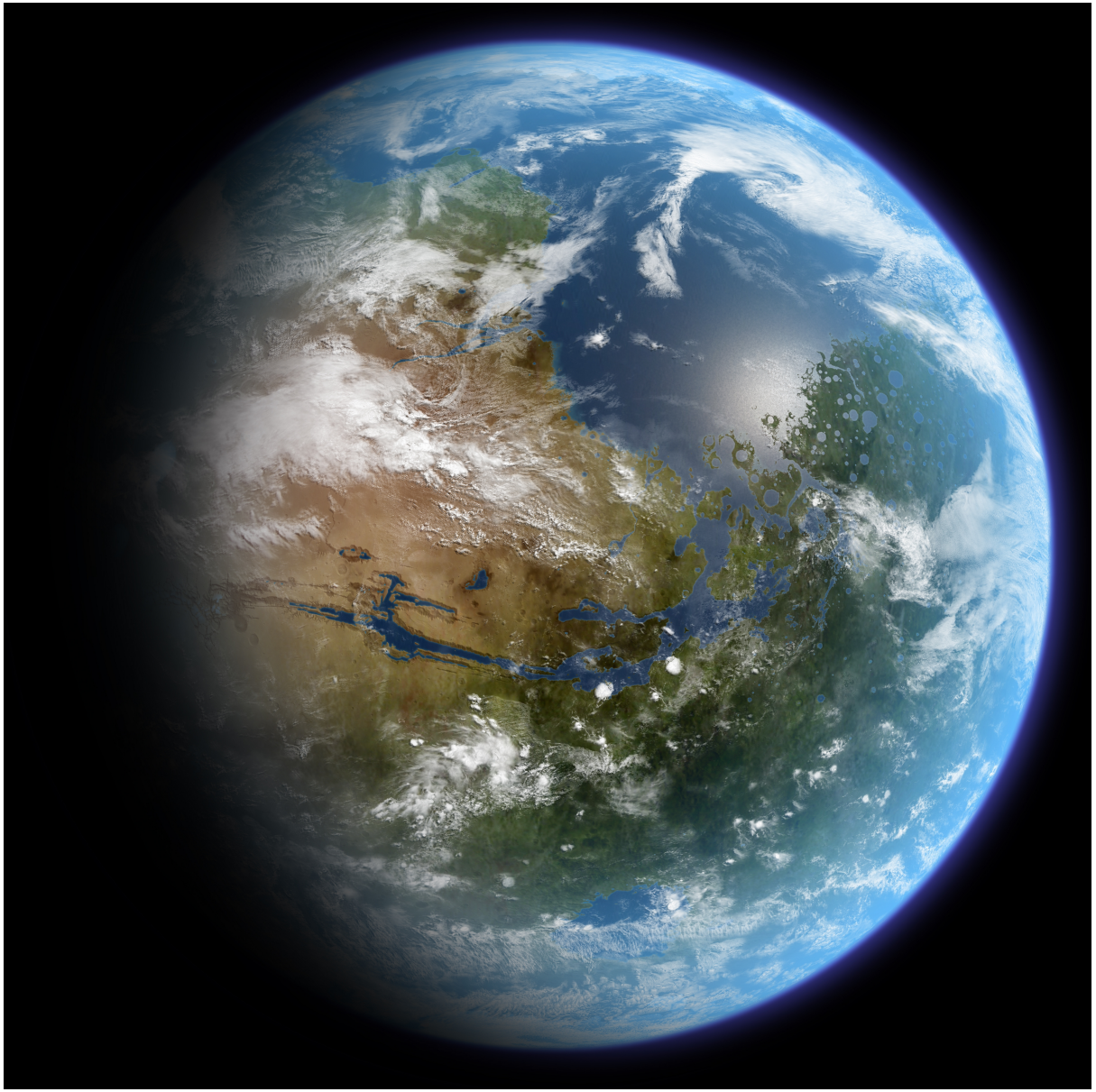
Life on Mars



Mars Terraformed – Artist's Conception: Wikimedia Commons

Life on Mars

- Does Mars have the building blocks for life? If not, did Mars ever have them?

- Was there ever life on Mars or even the potential for life? Is there any indication that life exists on Mars today?

- Could we turn Mars into a planet that can support life (i.e. terraform Mars)?

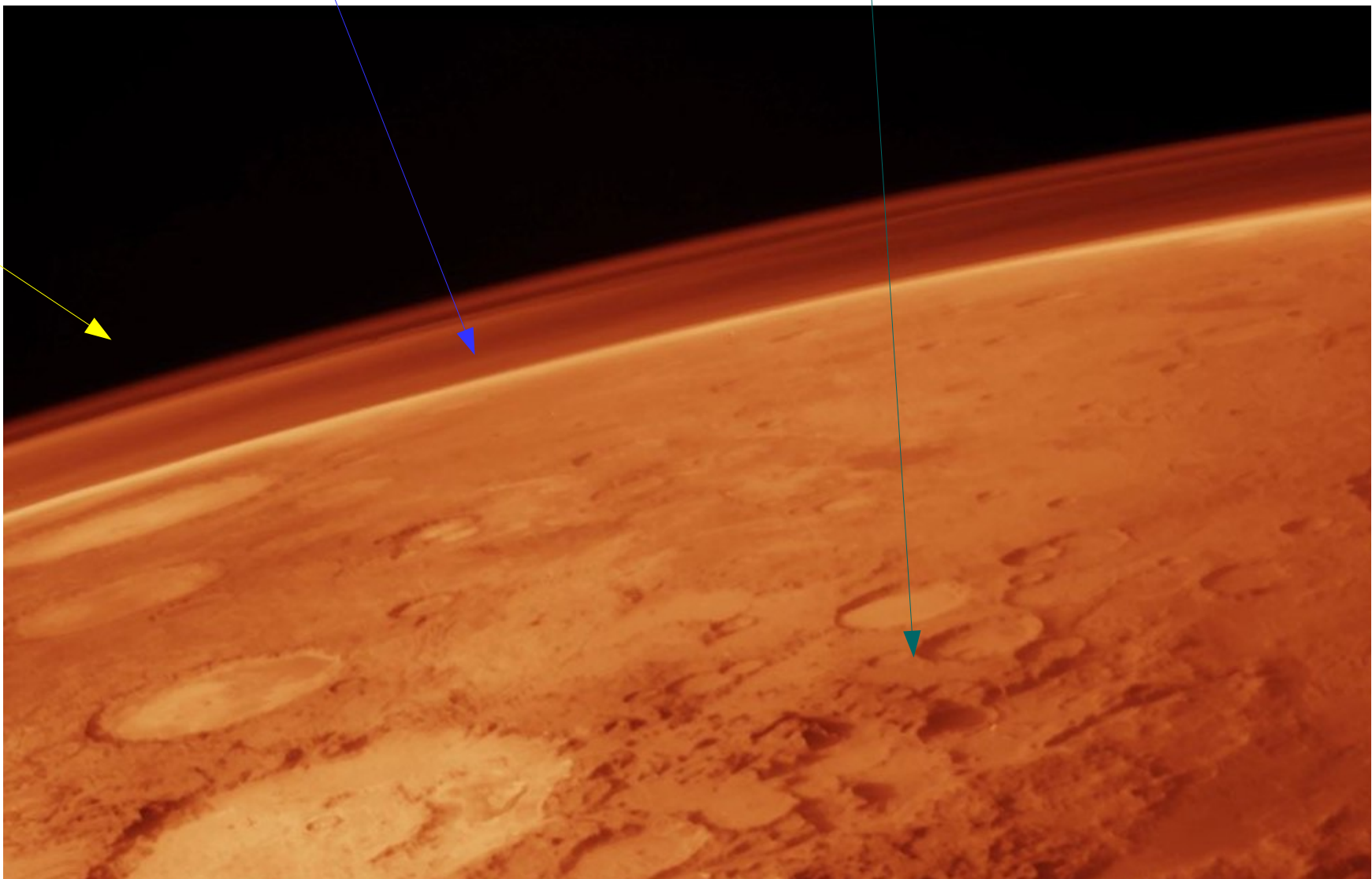
What we know about Mars and the potential for Earth-like life

Building Blocks of Life on Mars?

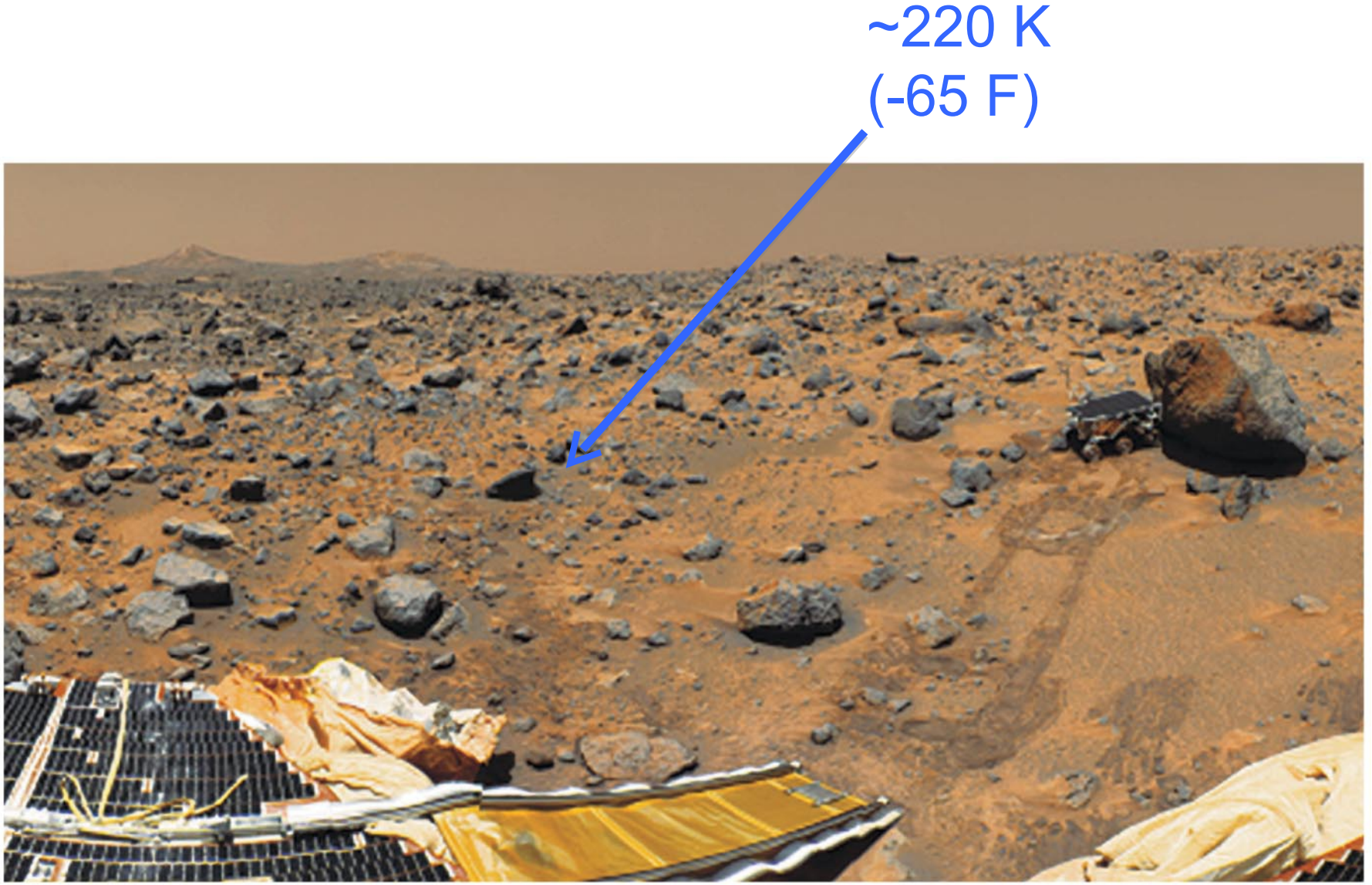
Thin atmosphere, mostly of CO_2

How much water below surface?

Much less sunlight than Earth



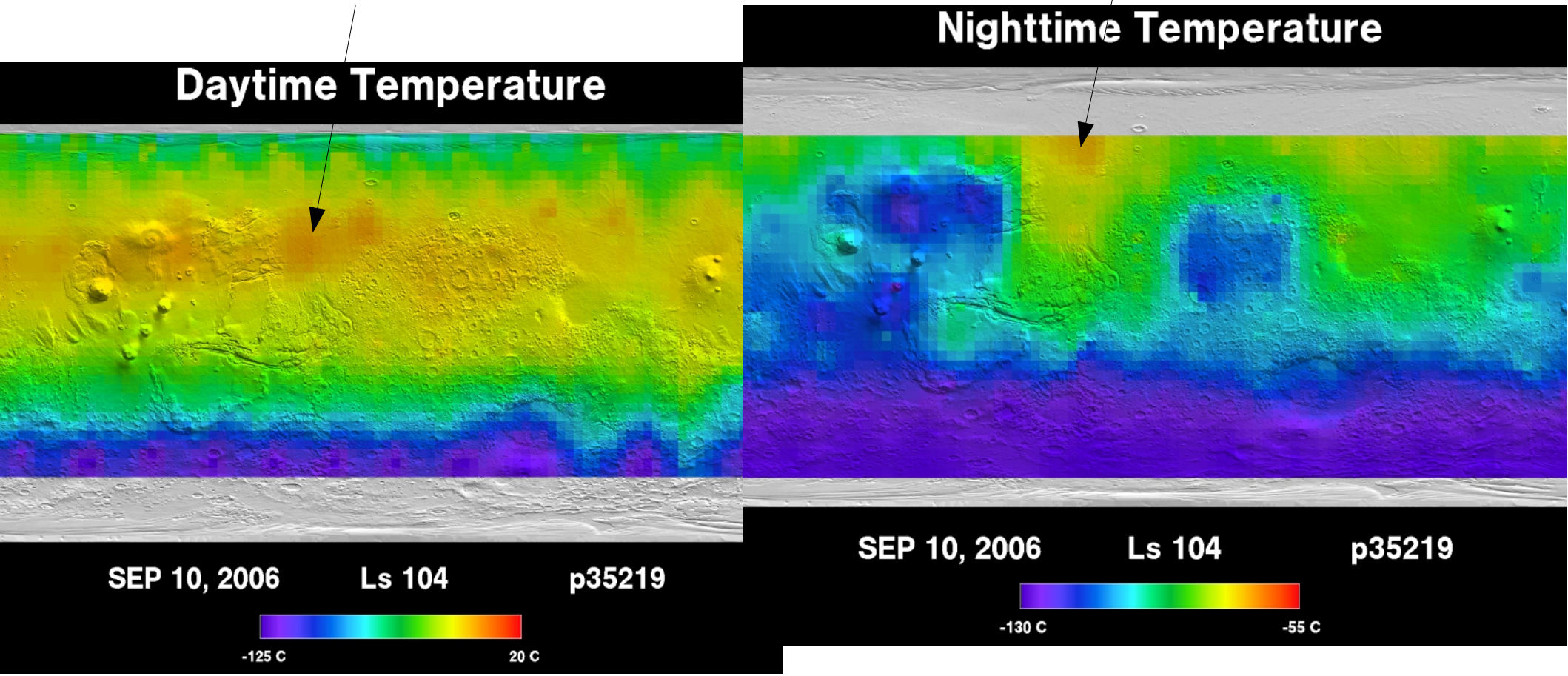
Is the sunlight (energy) a problem?



Not just cold, but huge variations

Daytime high of 68 F

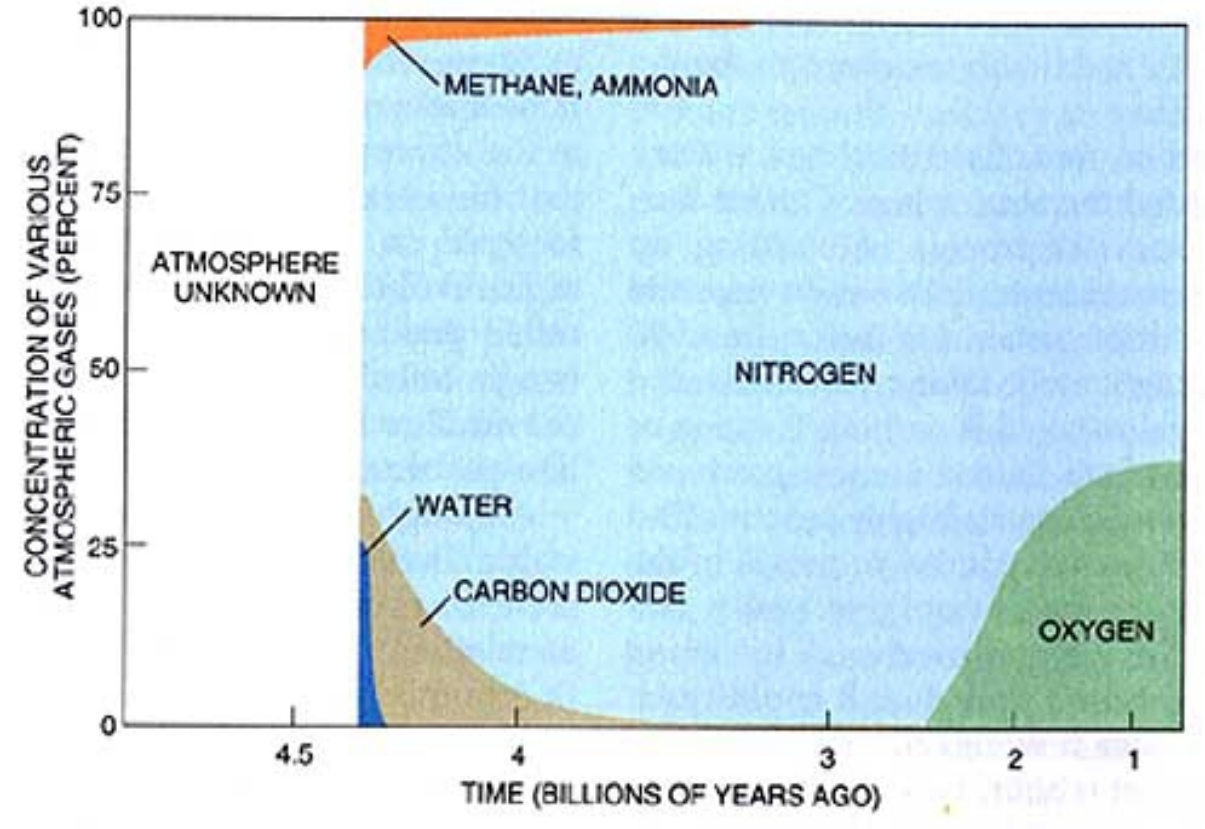
Nighttime high of -67 F



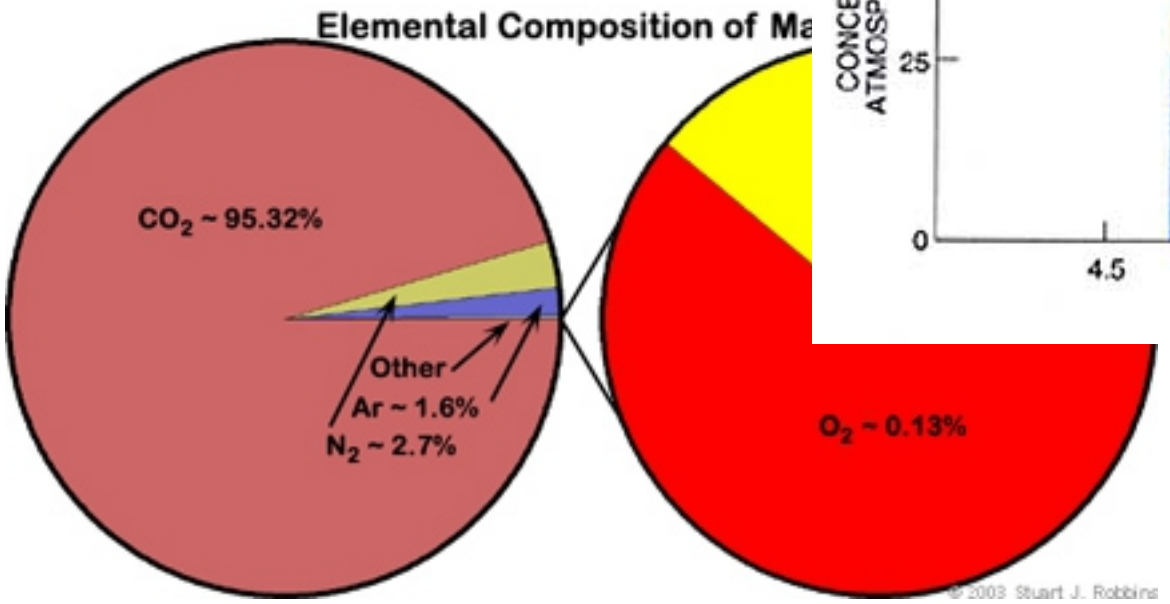
Credit: Brown-Stanford iGem group

Atmosphere of Mars isn't exactly like early Earth atmosphere – why?

Earth (before biological processes took over), is mostly nitrogen, CO_2, and organics

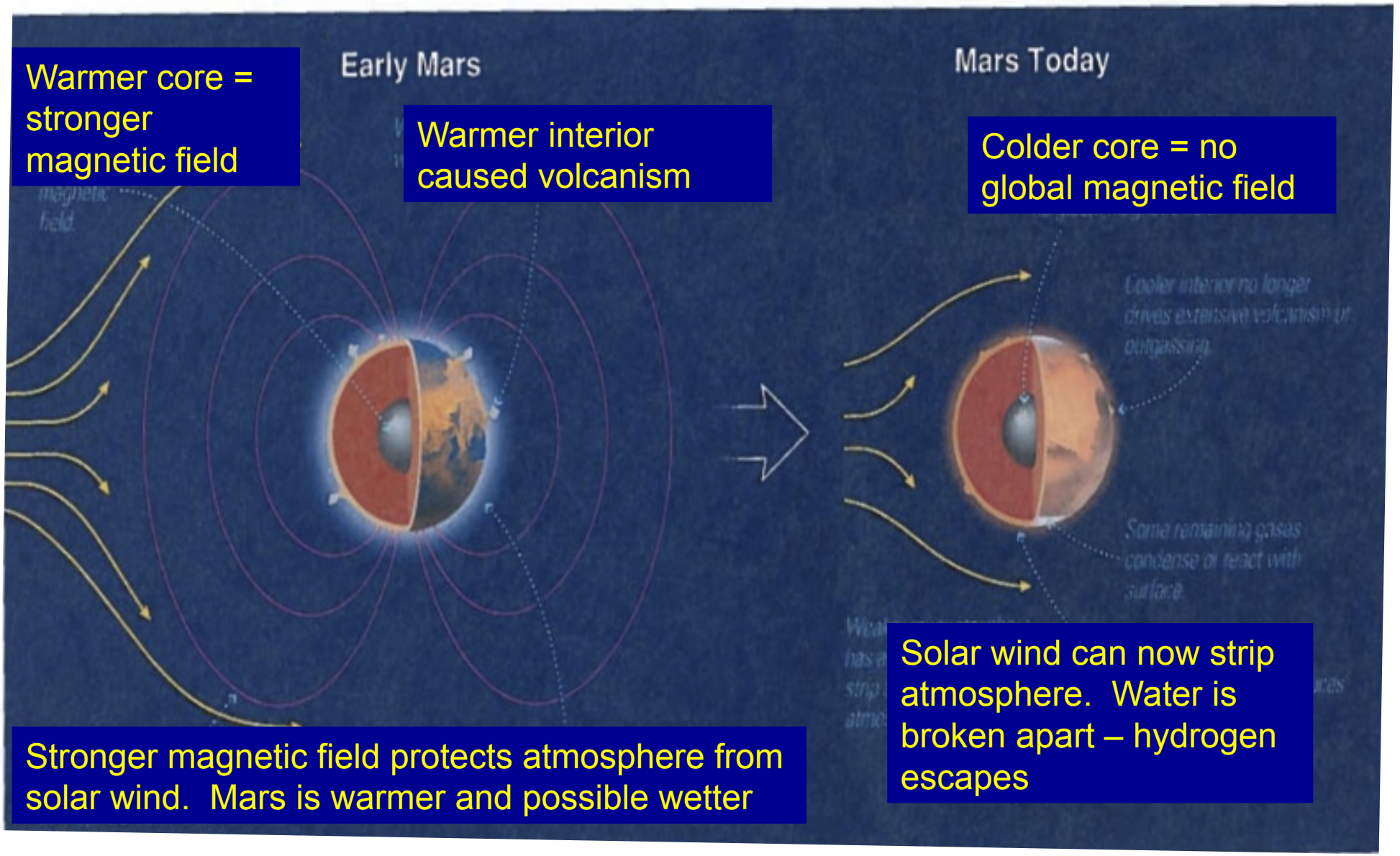


Mars is almost entirely CO_2

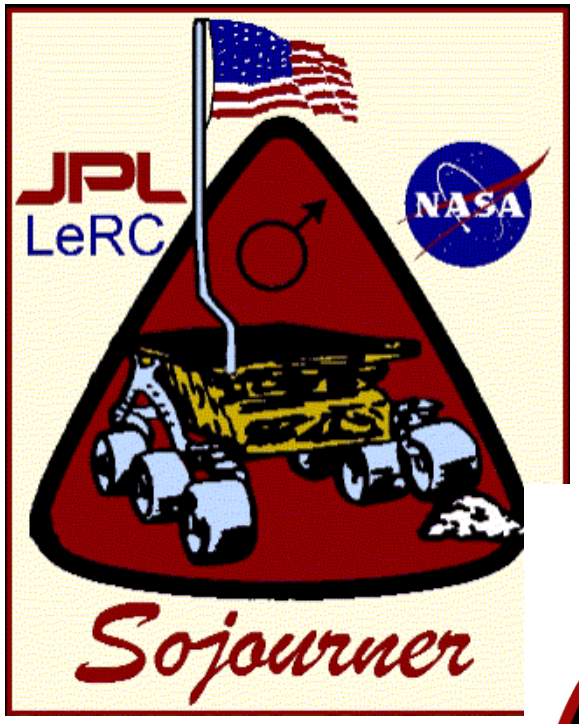


What happened? Did this prevent life from forming?

The Martian atmosphere is thin



The billion dollar question: where is the water on Mars?



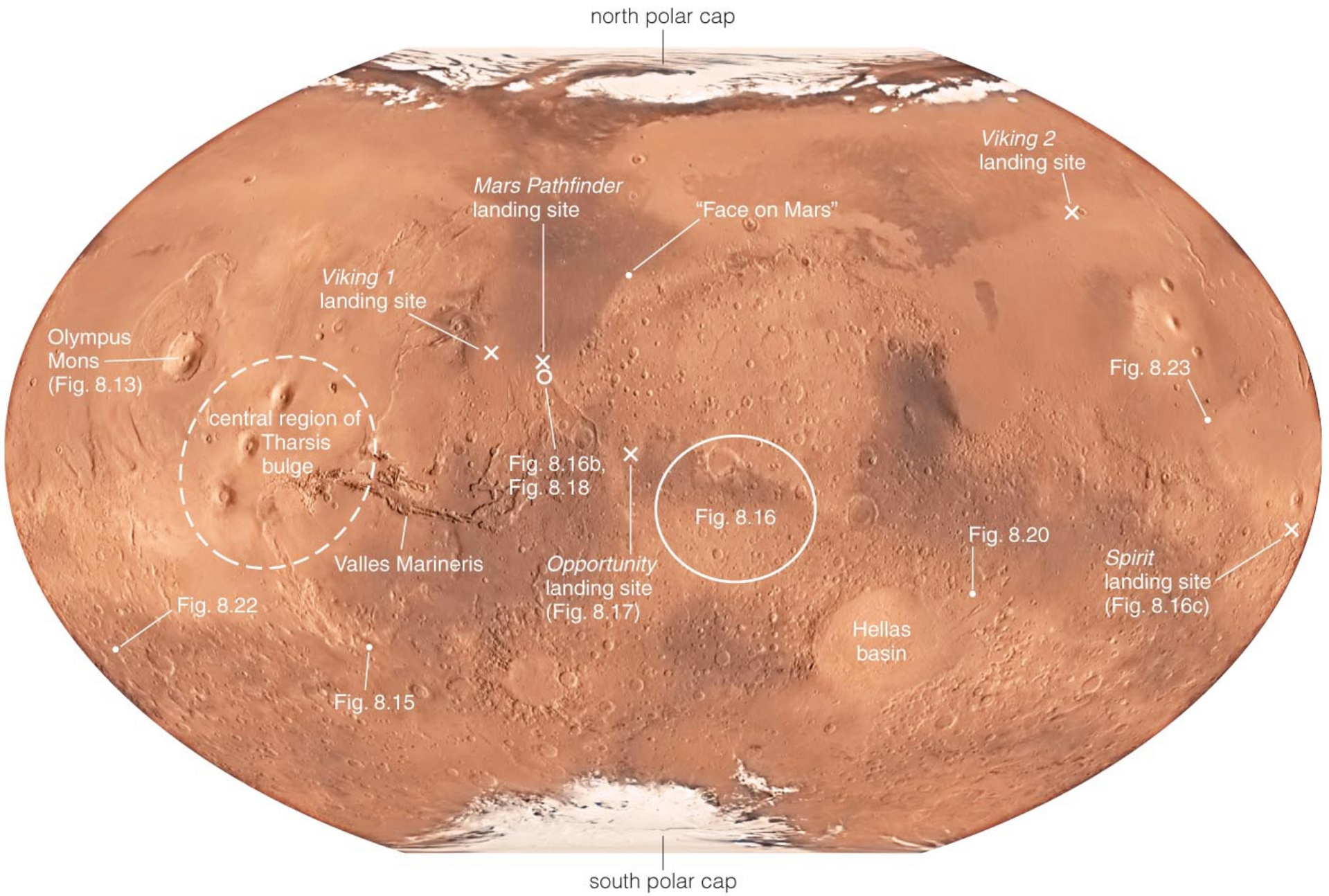
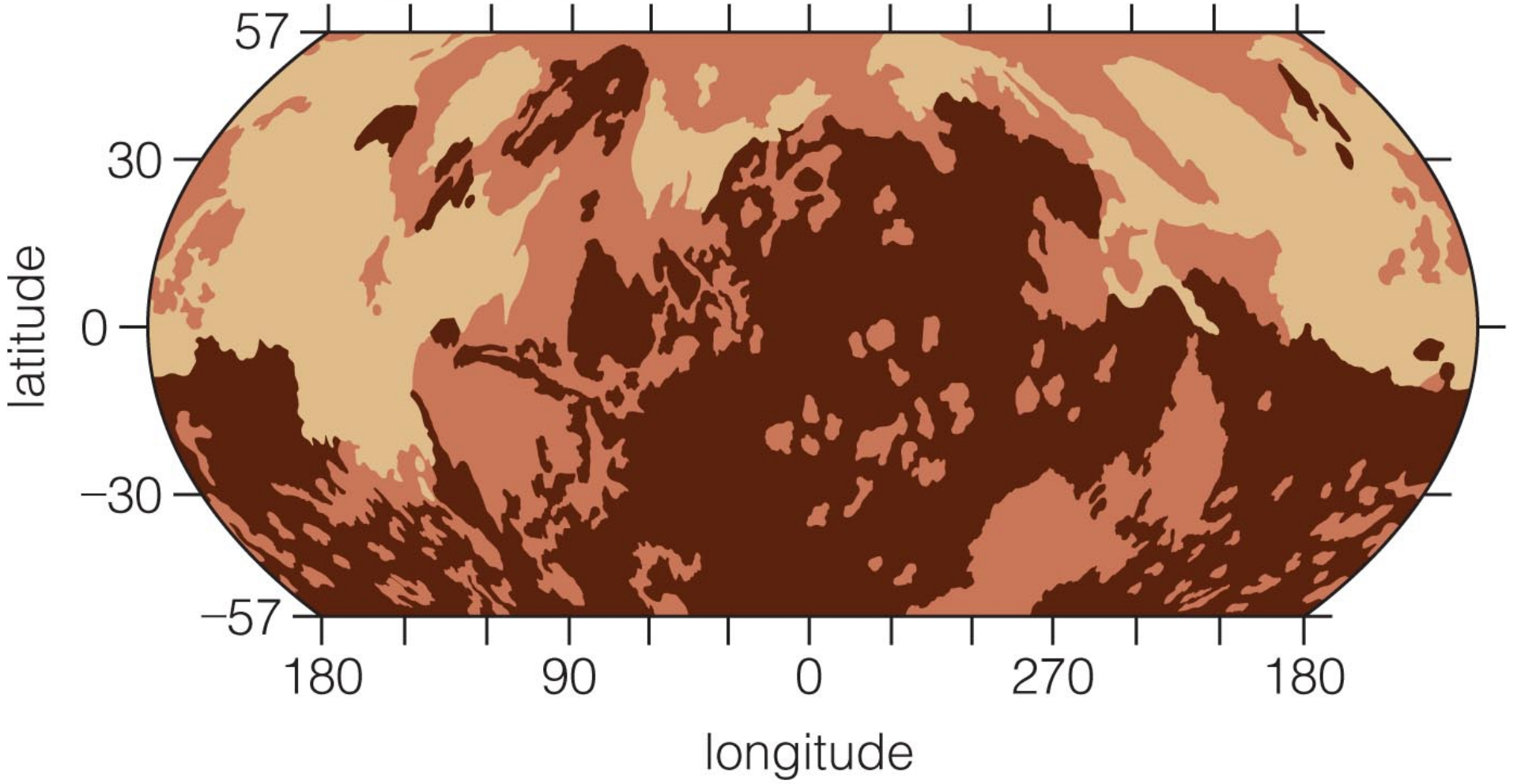


TABLE 8.2 *Geological Eras on Mars*

Era	*Color Code in Figure 8.14*	*Time*
Early (Noachian)		4.6–3.8 billion years ago
Middle (Hesperian)		3.8–1.0 billion years ago
Recent (Amazonian)		1.0 billion years ago to the present



We infer that water is trapped beneath the surface...

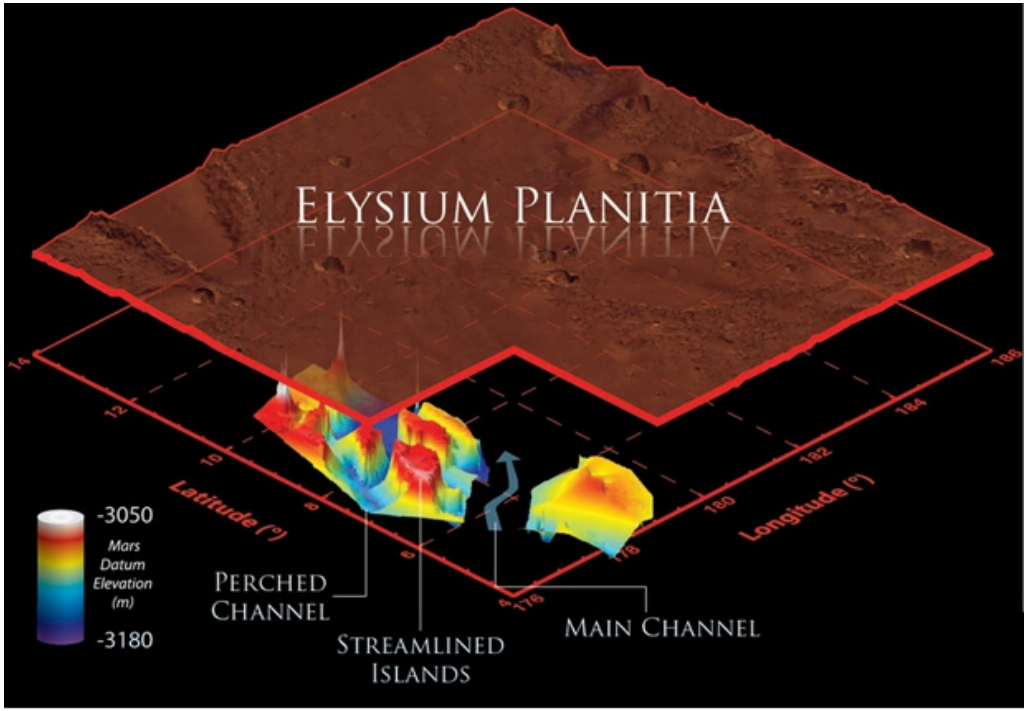
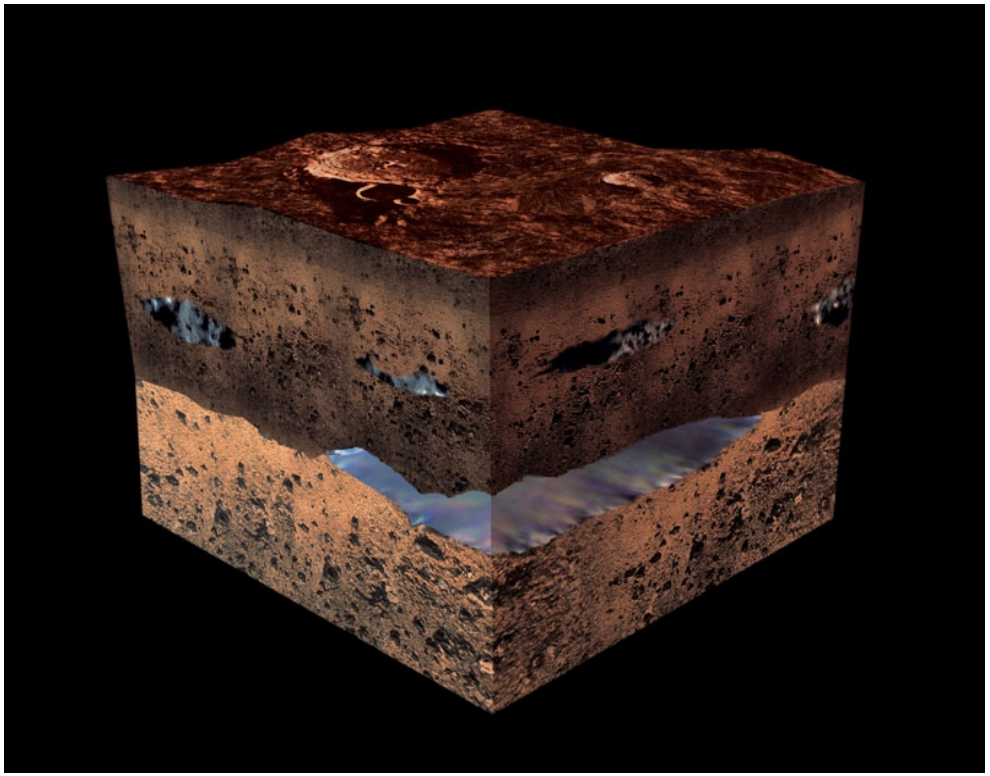
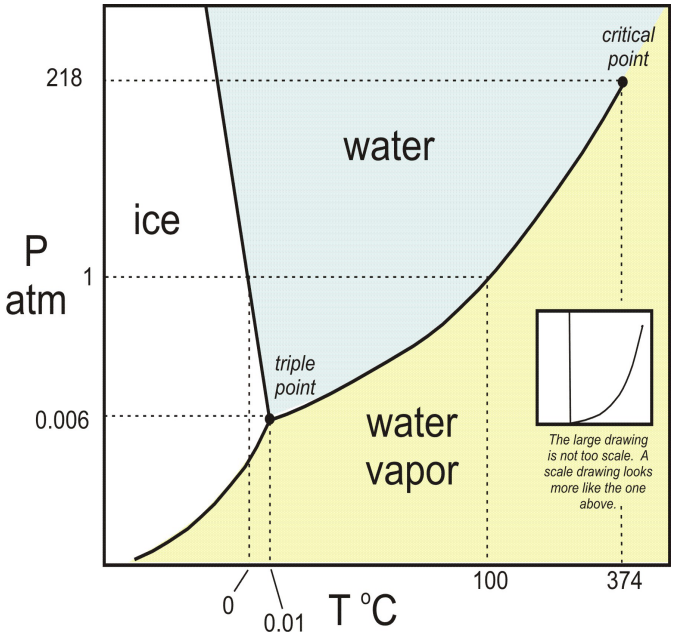


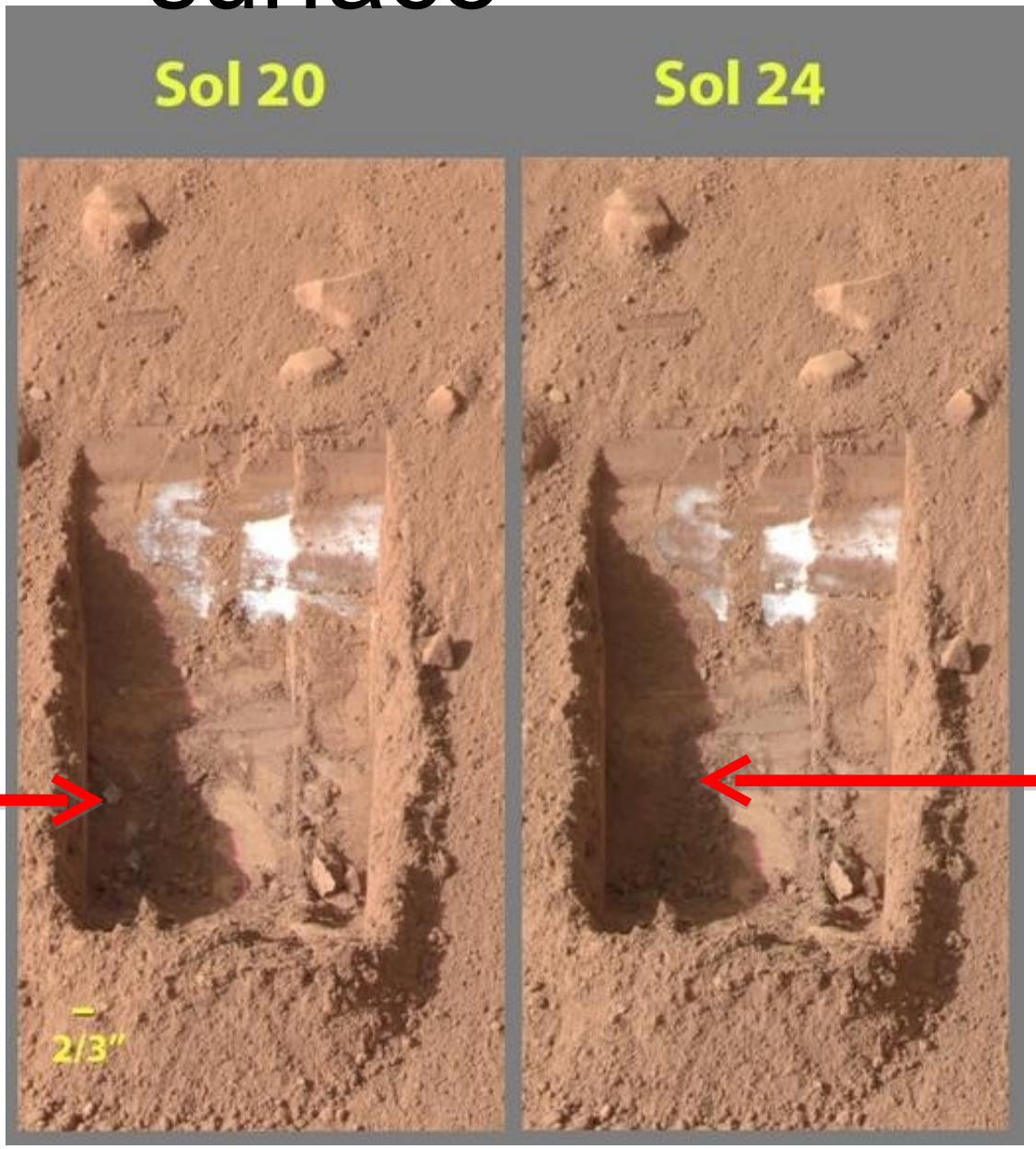
Image: Smithsonian/NASA/JPL-Caltech/Sapienza University of Rome/MOLA Team/USGS



Credit: ESA 2001

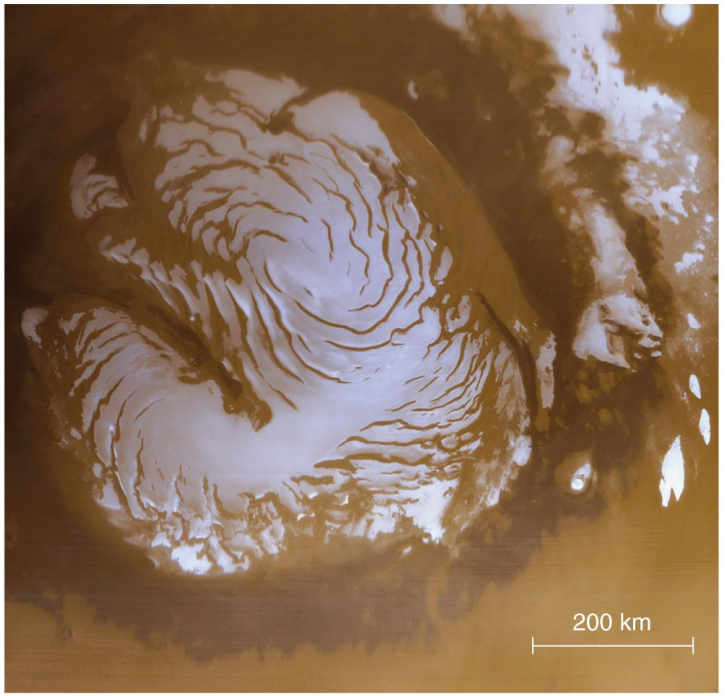
… and it evaporates quickly on the surface

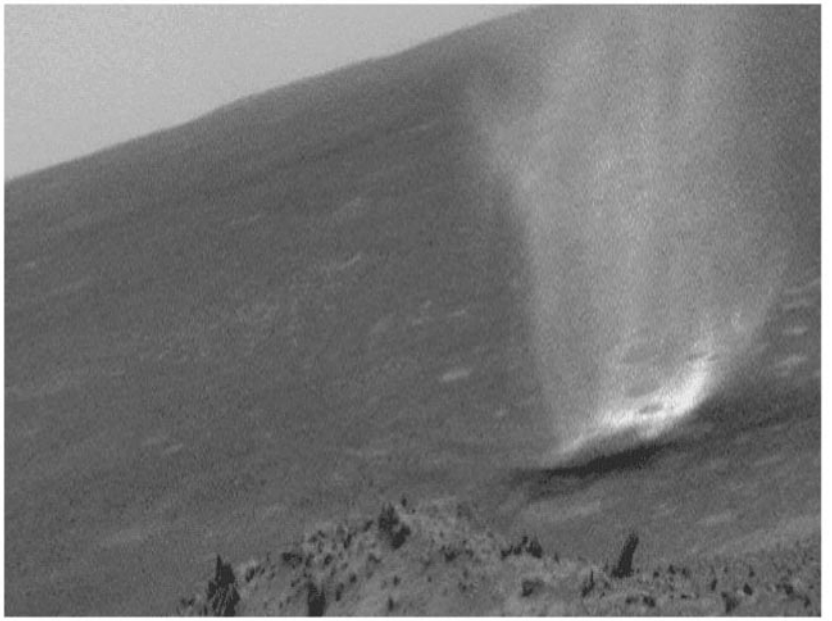




Ice chunks

Gone!

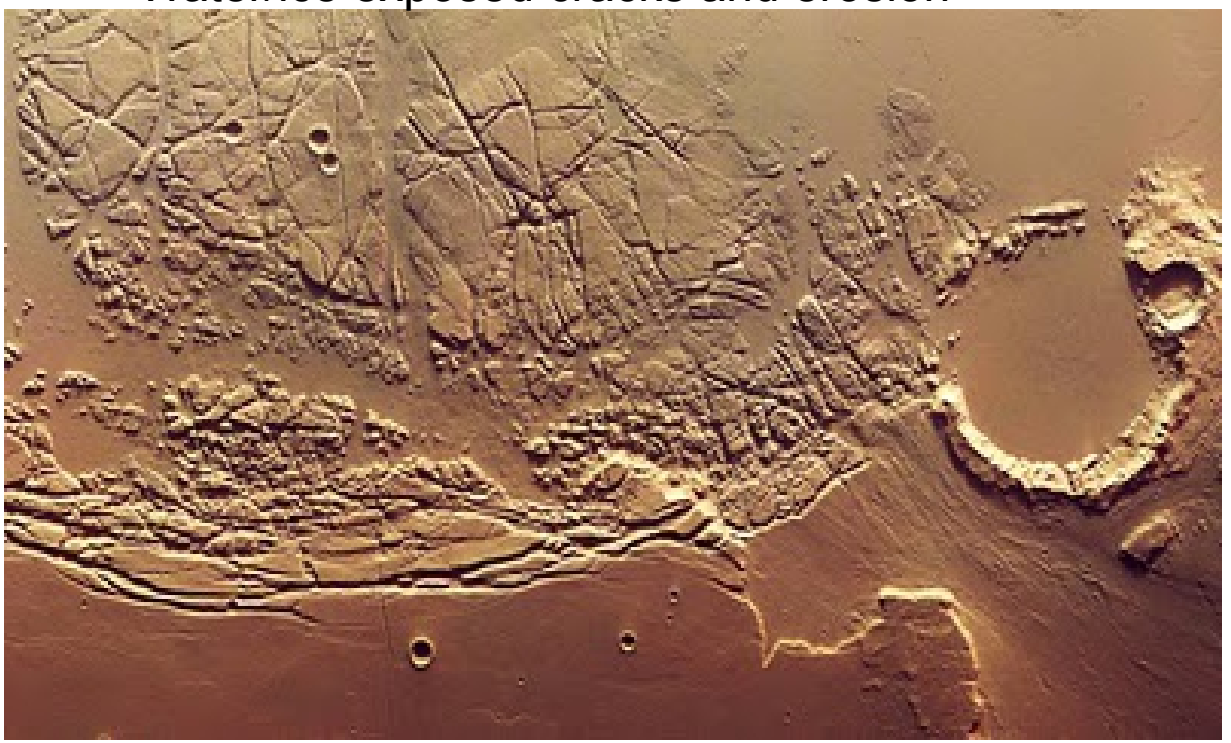




Sublimation

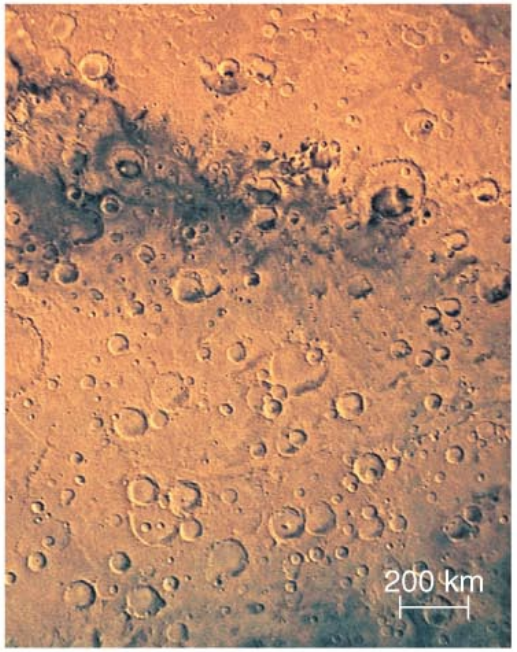
CO_2/H_2O ice cap

Water/ice exposed cracks and erosion

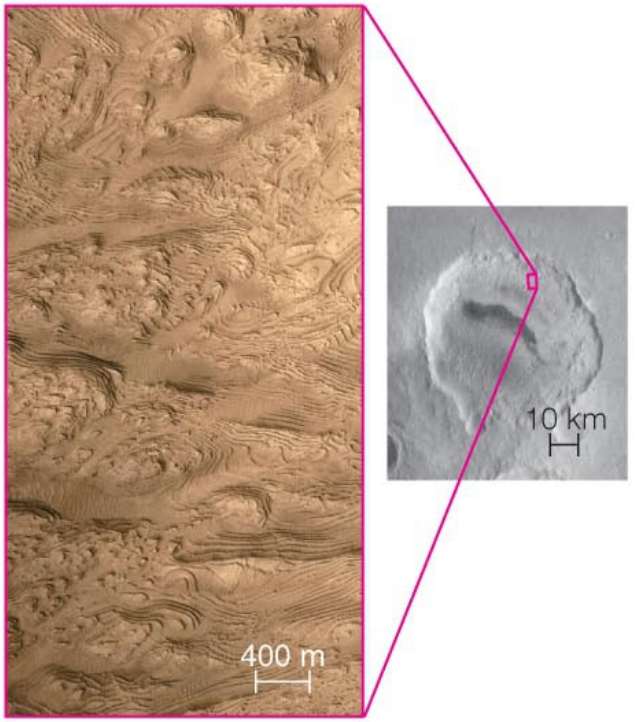


Variations in the cryosphere of Mars

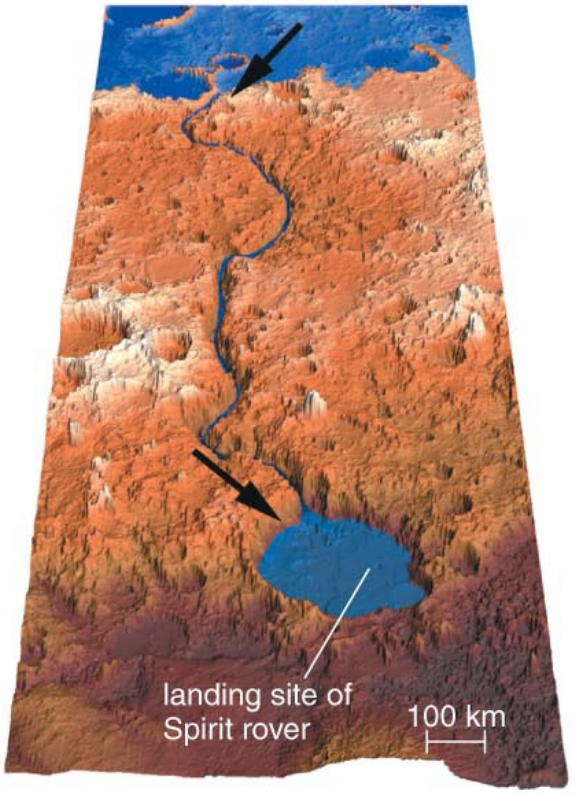
Evidence for water is indirect, but comes from a variety of sources



a This photo shows a broad region of the southern highlands. The eroded rims of large craters and the relative lack of small craters suggest erosion by rainfall.

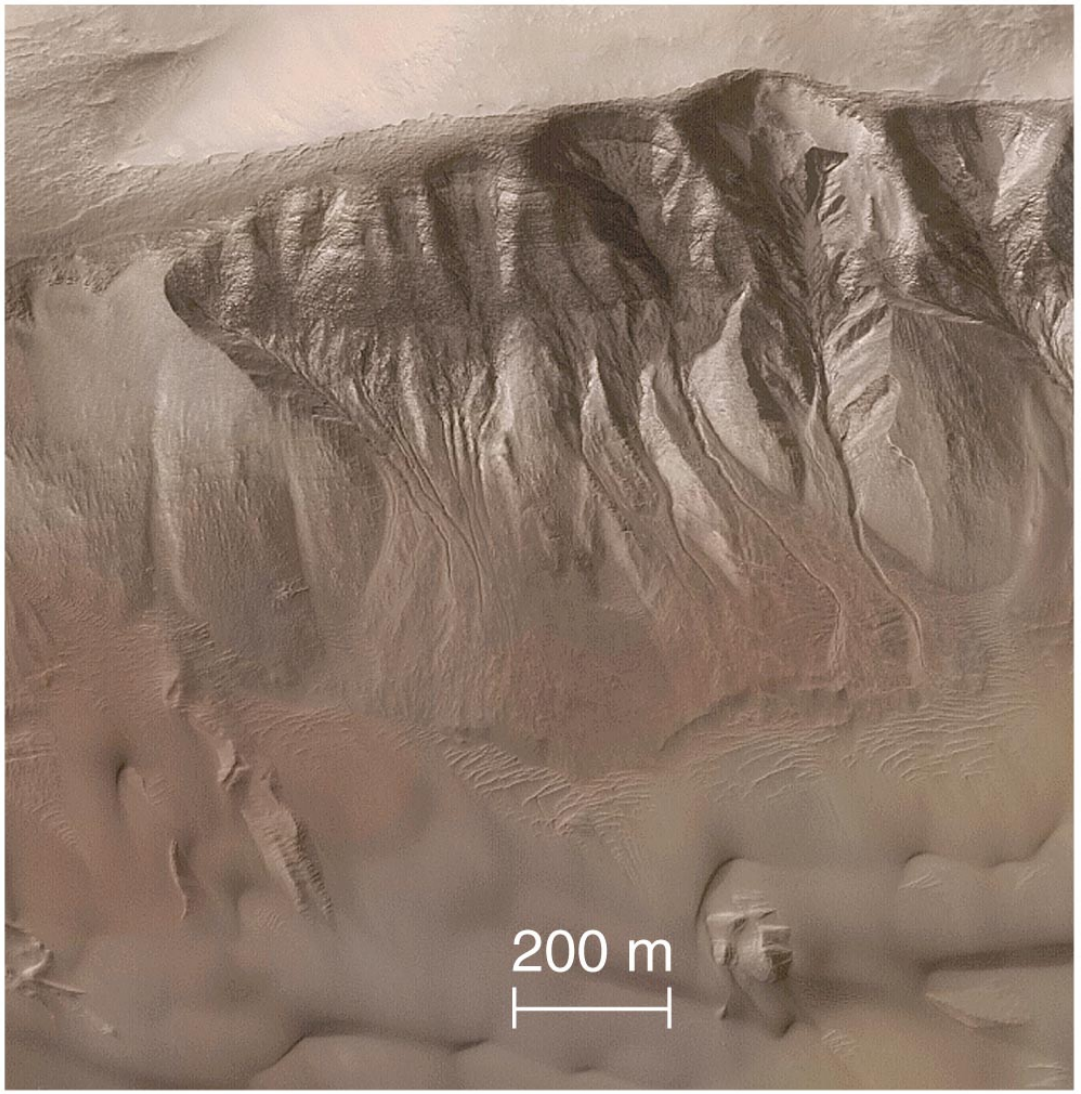


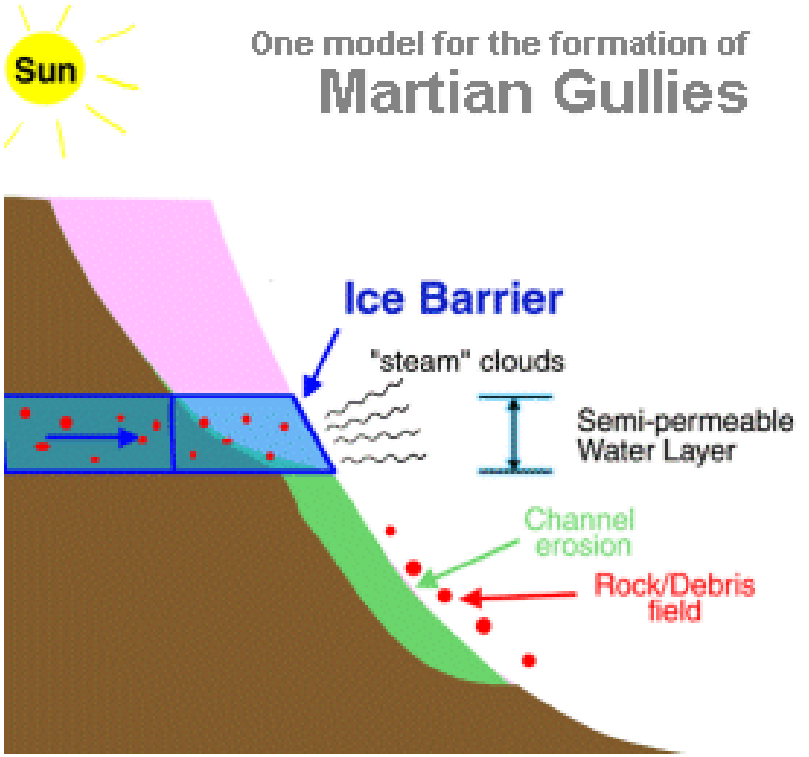
b The close-up view of this crater floor shows sculpted patterns that probably represent layers of sedimentary rock, presumably laid down at a time when water filled the crater.



c This computer-generated perspective shows how a martian valley forms a natural passage between two possible ancient lakes (shaded blue); the lower crater is Gusev, where the *Spirit* rover landed. Vertical relief is exaggerated 14 times to reveal the topography.

Evidence centers around erosion and sediment deposits





New gullies formed in this decade

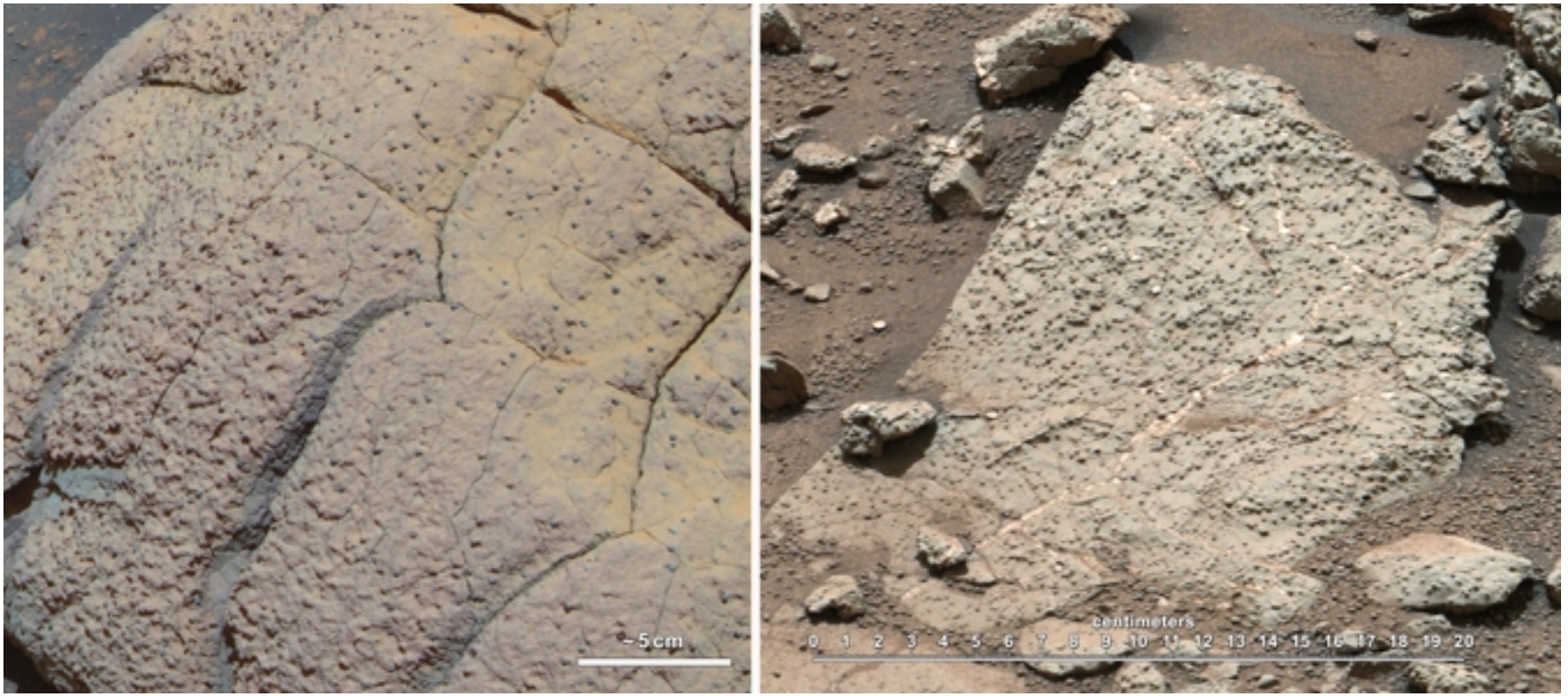
2001

Credit: NASA/JPL/MSSS

2005

Does this give us any indication of Mars' current or past habitability?

The geological history of Mars indicates physical and chemical conditions that can support microorganisms similar to Earth – this does not mean that there was life on Mars, only that it's possible (or probable)

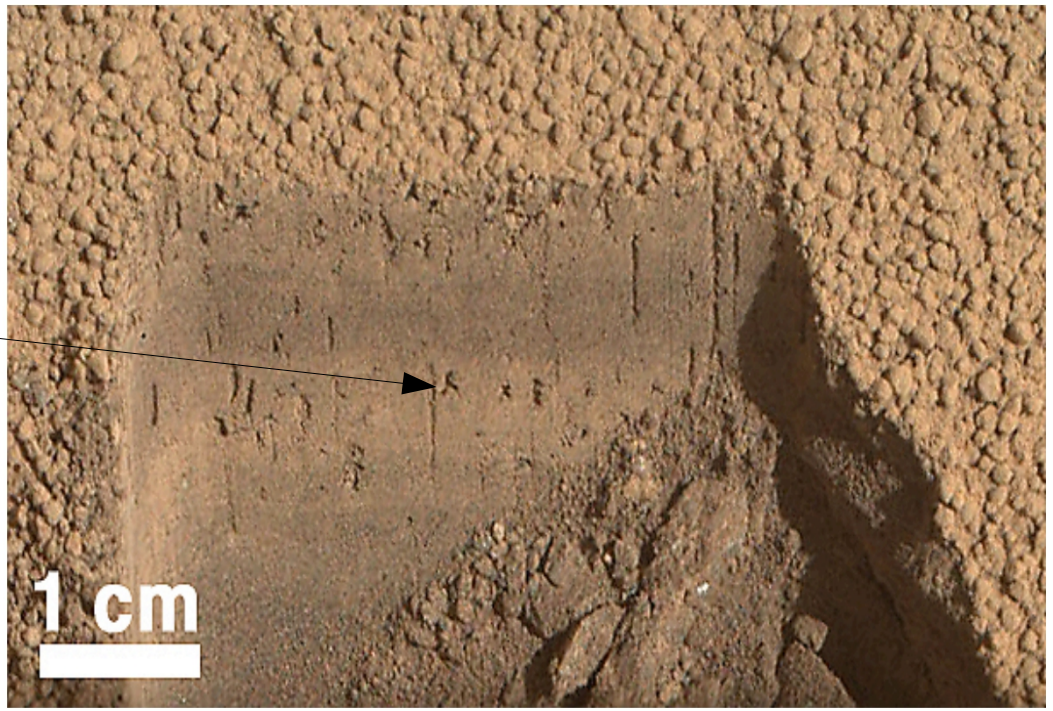


Wompay Rock containing oxidized and non-oxidized species organisms can use for energy, Credit: NASA/JPL Caltech/Cornell/MSSS

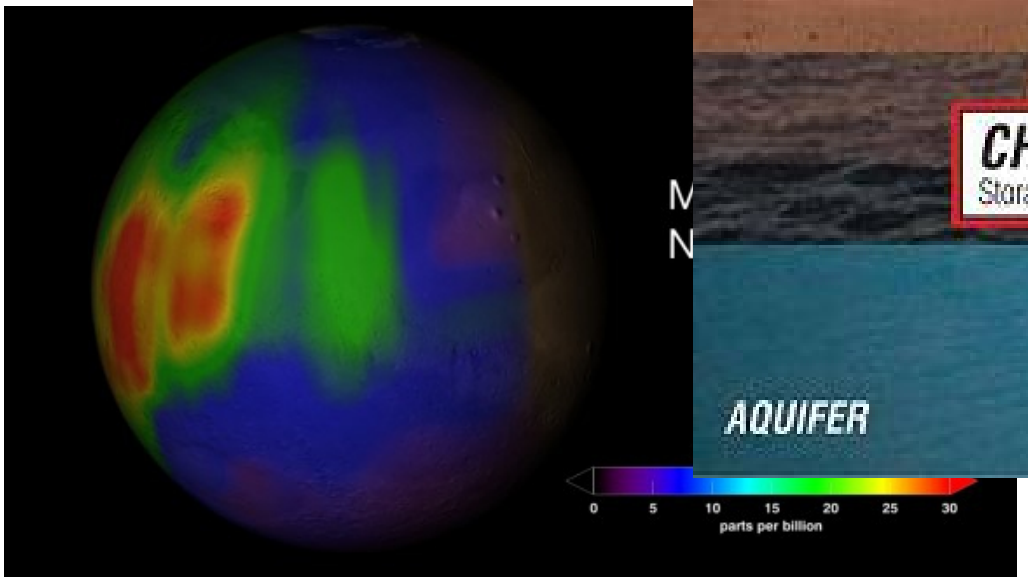
Current life on Mars

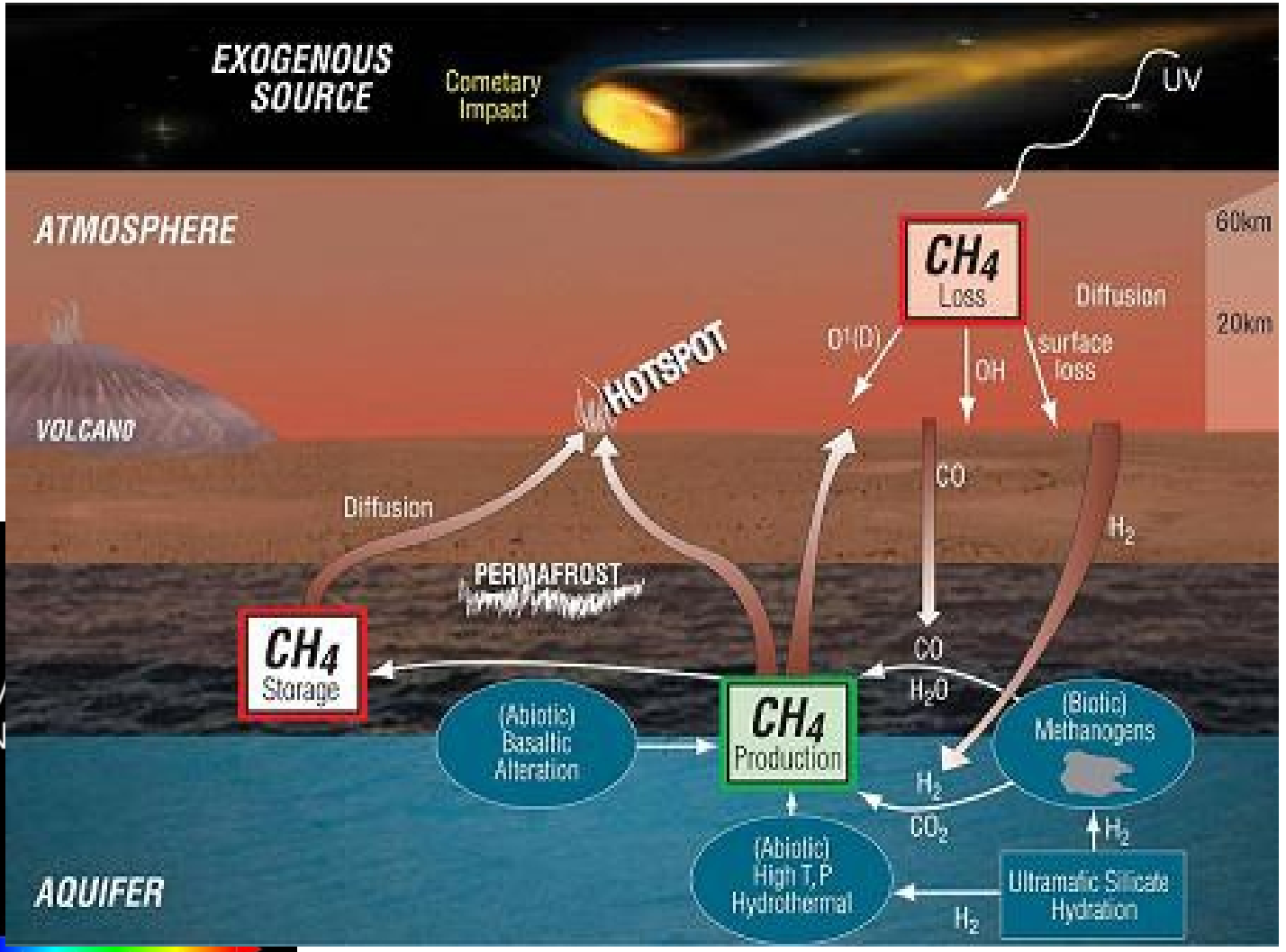
Nothing definitive has been found. Harsh radiation and lack of water suggest no life could exist on the surface. But subsurface life or life embedded in rock could potentially exist.

The Curiosity rover probes the soil for gas releases and finds CO_2, H_2O, O_2, SO_2. Lack of bio-signatures suggests there is no life in this crater.



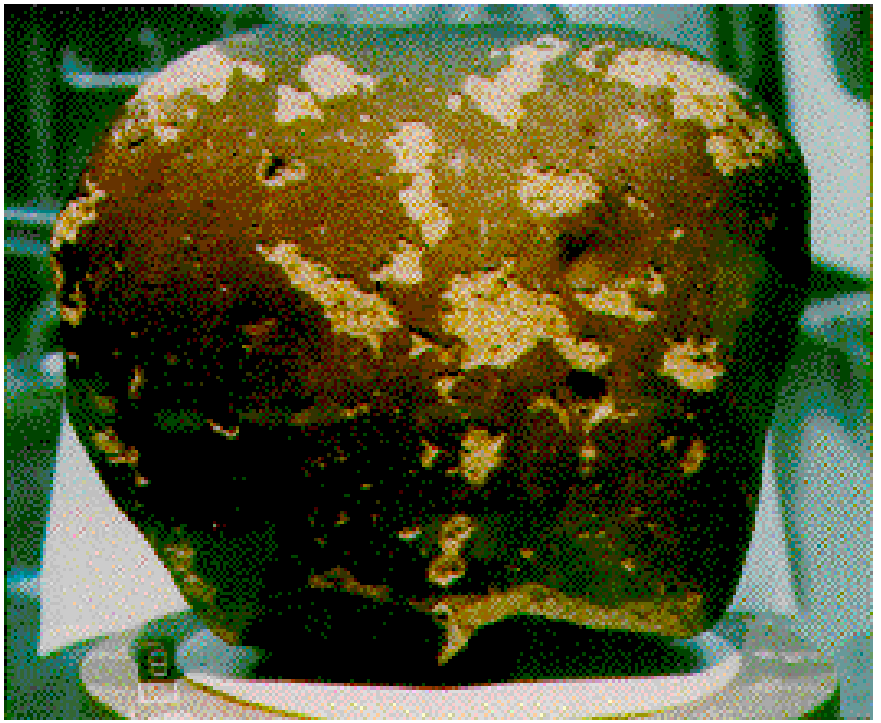
Bio-signatures on Mars as a whole





Gifts from Mars

Los Angeles meteorite 01
(California, 2000)

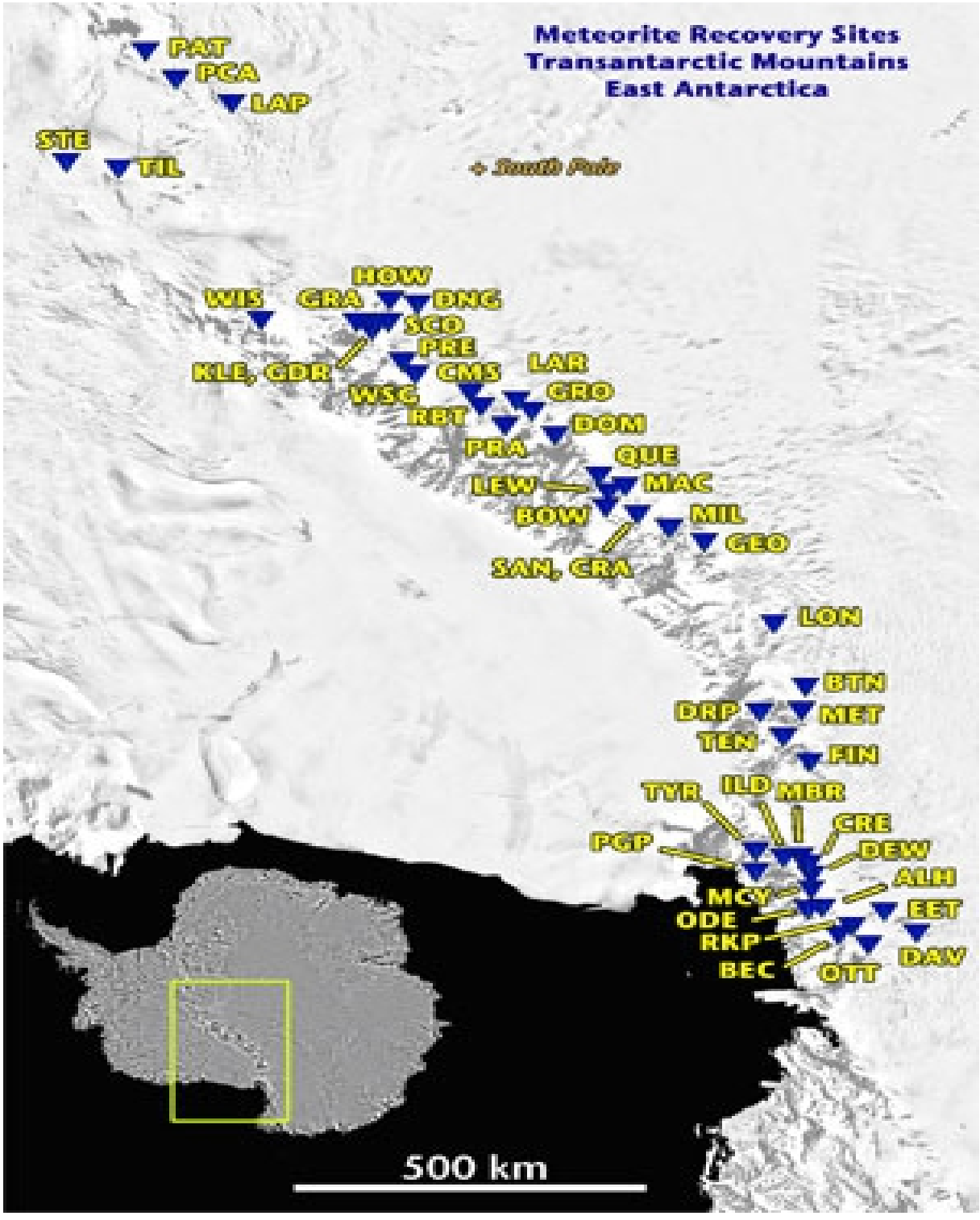


EETA 79001 meteorite
(Antarctica, 1980)

On the basis of isotopic abundances (the composition of the meteorite), we can say how old these meteorites are and what they're made of. In this way, NASA has identified. Of the tens of thousands of meteorites NASA possesses, about 130 have been identified as coming from Mars.

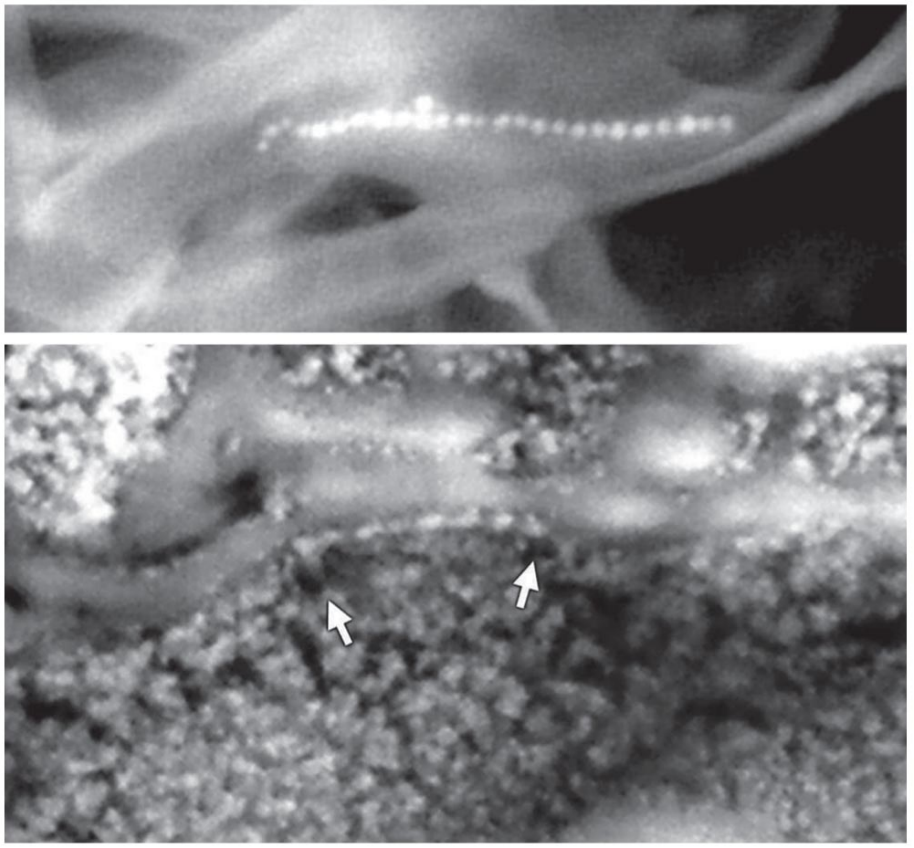
ANSMET

Why is Antarctica such an ideal place to look for meteorites?



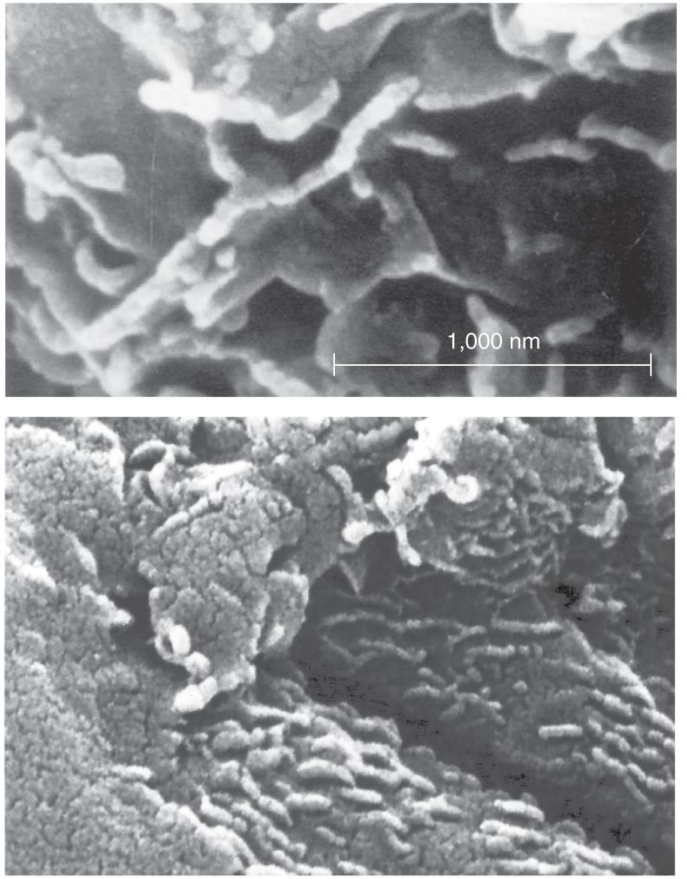
Antarctica Search for
Meteorites (ANSMET)

Bacteria-like structures and minerals associated with biological activity were found (Fe_3O_4). A biogenic origin (one in which the mineral was produced by microorganisms) is generally accepted as the origin of this mineral.

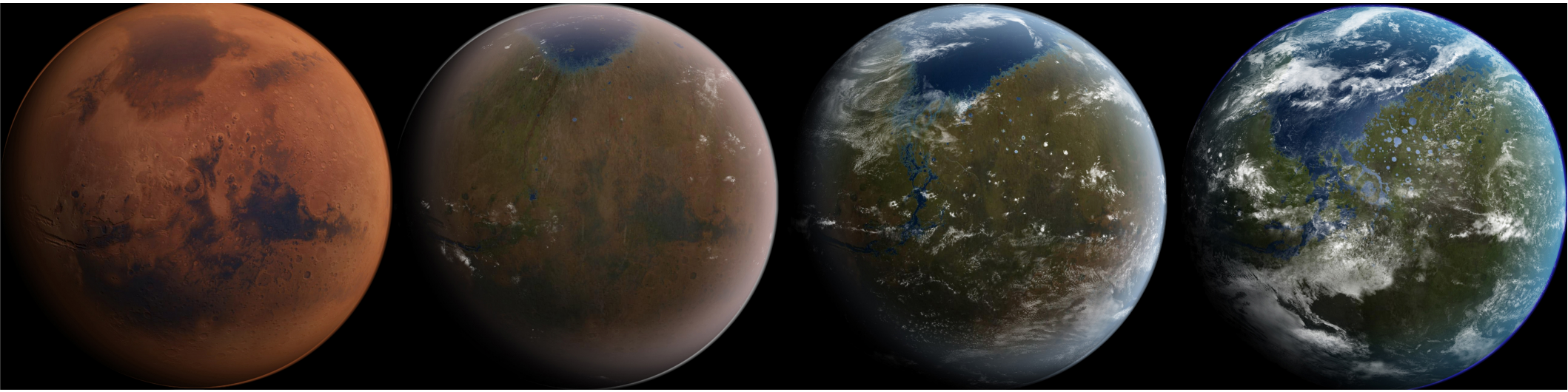


Top:
Earth

Bottom:
Mars



Terraforming

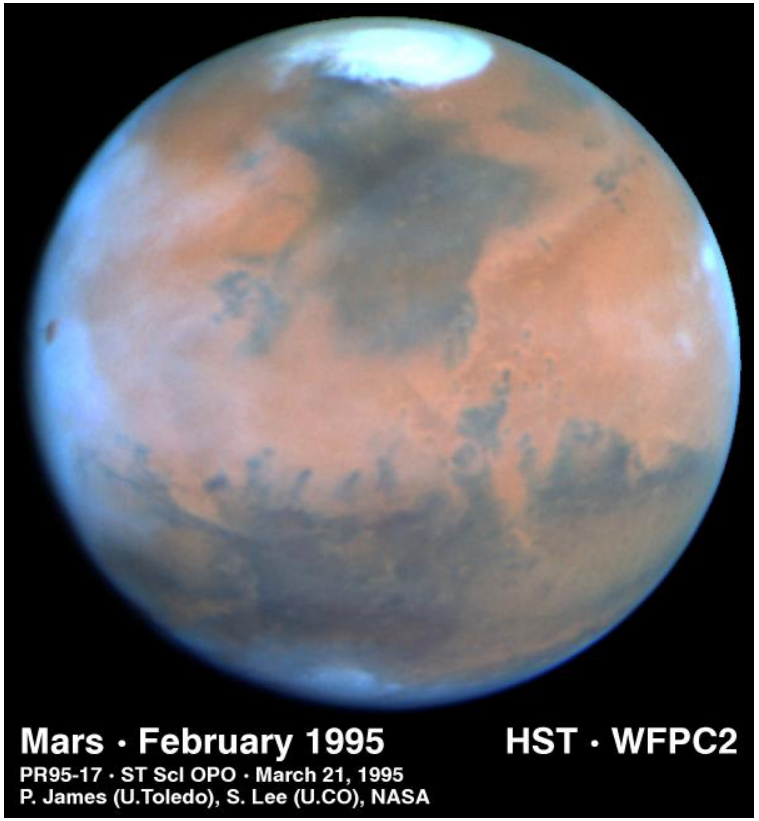


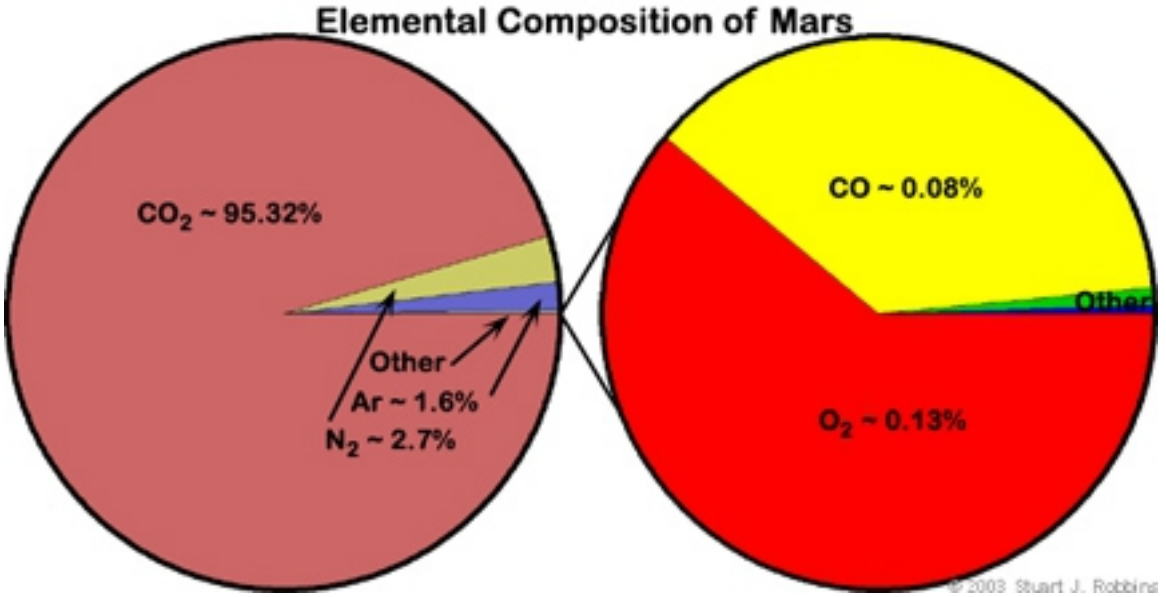
How would we turn Mars into a planet that is suitable for terrestrial life?

A note on science and thinking outside the box...

Mars terraforming to-do list:

- Build up an atmosphere capable of sustaining life and keep it from floating away
- Raise the surface temperature of Mars to a habitable value





Creating a hydrosphere

Stromatolites

These layered formations of rock and biofilm were the environment of the first cyanobacteria on earth

By using bacteria that can photosynthesize the CO2 atmosphere of Mars and importing hydrogen (2 pounds of hydrogen turn into 18 pounds of water), we can create both an oxygen atmosphere and fresh water – eventually even bodies of water

Importing hydrogen as ammonia (NH_3) could also provide a nitrogen atmosphere

Lack of a Magnetosphere

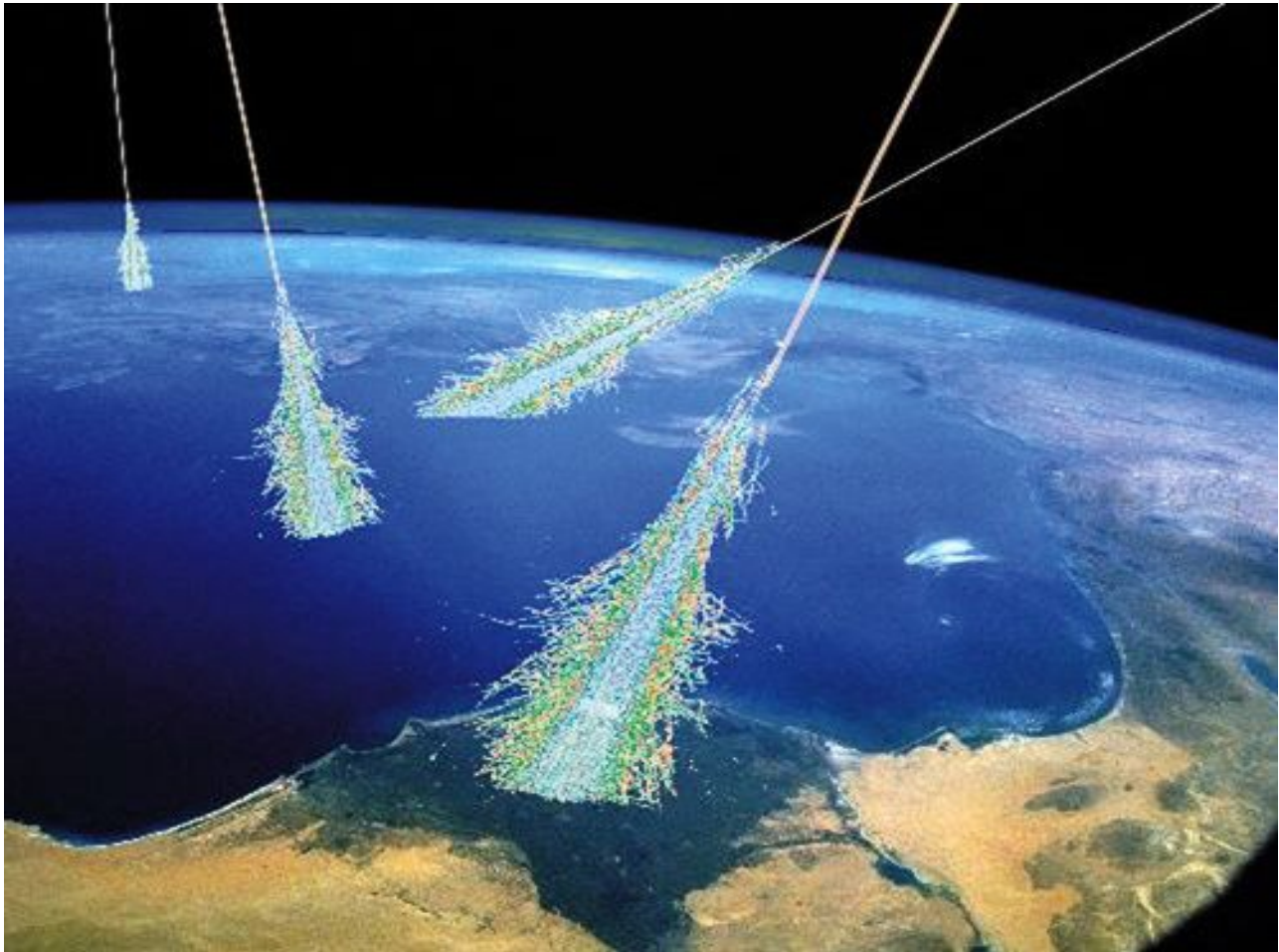
Unlike the Earth, Mars loses gas and water to space due to its lack of a magnetosphere. Cosmic rays (hazardous radiation) won't be deflected by the magnetosphere either.

One possible solution to this problem is to build up a sufficiently thick ozone layer

Water is less likely to dissociate into hydrogen and oxygen and float away (UV radiation does this)

The ozone layer in part protects us from high energy radiation

Cosmic Rays: Cherenkov Radiation



Credit: *NASA*

If all else fails, just pound it with asteroids

Directly increases the surface temperature of Mars

Increased temperature will melt ice caps and sublimate CO_2 – the greenhouse effect helps us increase the surface temperature

Asteroids can add useful gases to the atmosphere on their own – ammonia, oxygen, etc.