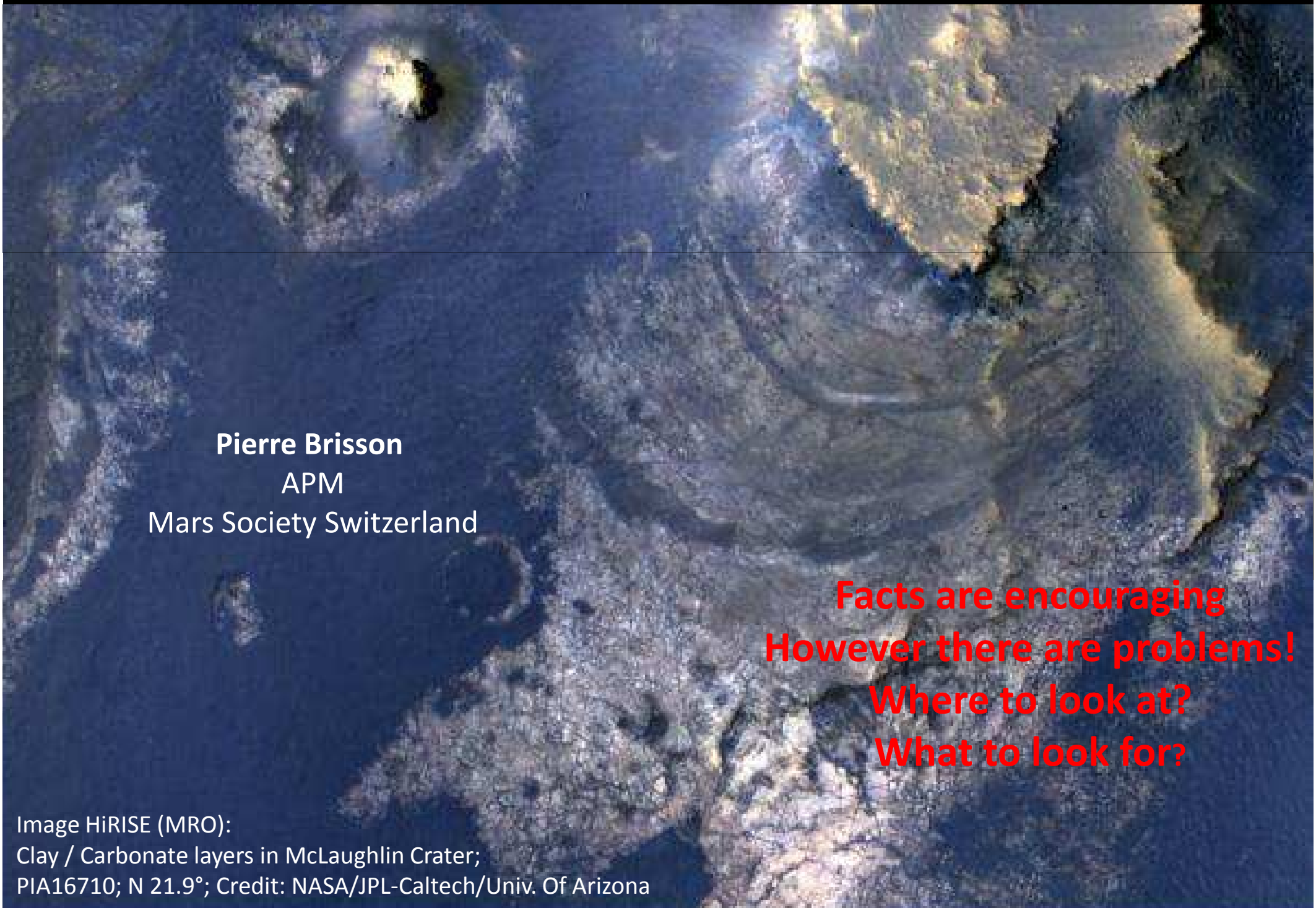
Life on Mars?



Pierre Brisson
APM
Mars Society Switzerland

Facts are encouraging
However there are problems!
Where to look at?
What to look for?

Image HiRISE (MRO):
Clay / Carbonate layers in McLaughlin Crater;
PIA16710; N 21.9°; Credit: NASA/JPL-Caltech/Univ. Of Arizona

Life on Mars?

Facts are encouraging:

Distance to the Star

Atmosphere

Energy received

Water

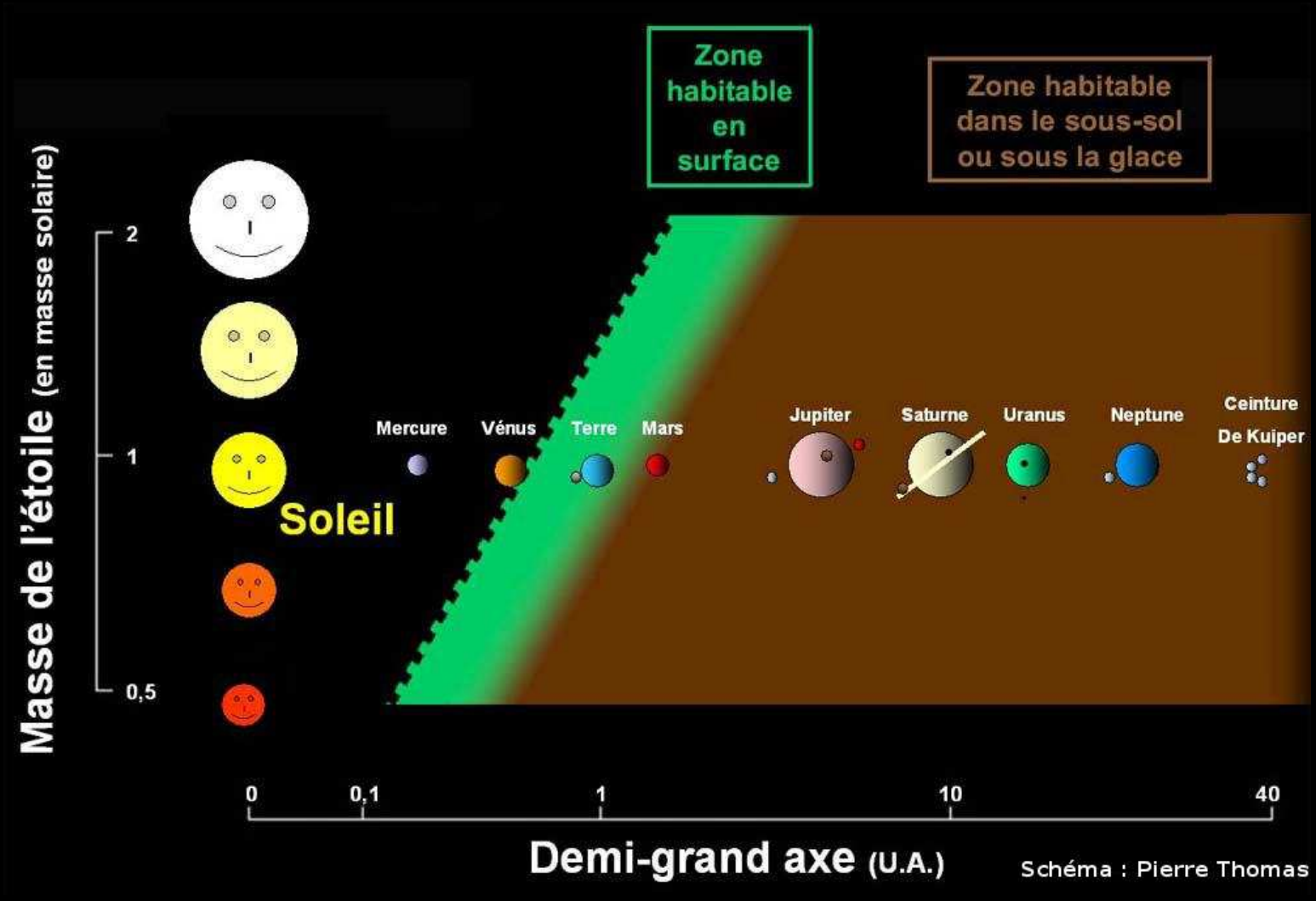
Chemical elements

However, there are Problems!

Where to Look at?

What to Look for?

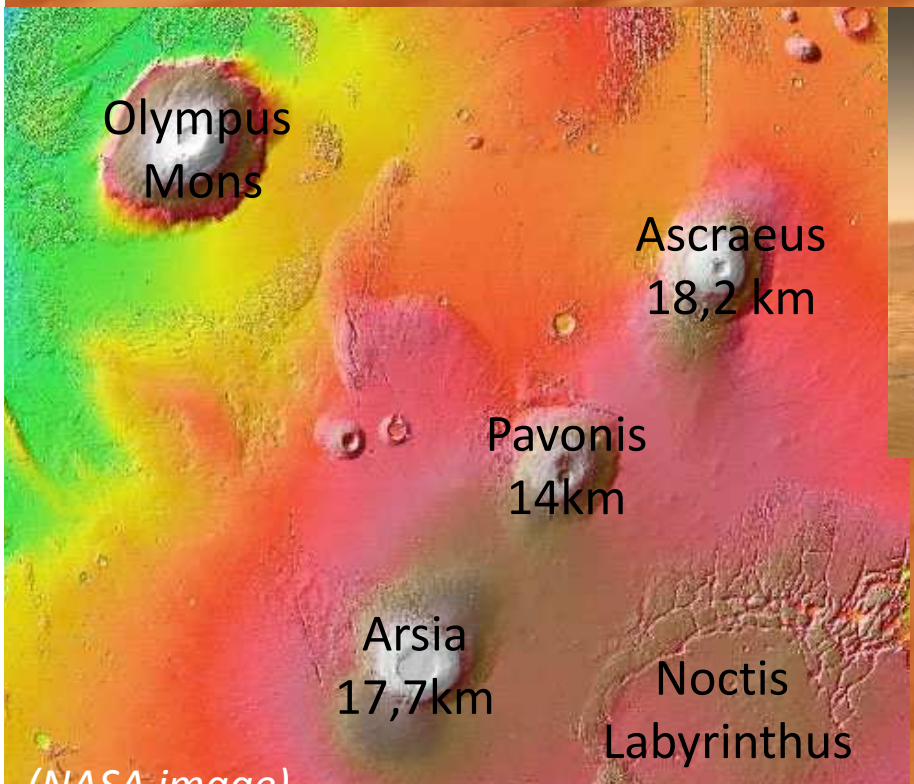
Mars is on the Rim of the Solar System Habitable Zone



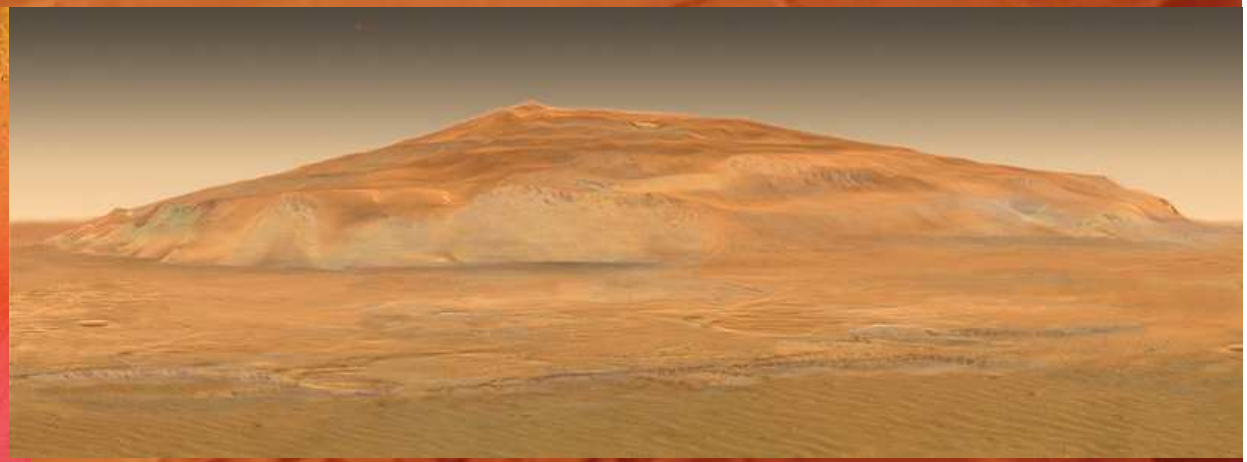
Mars is a rocky planet with an atmosphere

Image Viking Orbiter, 1976, Credit NASA

Volcanism has been a strong atmosphere regenerator:



(NASA image)



Olympus Mons *(image processed by Planetary Vision)*

Mars receives just enough light

Solar Irradiance:

Mars: 492 to 715 W/m^2

(Jupiter 50 W/m^2; Saturne 10W/m^2)

Earth: 1.321 to 1.413 W/m^2

Days (« sols ») of 24h39

Tilt of the rotation axis: 25°19

(Earth: 23°26)

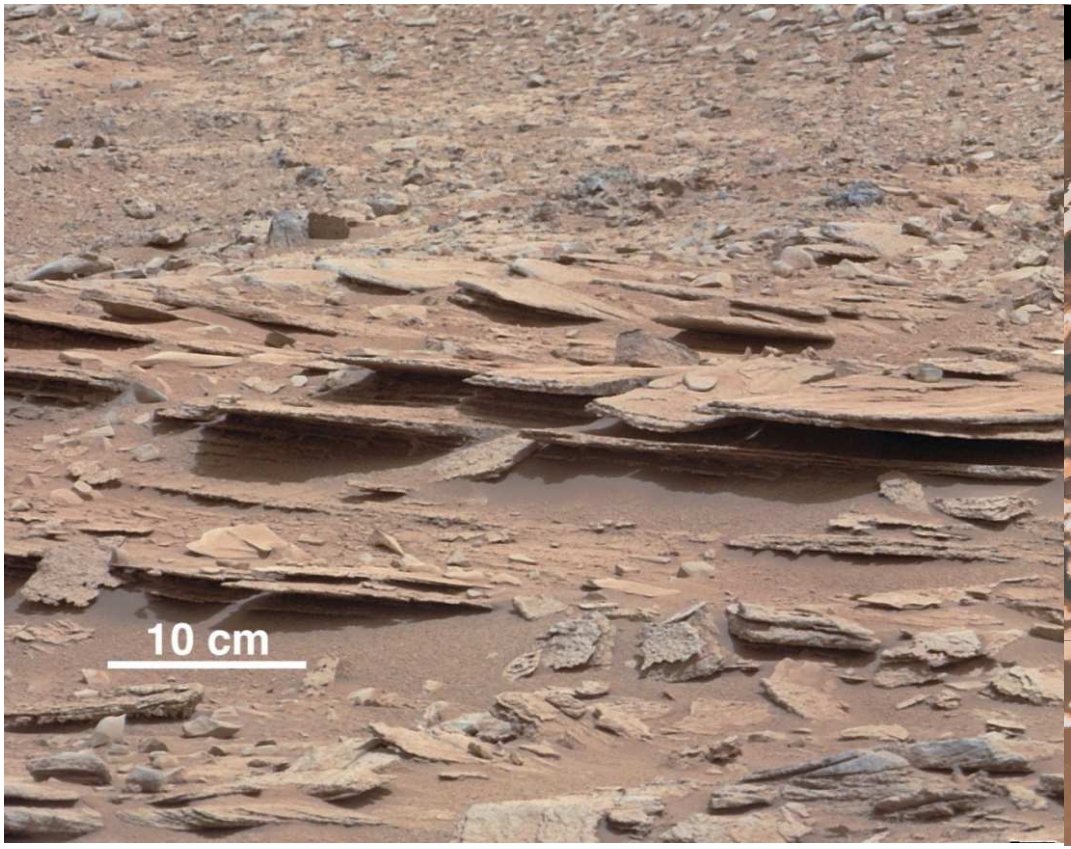
Endeavour Crater, Western rim.
Credit: NASA/JPL-Caltech/Cornell/ASU

Intensity of radiative fluxes is inversely proportional to the square of the distance from the Sun

There was a lot of water on Mars and much is left

In the past, liquid water flowed on the surface (T > 0°), with neutral PH

Today surface soil in Gale contains about 2 percent water by weight
(as per study of Laurie Leshin, Rensselaer Polytechnic Institute, Troy, N.Y.
Research paper published in Science on Sept 26th 2013)



Layered « Shaler » outcrop (in the « Glenelg » area);
Photo by Curiosity, MastCam Sol 120 (Dec. 7th 2012)
Image Credit: NASA/JPL-Caltech/MSSS (PIA16550)

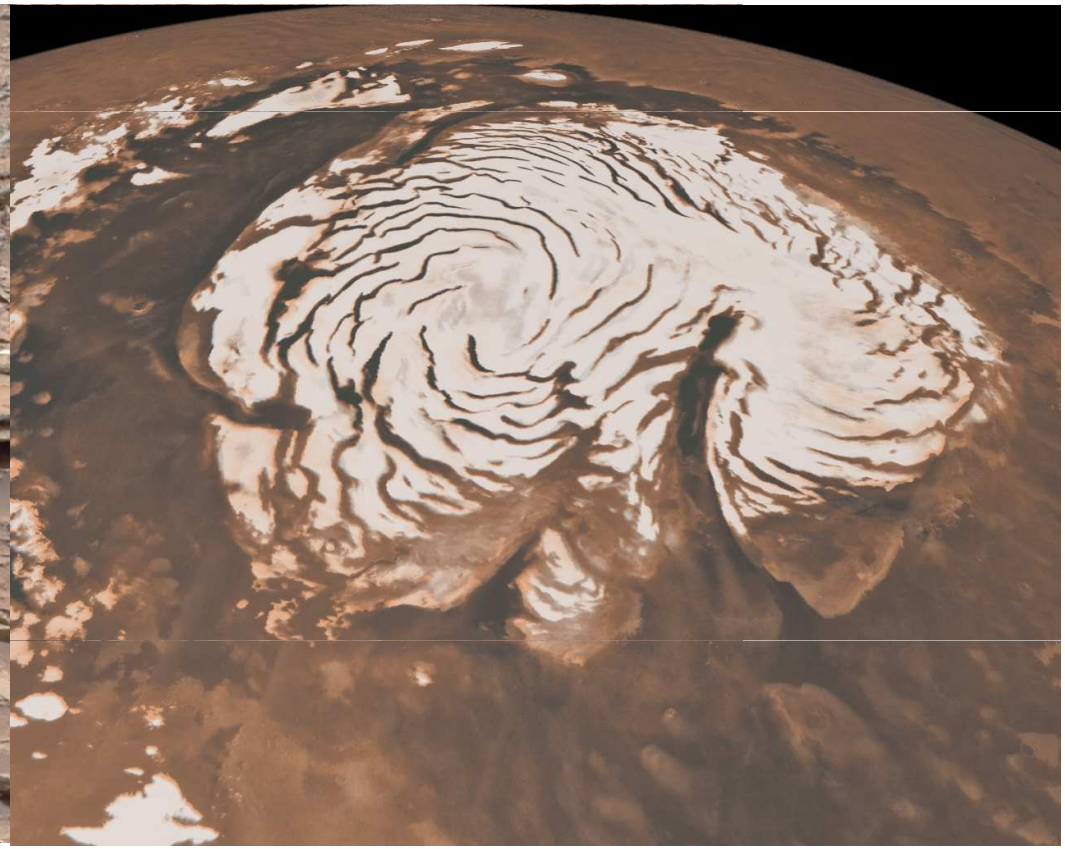


Image Credit: NASA/JPL-Caltech/MSSS

Results of Curiosity Datae collecting
As per SAM analysis (TLS & GC):

In the same location (« John Klein » drilling), Curiosity identified:

Chemical Elements used by Life:
Carbon, Hydrogen, Oxygen, Phosphorus, Nitrogen, Sulfur.

Evidence of Past Liquid Water
Liquid (T > 0°C), neither acidic nor basic.

Hydrated Composites / Rocks favored by Life:
Carbonates; Clays; Gypsum; Sulfates, sulfites, sulfides.

Mars was Habitable !

(To be developped to-morrow by Prof. Michel Cabane, co-PI of SAM)

Life on Mars?

Facts are encouraging

However, there are Problems:

Mass too small

Atmosphere too thin

Environment too dry

Radiations too strong

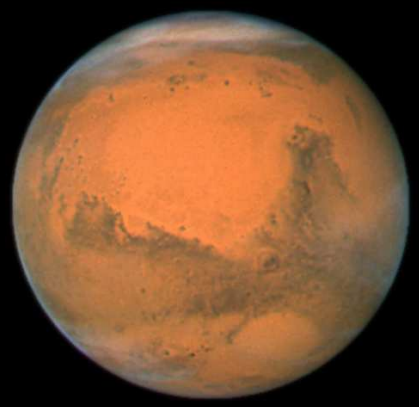
No methane

Perchlorates

Time too short?

Where to Look at?
What to Look for?

The atmosphere may be too thin:



The mass of Mars is only 1/10th that of Earth.

At « Datum » : 611 Pa (at 0°C, boiling point at freezing point)

At the top of Olympus Mons: 30 Pa
At the bottom of Hellas Basin: 1,115 Pa

Within Earth environment, active life has been noted up to 30,000 Pa (Everest 33,700 Pa**)**

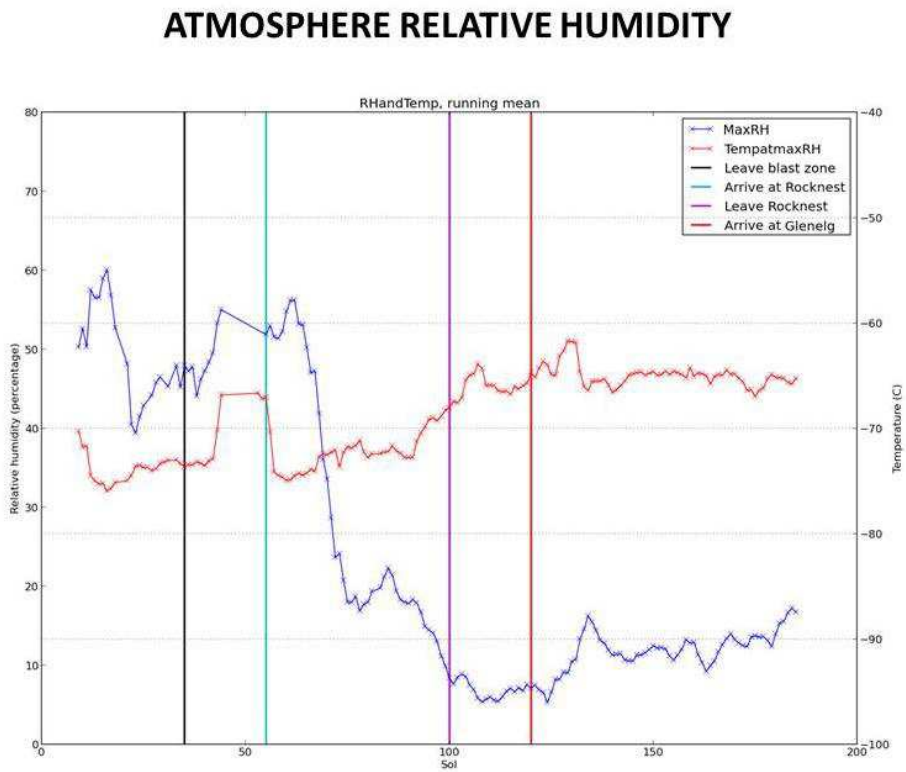
Temperatures may be too cold

	Mars *(at Datum)*	*Terre*
• Average:	-63°C	*+14°C*
• Highest:	+20°C (South) -3 (North)	*+53°C*
• Lowest:	-143°C	*-89°C*

Endeavour, Crater, Occidental rim.
Credit: NASA/JPL-Caltech/Cornell/ASU

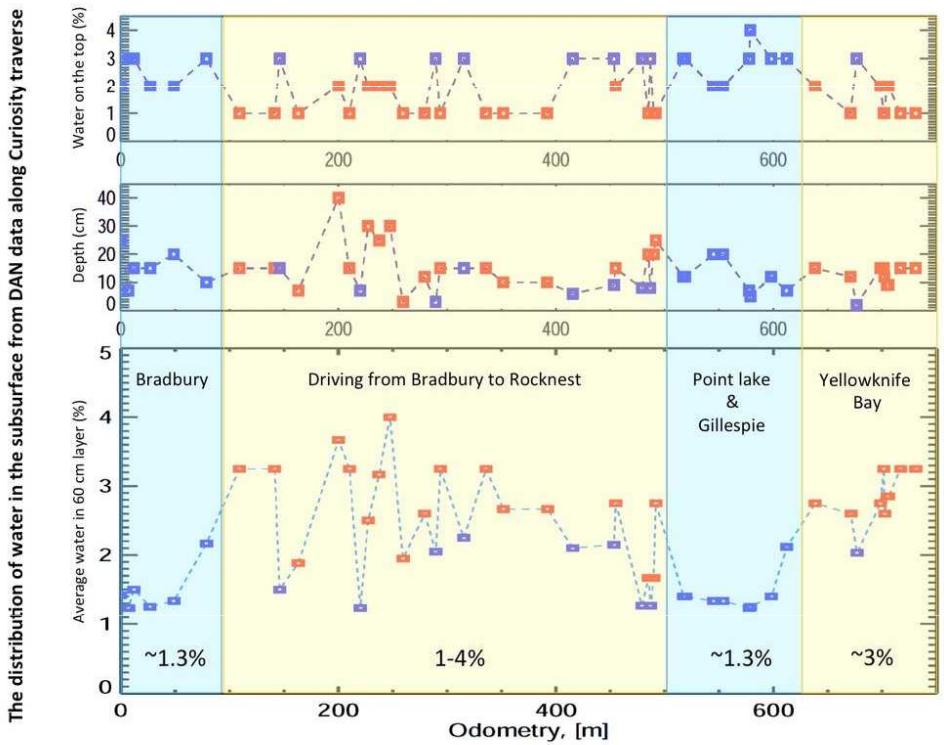
Surface may be too dry
ie: no liquid water

Mars atmosphere is saturated with water
but very thin



REMS measures
(Remote Environmental Monitoring Station)
Image PIA16915 (2013-04-08)
Credit:
NASA/JPL-Caltech/CAB(CSIC-INTA)/FMI/Ashima Research

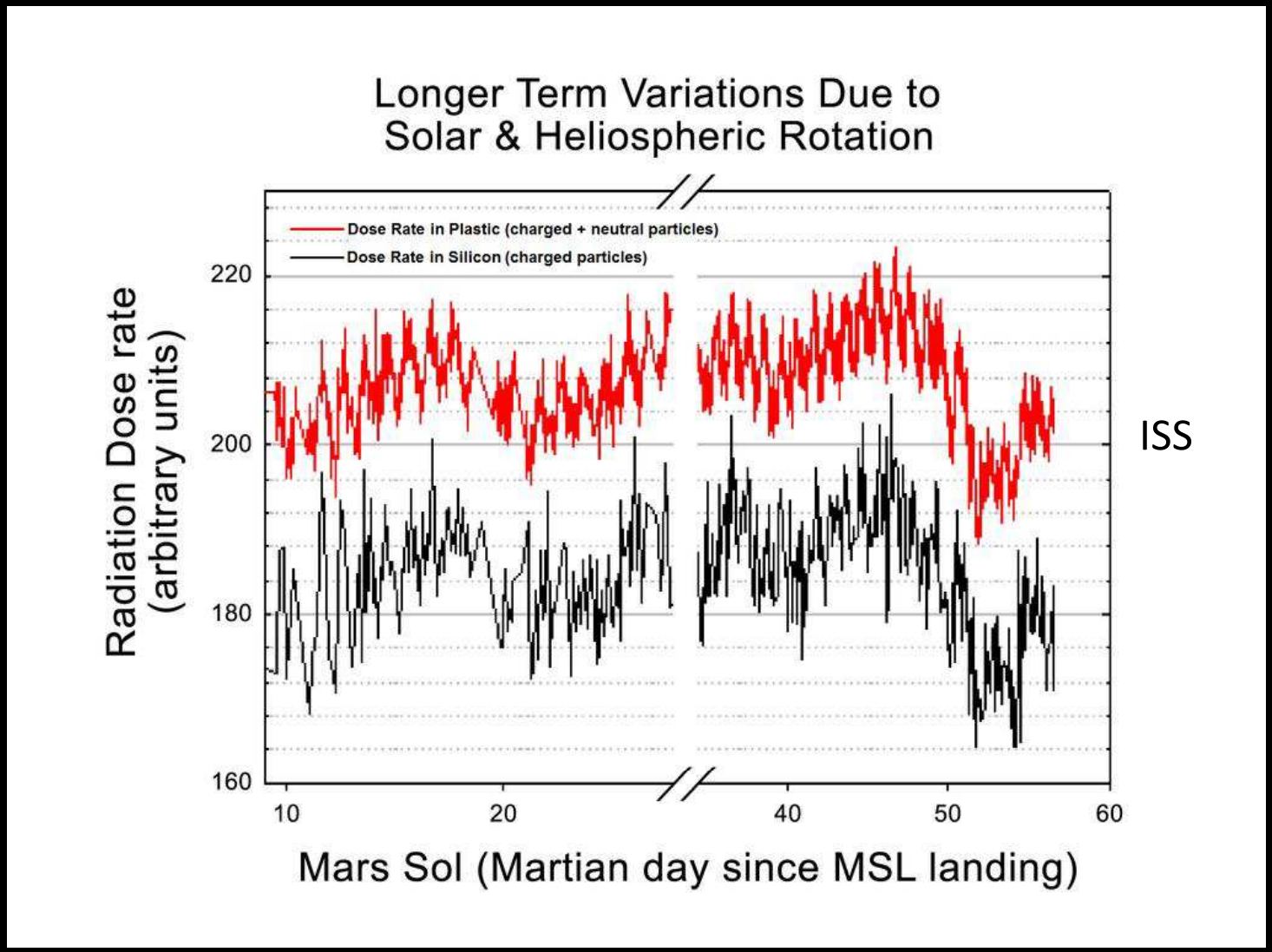
Soil water content is between 1.3 & 4%



DAN Measures (Dynamic Albedo of Neutrons)
in the top 60 cm of Gale Crater soil

Image PIA16809 (March 18th 2013-03-18)
Credit:
NASA/JPL-Caltech/Russian Space Research Institute

Radiations level may be a hazard for Life on surface



ISS

Solar particles radiations are in blue , total radiations are in red
The strongest the solar radiations, the less GCR reach the ground
The highest the atmospheric pressure, the lowest the radiation level.

Measures taken by RAD Image Credit: NASA/JPL-Caltech/SwRI (PIA16480)

Abundance of Methane is below the sensitivity of Curiosity's Instruments !

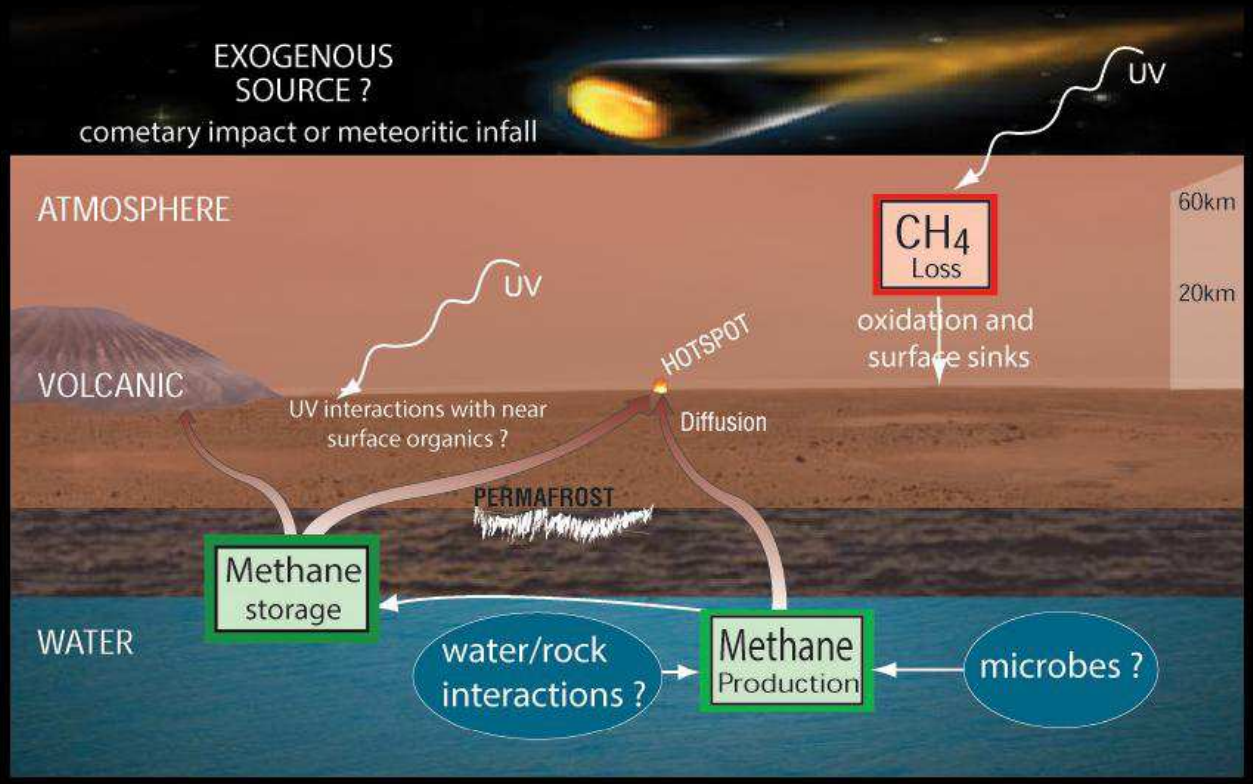
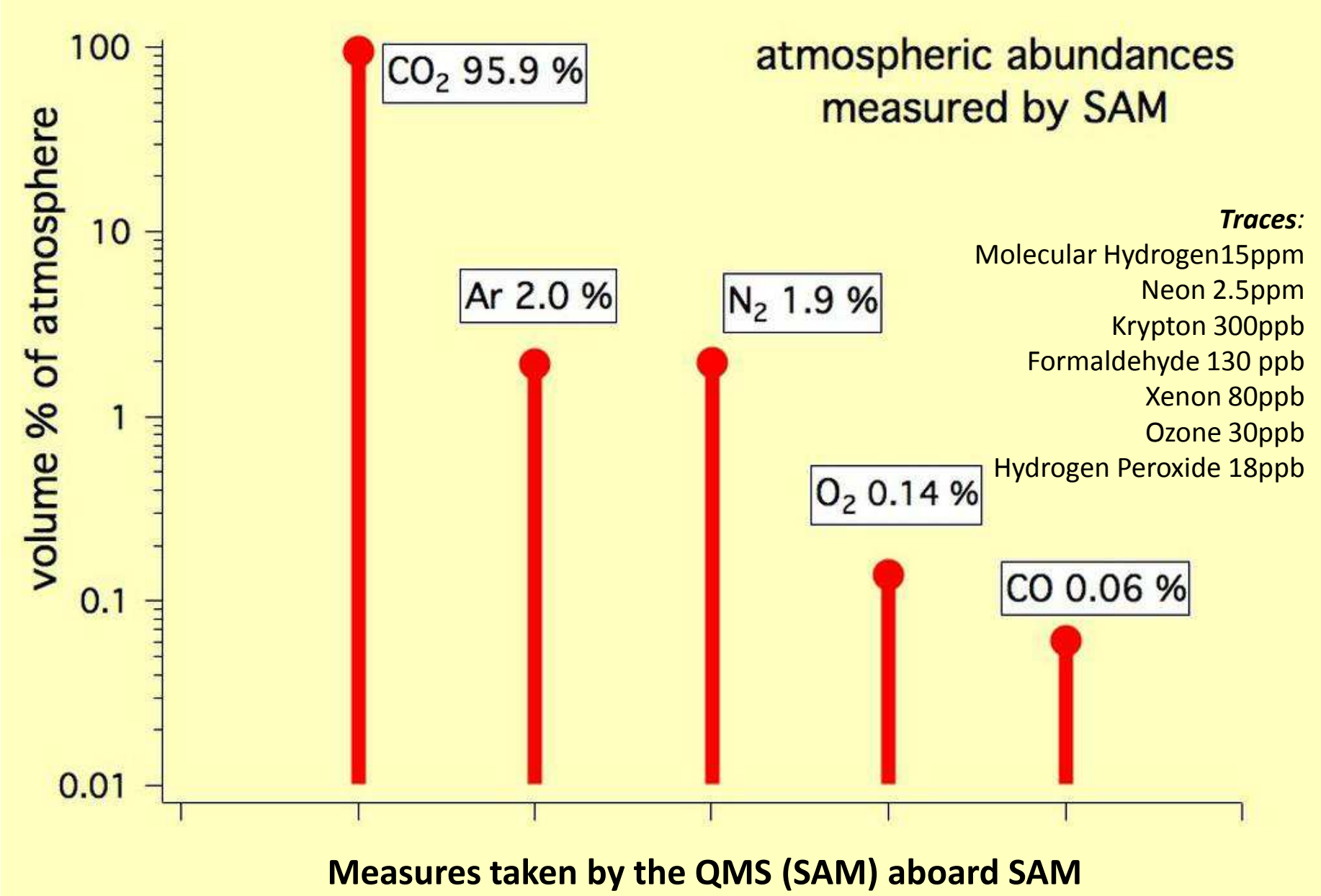


Image Credit: NASA/JPL-Caltech, SAM/GSFC
PIA16461 Nov. 2nd 2012

This pretty image is to be forgotten!
The TLS specrometer of Curiosity's SAM suite of instruments found no Methane on Mars (Sept 19th 2013)

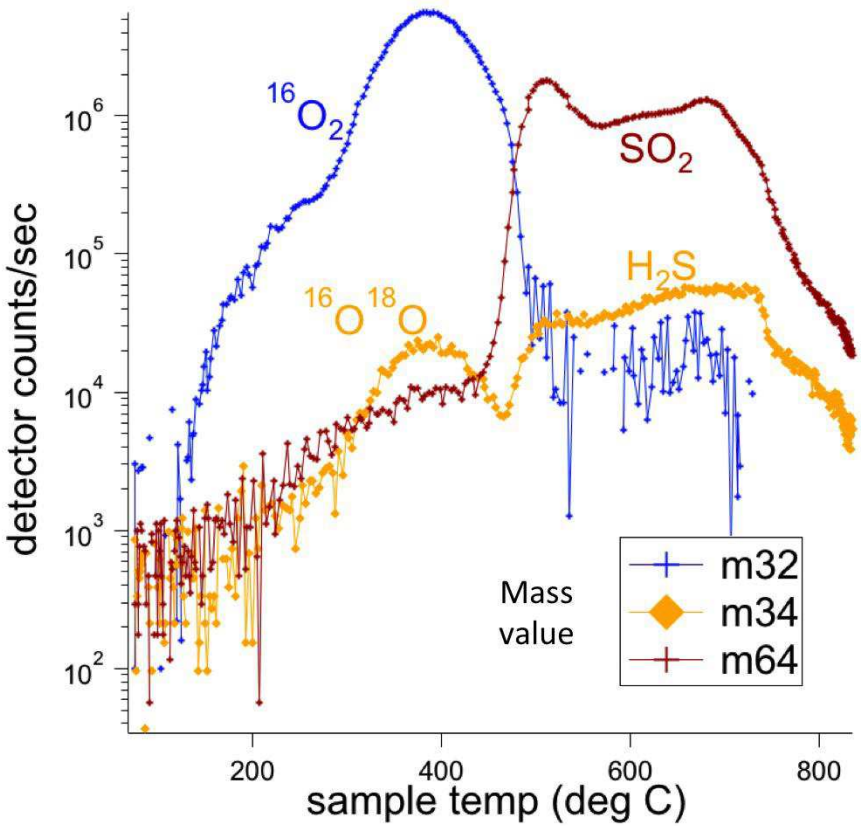
Since there is no Methane in the Atmosphere,
What else could be rejected by Living Beings?



Measures taken by the QMS (SAM) aboard SAM
Nov. 2nd 2012 (Spring on Mars)
PIA16460; Image Credit: NASA/JPL-Caltech, SAM/GSFC

Perchlorates

Oxygen and Sulfur compounds from Rocknest samples



Oxygen released may be from decomposition of a perchlorate such as Ca $(ClO_4)_2$

Similar chemicals were observed by the Phoenix polar lander

Higher temperature S containing compounds suggest the presence of sulfates or sulfides

Sulfur, chlorine, and oxygen compounds were identified by SAM in Rocknest wind drift. The oxygen and chlorine may come from perchlorates (also found by PHOENIX).

"Rocknest" sample, in Glenelg area, Dec 3rd 2012, PIA16575; Image Credit: NASA/JPL-Caltech/GSFC

Life may have had not enough time to get a start

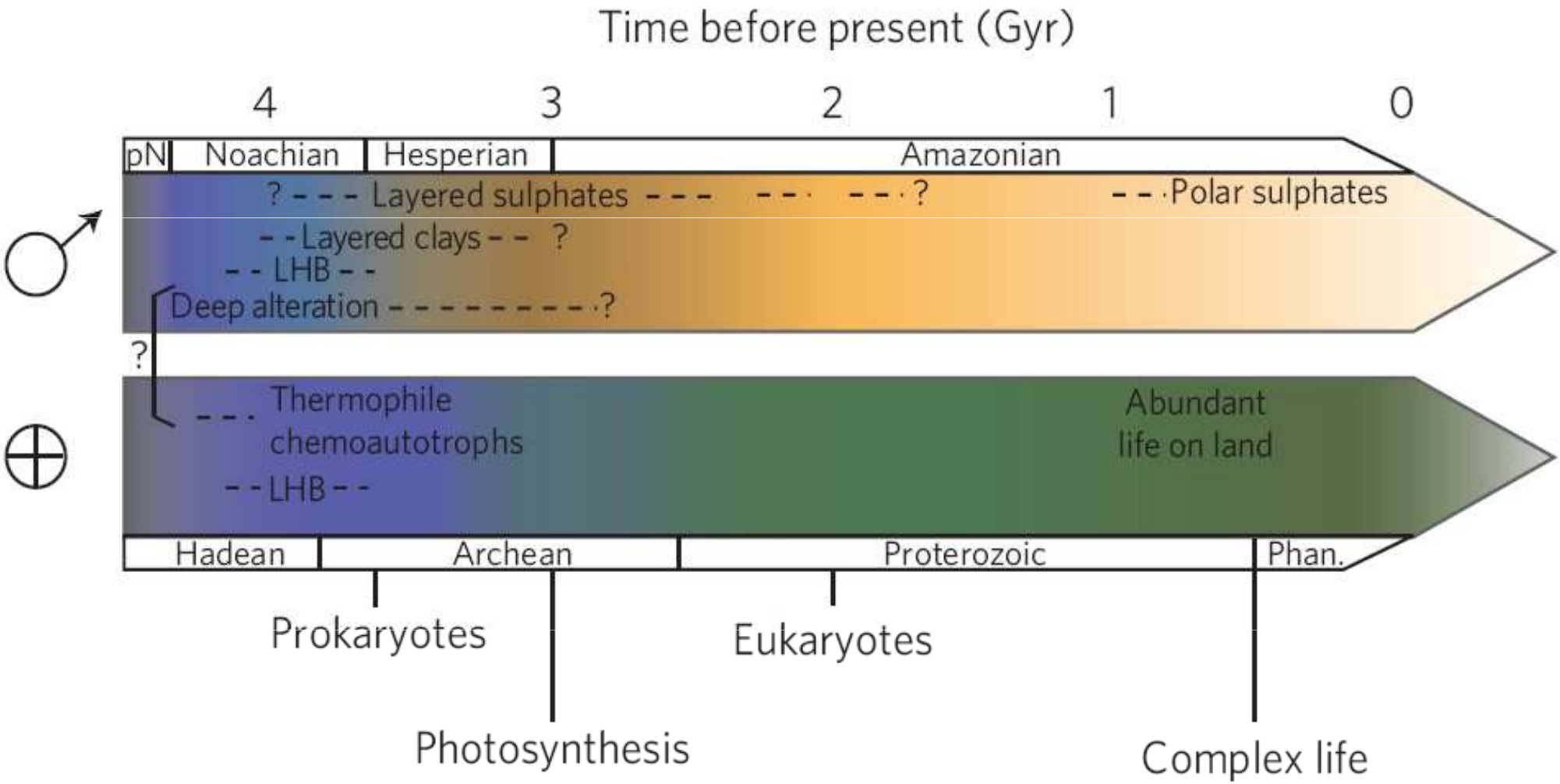


Fig. 2, « Major evolutionnary events on Earth compared with geologic evolution on Mars »
in « Groundwater activity on Mars and implications for a deep biosphere »
by Joseph R. Michalski et al. in Nature Geoscience, published 20th Jan 2013/
DOI:10.1038/NGEO1706

Life on Mars?

Facts are encouraging

However, there are Problems

Where to Look at

Anywhere (dust drift)

Old hydrated layers (lower layers of Mount Sharp)

At the bottom of deep craters (McLaughlin?)

Underground

What to Look for

On Mars Surface?

Organic compounds may be hidden by perchlorates.

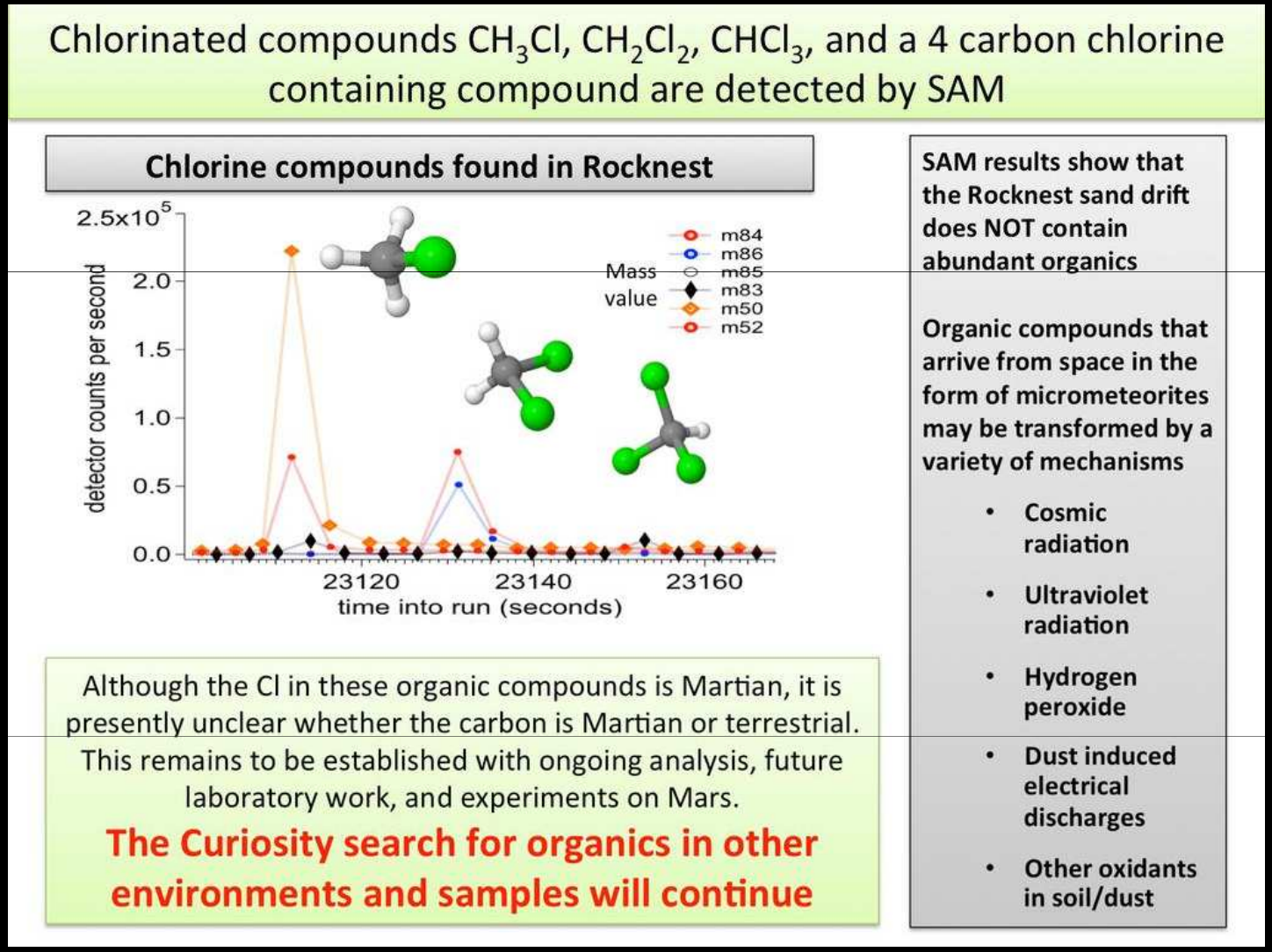
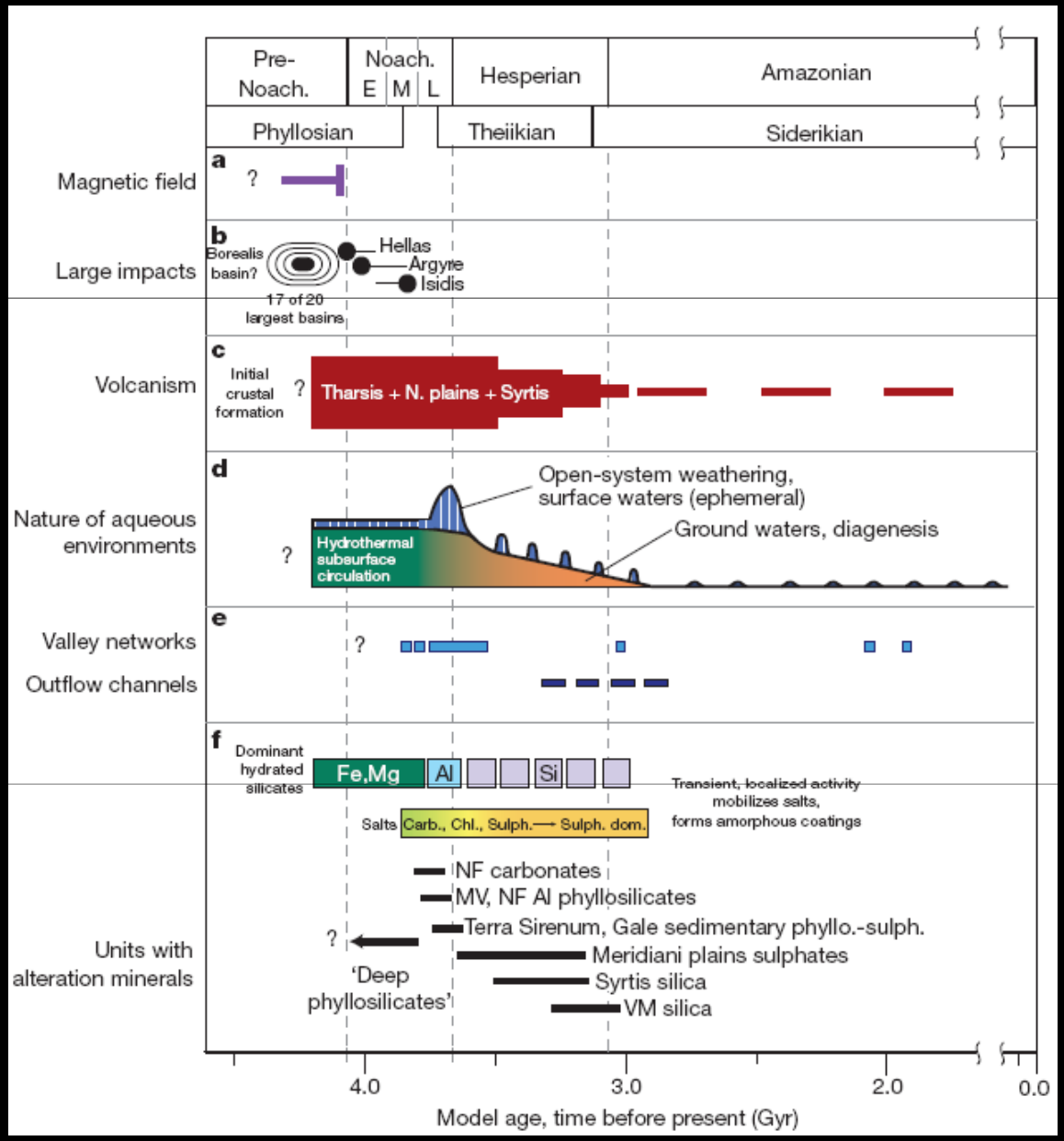


Image Credit: *NASA/JPL-Caltech/GSFC. 03.12.2012; PIA16576*

For the time being, SAM found chlorinated compounds (Hydrogen + Carbon + Chlorine). These compounds could come from the action of perchlorates upon carbonaceous products. We cannot yet say whether the carbon is coming from Mars.

In the Oldest Rocks?

Look at Phylosian or Theiikian Rocks



In « *Subsurface water and clay mineral formation during the early history of Mars* ».
Bethany L. Elhmann et al. doi:10.1038/Nature 10582

Underground?

Pressure:
0.3 bar is the minimum pressure noted for active life on Earth
On Mars this is reached only underground or within rocks.
Maximum pressure for liquid water: 310 km on Mars; 75 km on Earth at.

Caves:
On Mars down to 5 km, on Earth, down to 2 km
Porosity down to 85 km

Temperature:
-20°C is the minimum for active life (on Mars mostly underground).
+122°C is the maximum for active life (on Earth down to 5 km; on Mars down to 36 km).

As per “An Extensive Phase Space for the Potential Martian Biosphere », Eriita G. Jones et al.
ASTROBIOLOGY, Volume 11, Number 10, 2011, DOI: 10.1089/ast.2011.0660

Habitability might still be possible today some 3 km underground

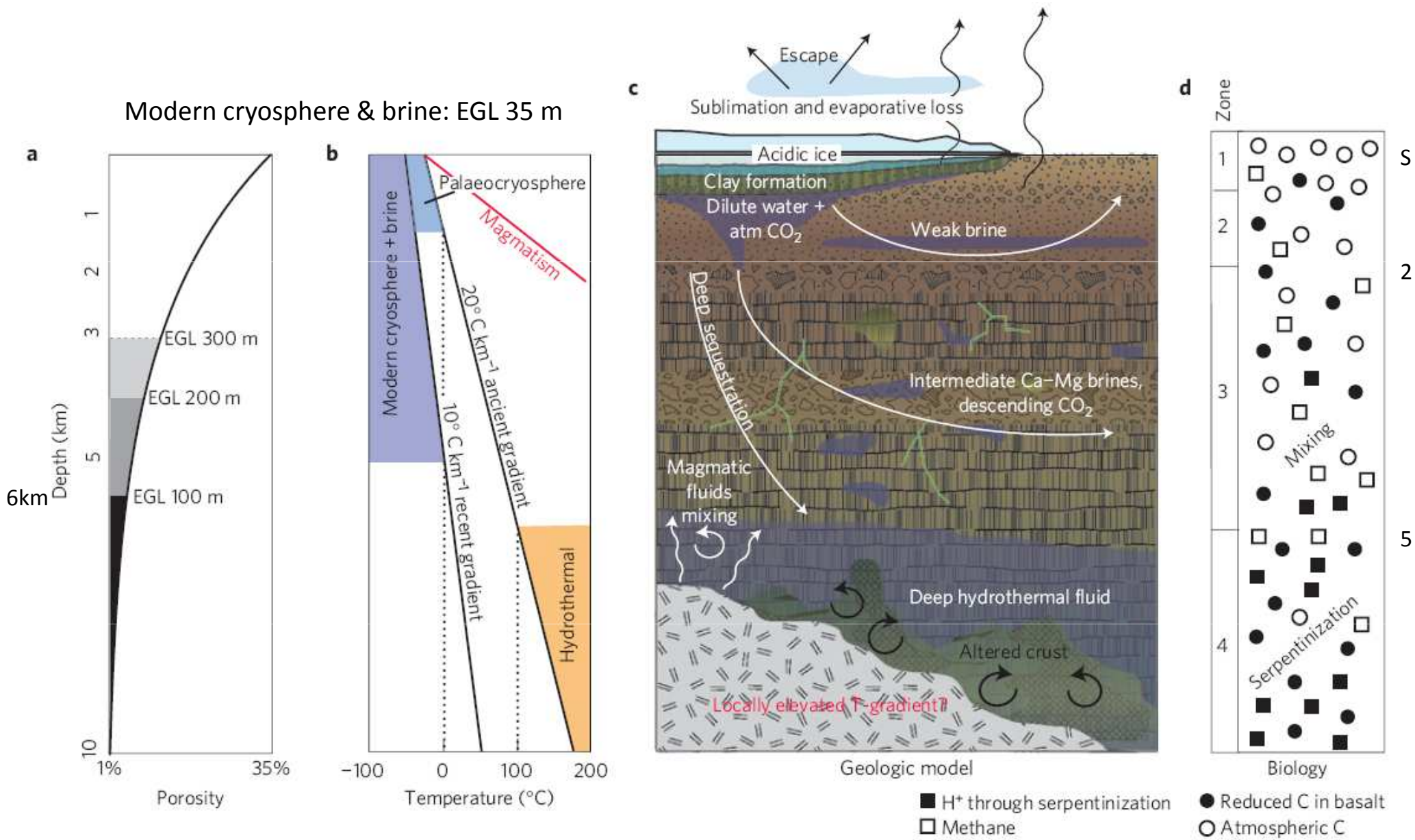


Figure 3, of « Groundwater activity on Mars and implications for a deep biosphere »
by Joseph R. Michalski et al. in Nature Geoscience, published 20th Jan 2013/
DOI:10.1038/NGEO1706

Upwelling fluids might have brought
biologic elements from underground into deep craters
Located on the crustal dichotomy

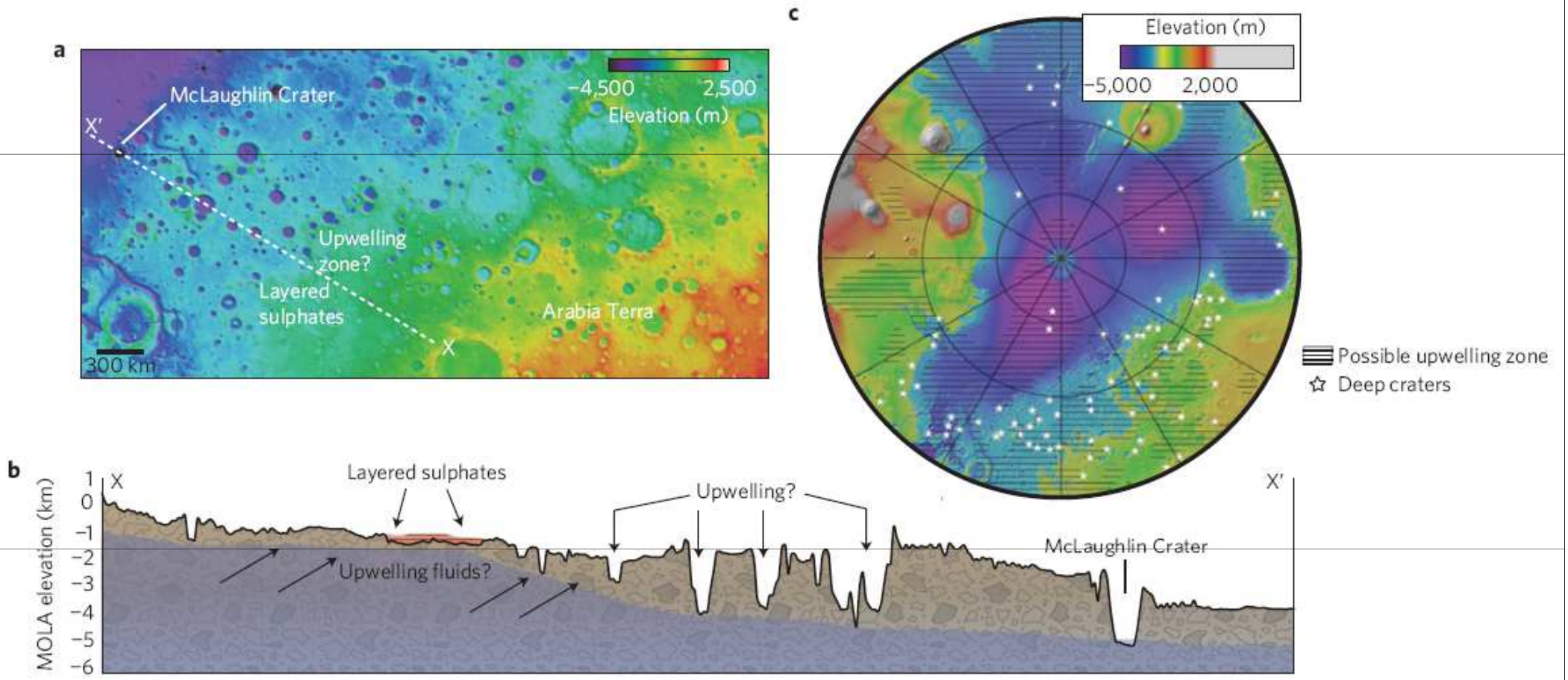


Figure 6, of « Groundwater activity on Mars and implications for a deep biosphere »
by Joseph R. Michalski et al. in Nature Geoscience, published 20th Jan 2013/
DOI:10.1038/NGEO1706

Possible Caves
in the Hebrus Valles area (or elsewhere)
may provide shelter (pression, humidity, warmth)

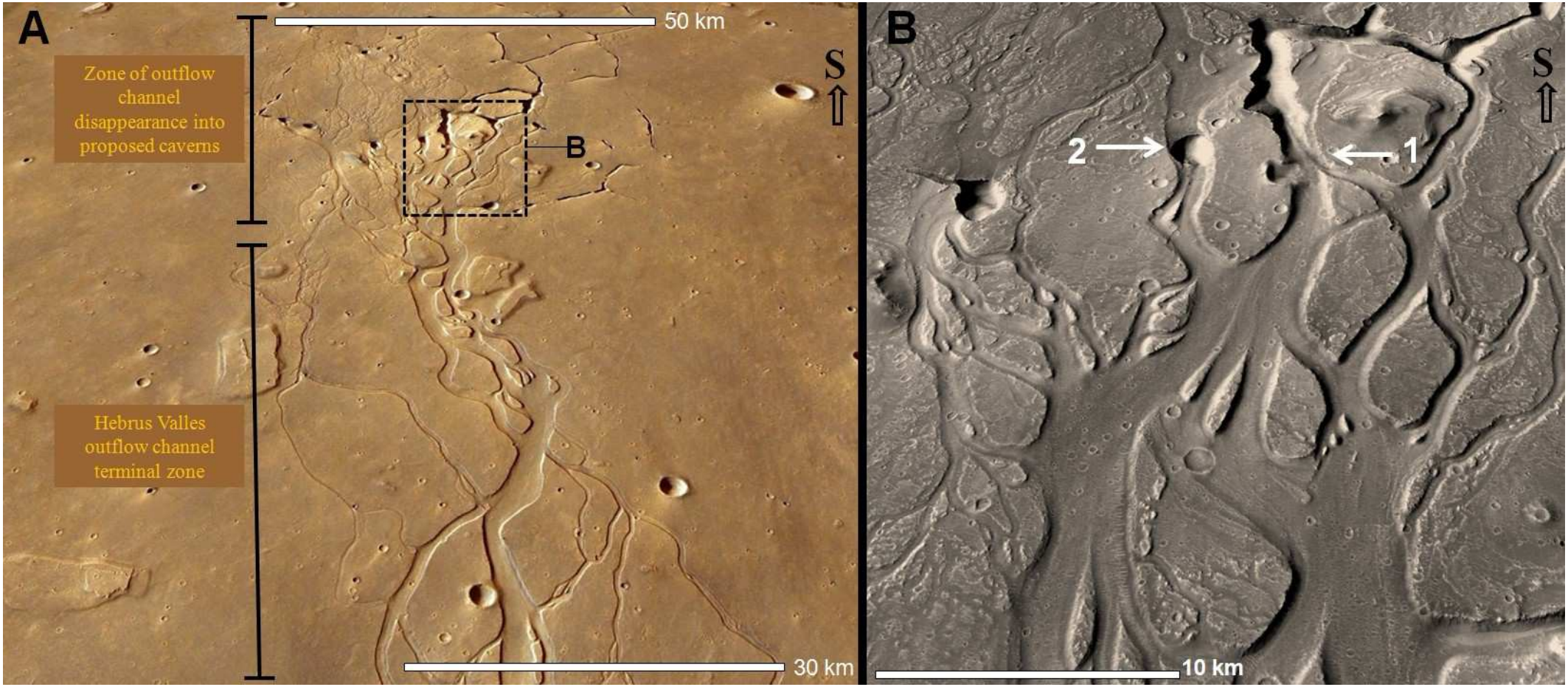
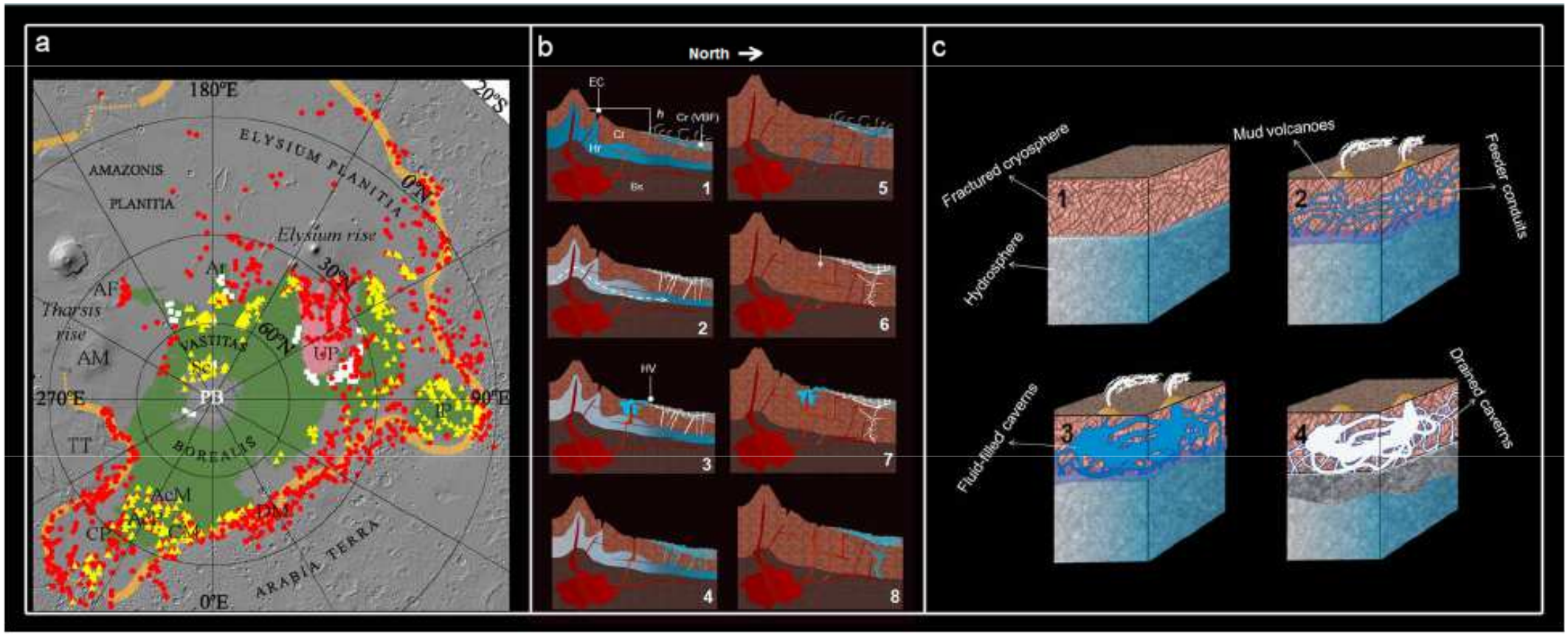


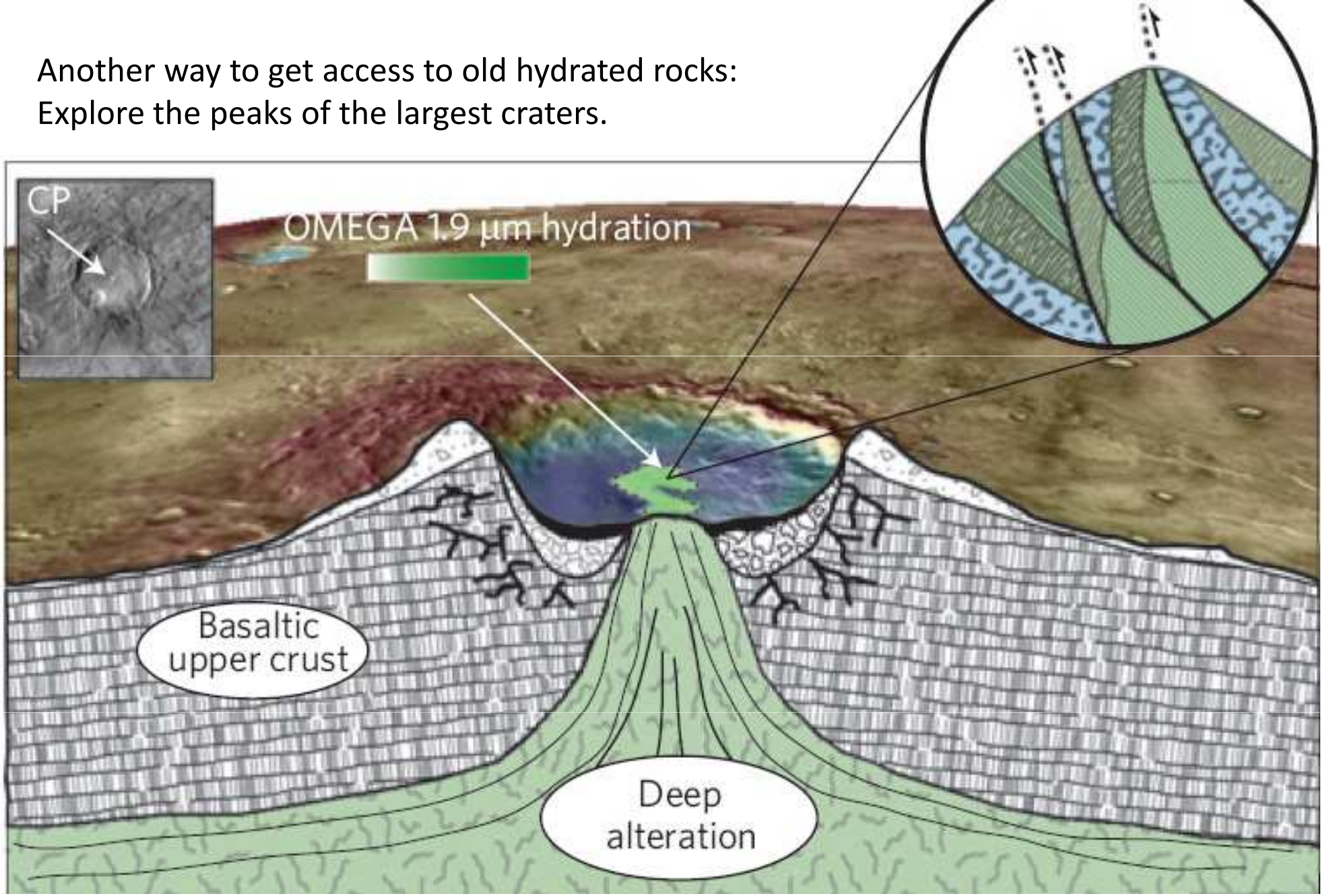
Image CTX (aboard MRO), credit NASA/JPL-Caltech/MSSS/PSI

Many places in the Northern Lowlands and on the Crustal Dichotomy
Could hide underground caves



Rodriguez et al. : Outflow channel floodwater infiltration, published 29th Nov. 2012 (Fig.3)
In Geophysical Research Letters, Vol. 39, L22201, doi:10.1029/2012GL053225, 2012

Another way to get access to old hydrated rocks:
Explore the peaks of the largest craters.



The Statigraphic Uplift of a Central Peak represents about 1/10th of the final diameter of its Crater (here Leighton, 65 km)

Fig 4; "Deep Crustal Carbonate Rocks exposed by Meteor Impact on Mars"
Joseph R. Michalski and Paul B. Niles in Nature Geoscience Vol. 3 Nov. 2010

Life on Mars?

Facts are encouraging

Problems

Where to Look at

What to Look for

Bacteria or archea

Nucleotides

Organic molecules

Life favoured isotopes

Phylogenetic tree.

Has Mars got its own?

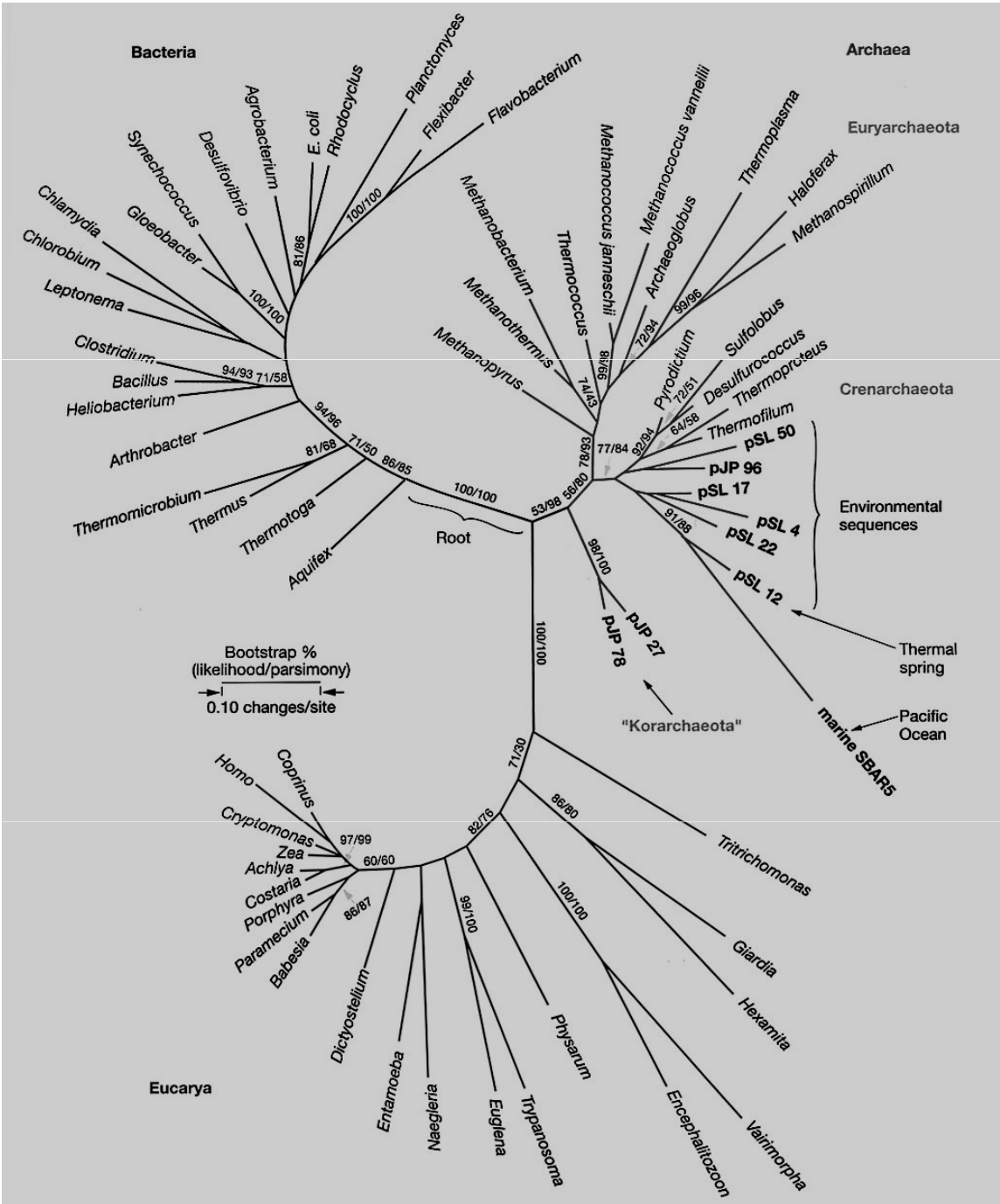


Figure 14.19 An estimate of the phylogeny of all extant organisms based on rRNA sequences Codes such as "pSL 22" designate organisms known only from their ribosomal RNA genes. From Barns et al. 1996.

Up to what level?

Active Life?

Surviving through adaptation
Underground rather than on surface.
Archea?

Fossil Life?

Could not survive the harshness of Mars Conditions
Not identifiable through metabolic processes.

Dormant Life?

Unlikely after a few million years.

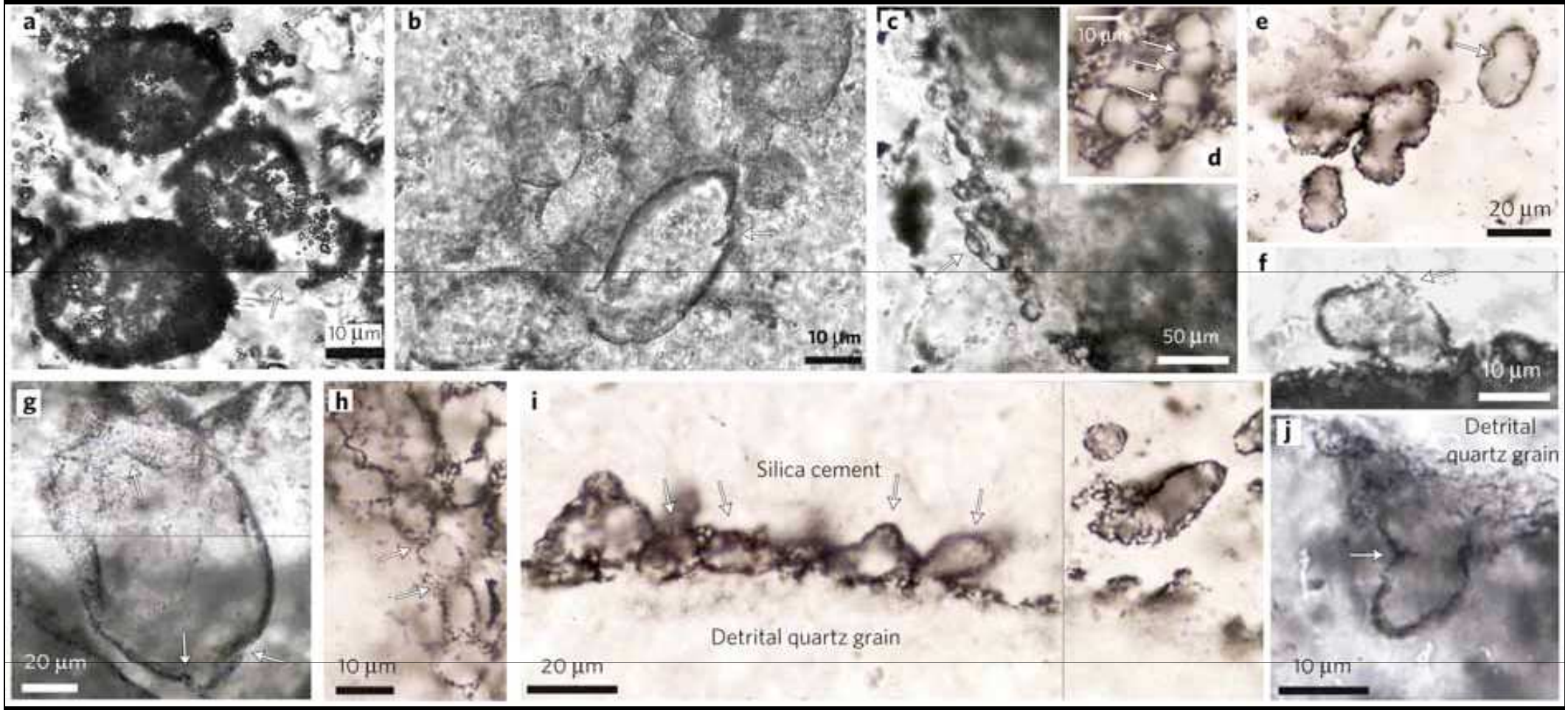
Optical Investigation

Stromatolites from Strelley Pool (3.6 to 3.2 billion years)

Source: Wikipedia Commons

Cryptoendolitic organisms colony

On Earth, first evidence of Life goes back to a time when conditions on Mars began to turn adverse to Life

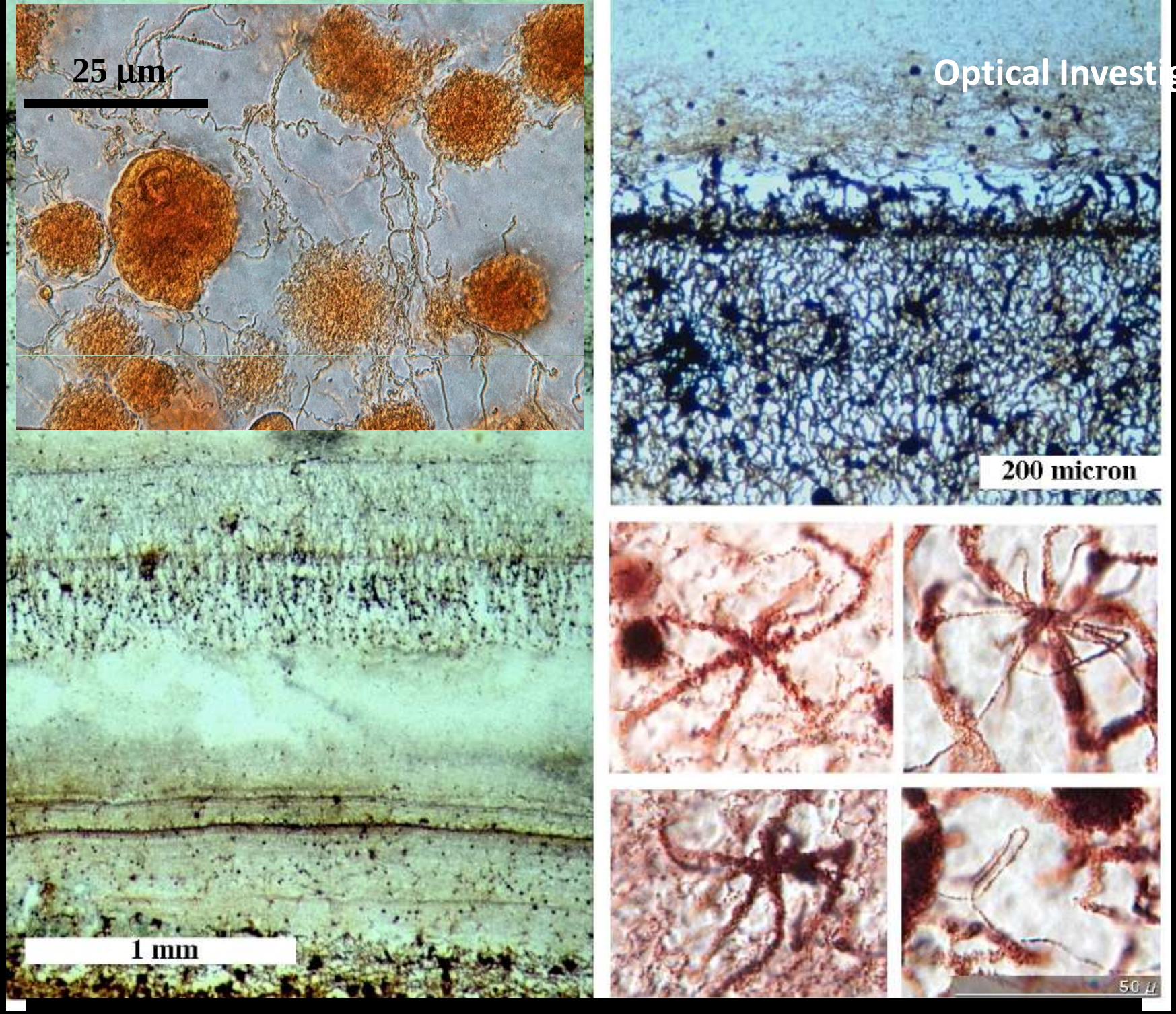


Microstructures (a few micrometers) associated to pyrite crystals (iron sulfide) found in the Strelley Pool rocks (Western Australia)-sandstone.

dated -3.4 Gy

In "***Microfossils of sulphur-metabolizing cells in 3.4-billion-year-old rocks of Western Australia***" by **David Wacey et al.** published on 21/08/2011 in **"Nature Geoscience"**

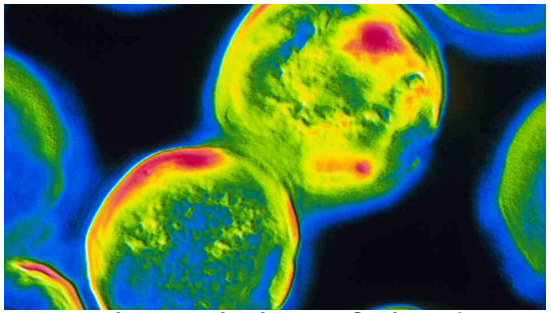
DOI: 10.1038/NGEO1238



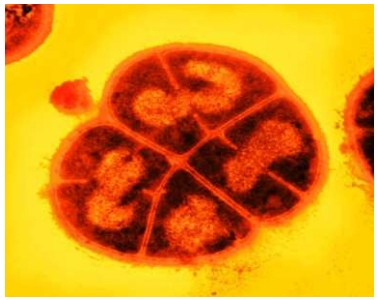
Filamentous fabrics in basalt-hosted quartz, Iceland

Breiddalur, Eastern Iceland
Courtesy: Beda Hoffmann, MHNB

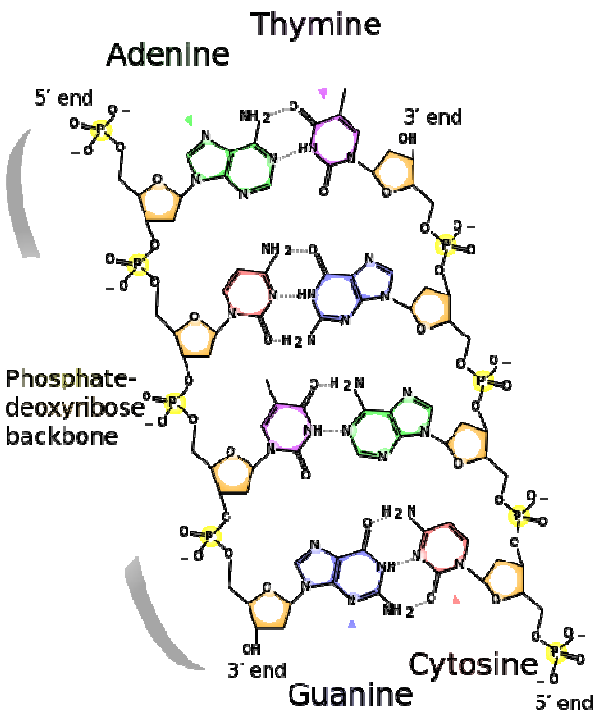
From Optical to Biochemical and Chemical Investigation



Archaeglobus fulgidus
Credit: Alfred Pasieka



Deinoccocus Radiodurans
Credit:
Michael Daly Lab.
USU



Nucleotides
(from Wikipedia Commons)

We would be happy to find
any biologic molecule,
to see how far Mars
has progressed towards Life.

But just hints would be welcome:

Molecules with Chiral Properties

Enhanced ^{12}C / ^{13}C ratio

Hydrocarbones
hidden by perchlorates
into
Chlorohydrocarbone
(Chloromethane)

Life on Mars?

Upward to Solander Point
Aug 3rd 2013
Credit: NASA/JPL-CalTech;
pia17087_Sol13387-navcam.jpg

Pierre Brisson
Association Planète Mars
Mars Society Switzerland