Life on Mars?

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

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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.

Volcanism has been a strong atmosphere regenerator:

Olympus Mons
Ascraeus
Pavonis
Arsia
Noctis Labyrinthus

Olympus Mons (image processed by Planetary Vision)
Mars receives just enough light

Solar Irradiance:

Mars: 492 to 715 W/m²

(Earth: 1.321 to 1.413 W/m²)

(Jupiter 50 W/m²; Saturne 10 W/m²)

Earth: 1.321 to 1.413 W/m²

Days (« sols ») of 24h39

Tilt of the rotation axis: 25°19

(Earth: 23°26)

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 ($T > 0^\circ$), 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)
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:

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)

• Average: \(-63°C\)
• Highest: \(+20°C\) (South) \(-3°C\) (North)
• Lowest: \(-143°C\)

Terre

• Average: \(+14°C\)
• Highest: \(+53°C\)
• Lowest: \(-89°C\)

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

Soil water content is between 1.3 & 4%

ATMOSPHERE RELATIVE HUMIDITY

REMS measures
(Remote Environmental Monitoring Station)
Image PIA16915 (2013-04-08)

Credit:
NASA/JPL-Caltech/CAB(CSIC-INTA)/FMI/Ashima Research

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

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!

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)

Image Credit: NASA/JPL-Caltech, SAM/GSFC
PIA16461 Nov. 2\textsuperscript{nd} 2012
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. 2\textsuperscript{nd} 2012 (Spring on Mars)

PIA16460; Image Credit: NASA/JPL-Caltech, SAM/GSFC
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
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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.

Chlorinated compounds CH$_3$Cl, CH$_2$Cl$_2$, CHCl$_3$, and a 4 carbon chlorine containing compound are detected by SAM.

SAM results show that the Rocknest sand drift does NOT contain abundant organics.

Organic compounds that arrive from space in the form of micrometeorites may be transformed by a variety of mechanisms:
- Cosmic radiation
- Ultraviolet radiation
- Hydrogen peroxide
- Dust induced electrical discharges
- Other oxidants in soil/dust

Although the Cl in these organic compounds is Martian, it is presently unclear whether the carbon is Martian or terrestrial. This remains to be established with ongoing analysis, future laboratory work, and experiments on Mars.

The Curiosity search for organics in other environments and samples will continue.

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)
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 1/10\textsuperscript{th} 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?  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.
Stromatolites from Strelley Pool (3.6 to 3.2 billion years)

*Source: Wikipedia Commons*
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
Quartz vein in basalt flow

Optical Investigation

Breiddalur, Eastern Iceland

Courtesy: Beda Hoffmann, MHNB
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 $^{12}\text{C} / ^{13}\text{C}$ ratio

Hydrocarbons hidden by perchlorates into Chlorohydrocarbone (Chloromethane)
Life on Mars?

We Must Keep Searching!

Pierre Brisson
Association Planète Mars
Mars Society Switzerland

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