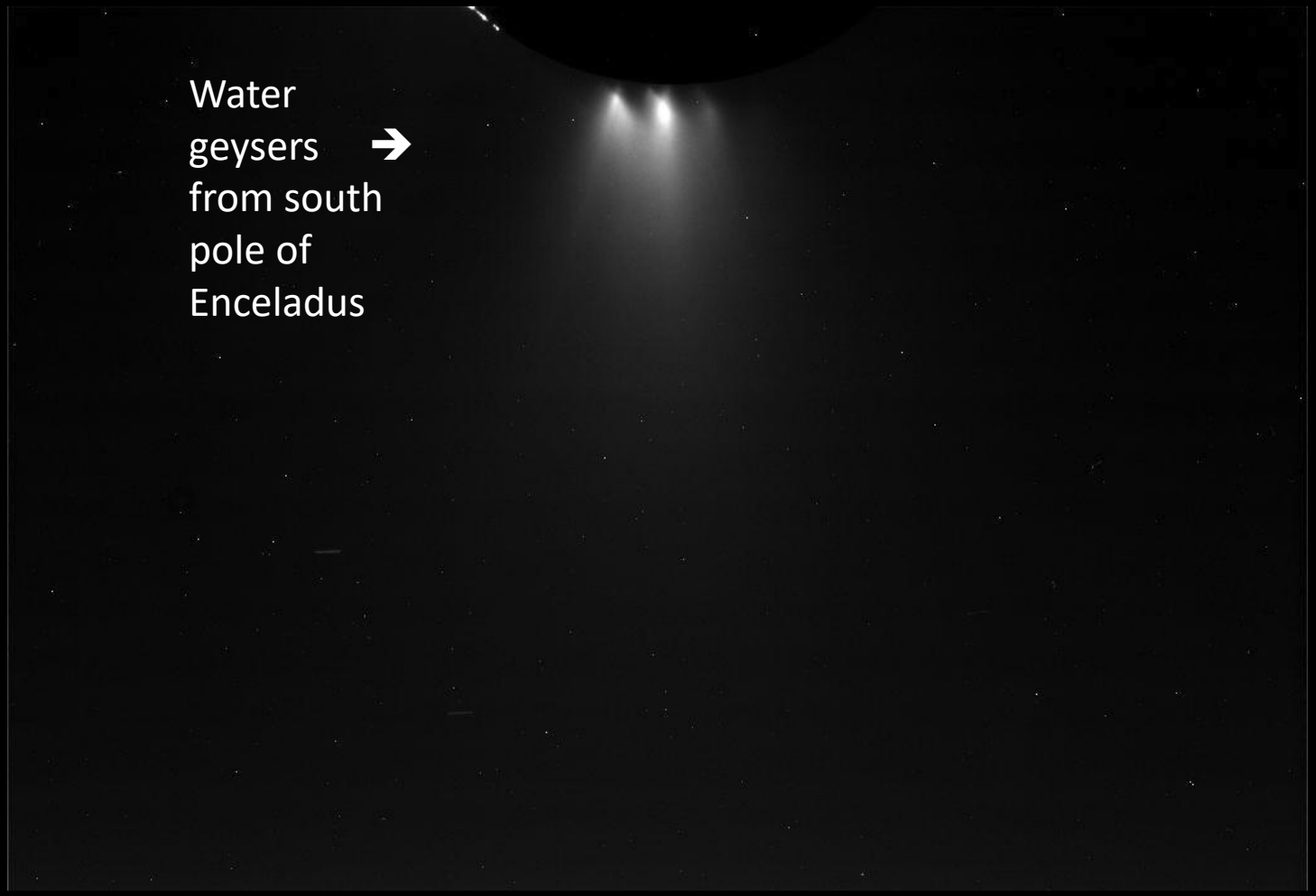


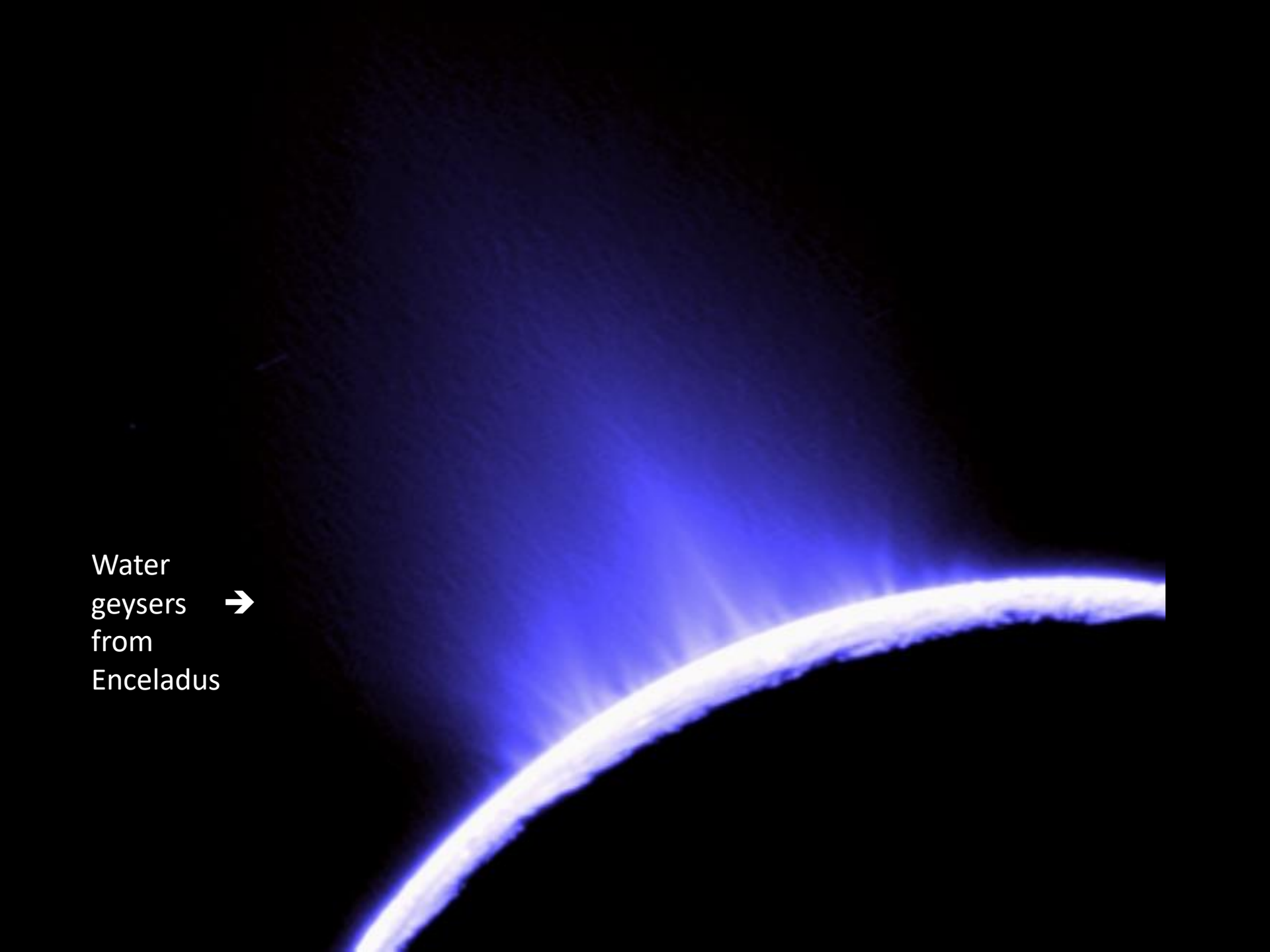
Internal structure of Europa

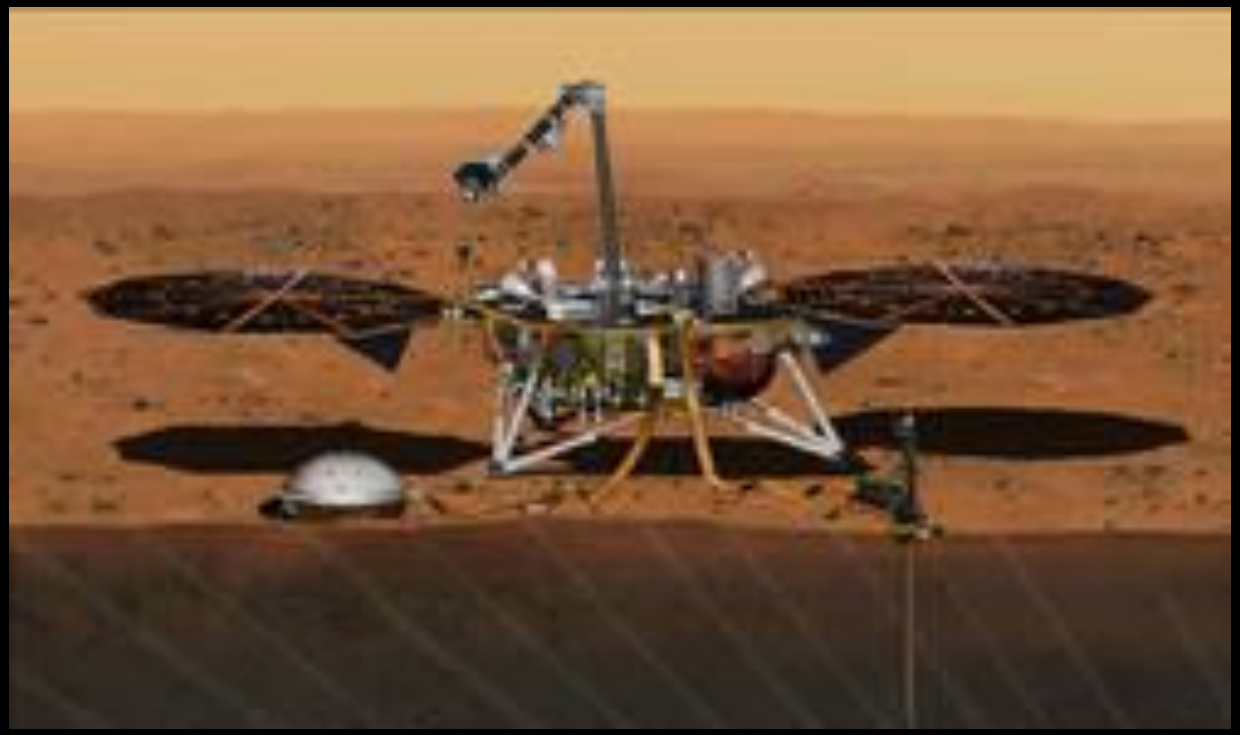

Water
geysers ➔
from surface
of Europa



Enceladus (moon of Saturn)


Water geysers ➔ from south pole of Enceladus


Water
geysers ➔
from
Enceladus



2018 Insight

Arrives Mars: Nov 26

2020 (launch date) ExoMars Rover