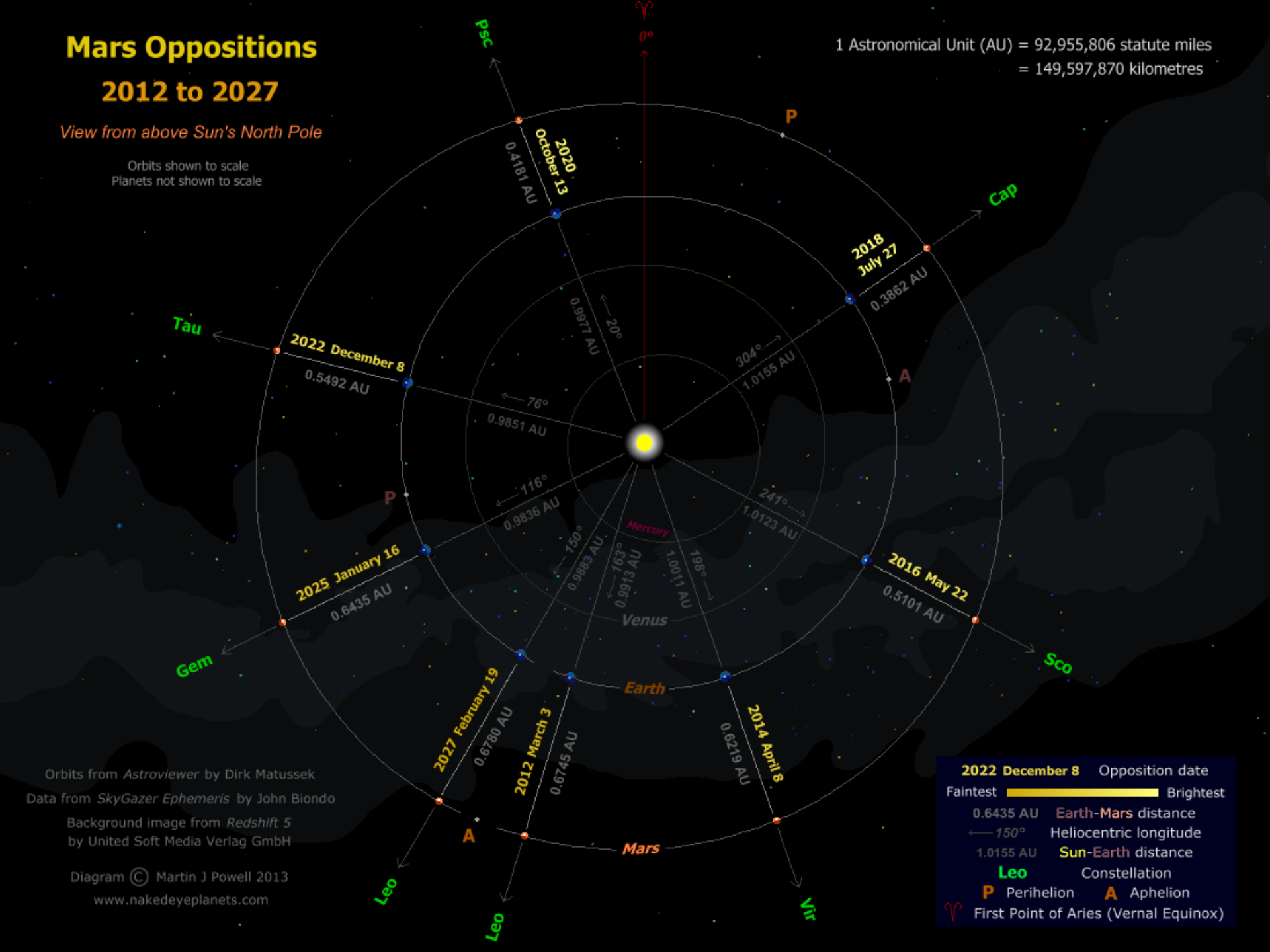
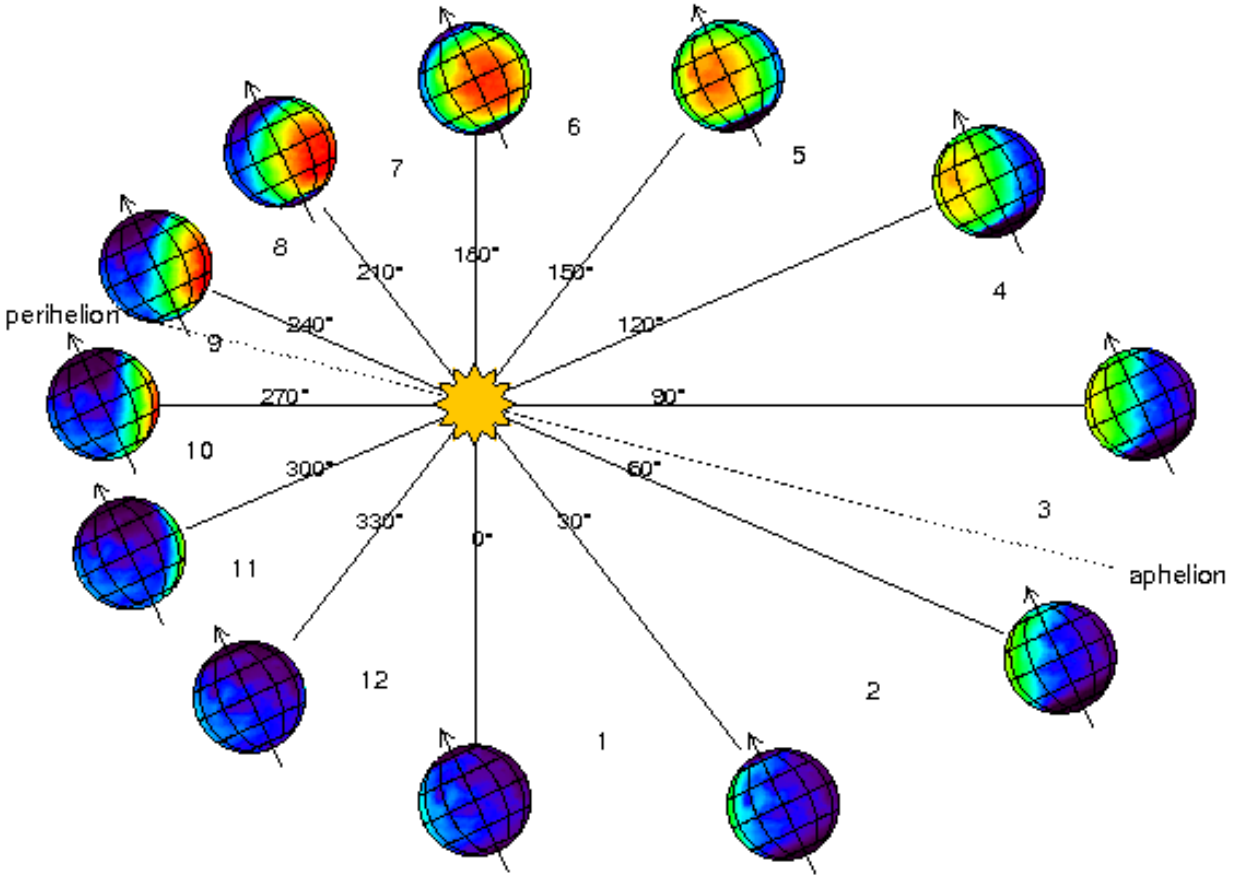
ASTR/GEOL-2040: Search for life in the Universe: Lecture 20

- Conditions on Mars
- Phase diagram
- Life on Mars?

Axel Brandenburg
(Office hours: Mondays 2:30 – 3:30 in X590 and Wednesdays 11-12 in D230)


Mars Oppositions
2012 to 2027
View from above Sun's North Pole
Orbits shown to scale
Planets not shown to scale
1 Astronomical Unit (AU) = 92,955,806 statute miles
= 149,597,870 kilometres
0°
Psc
P
Cap
A
Tau
P
Gem
Sco
A
Leo
Leo
Vir
2020 October 13
0.4181 AU
2018 July 27
0.3862 AU
2022 December 8
0.5492 AU
2025 January 16
0.6435 AU
2016 May 22
0.5101 AU
2027 February 19
0.6780 AU
2012 March 3
0.6745 AU
2014 April 8
0.6219 AU
0.9977 AU
20°
304°
1.0155 AU
76°
0.9851 AU
116°
0.9836 AU
241°
1.0123 AU
Mercury
150°
0.9883 AU
163°
0.9913 AU
1.0011 AU
198°
Venus
Earth
Mars
2022 December 8 Opposition date
Faintest Brightest
0.6435 AU Earth-Mars distance
150° Heliocentric longitude
1.0155 AU Sun-Earth distance
Leo Constellation
P Perihelion A Aphelion
First Point of Aries (Vernal Equinox)
Orbits from Astroviewer by Dirk Matussek
Data from SkyGazer Ephemeris by John Biondo
Background image from Redshift 5
by United Soft Media Verlag GmbH
Diagram © Martin J Powell 2013
www.nakedeyeplanets.com

Martian seasons



Orbital period

– 687 days=1.9 yr

Rotation period

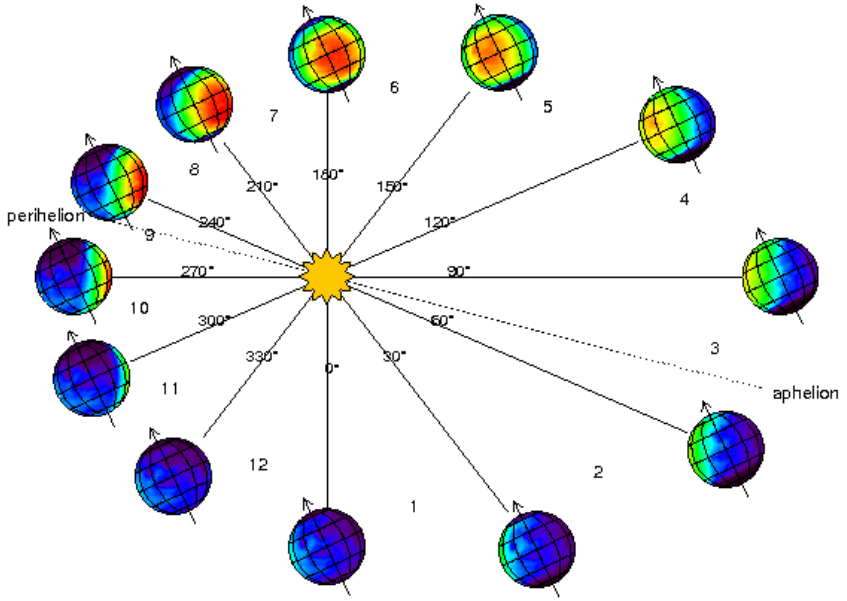
– $1^{d}37^{m}22^{s}$

Solar day = sol

– $1^{d}39^{m}35^{s}$

Summers/winters in north/south?

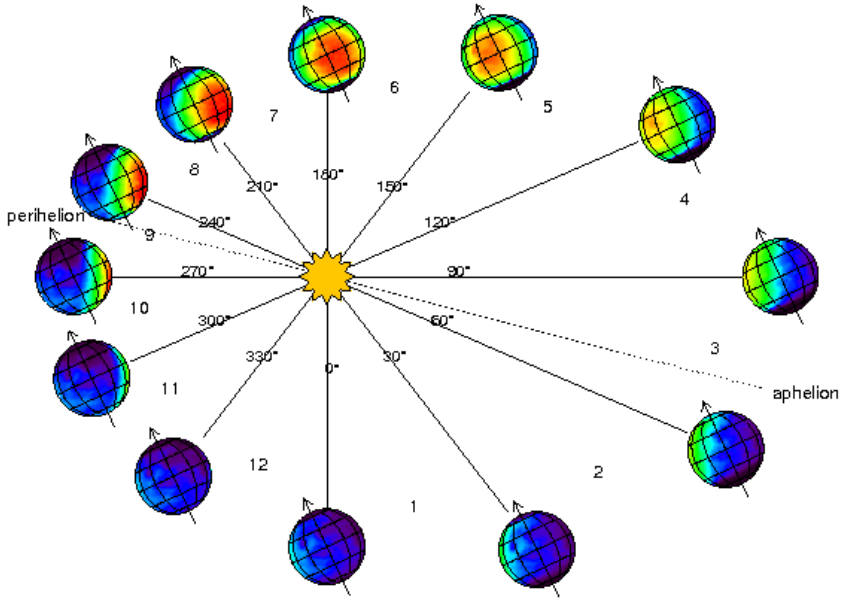
Martian seasons



	Summer	Winter
North	Cooler	wamer
	longer	shorter
	caps sublimate less	Caps freeze less
South	hotter	cooler
	shorter	longer
	caps sublimate more	freeze more

South more extreme

- Caps evaporate
- 1/3 more CO_2 gas
- Lots of wind
- Dust storm season!



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	shorter	longer
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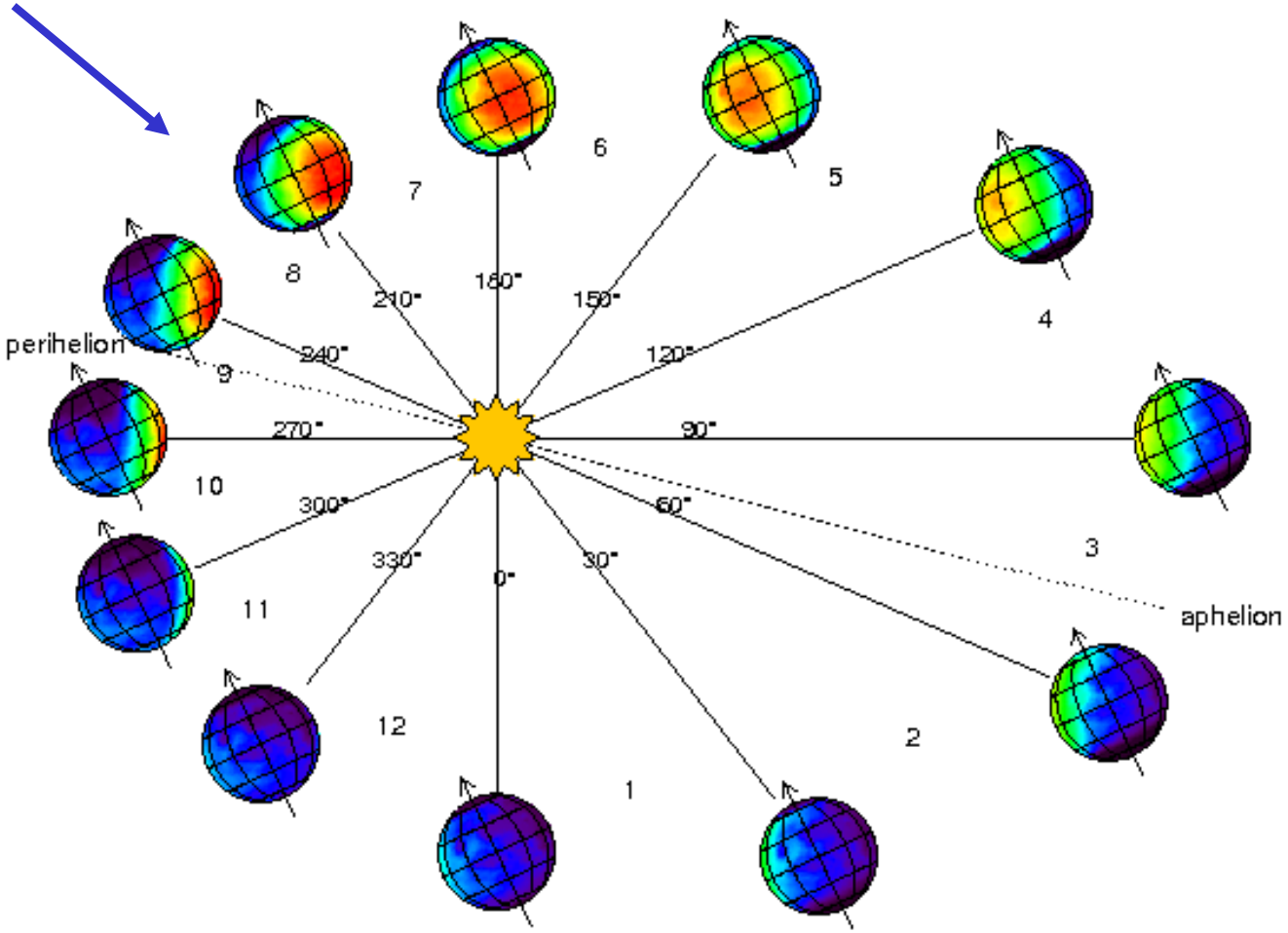
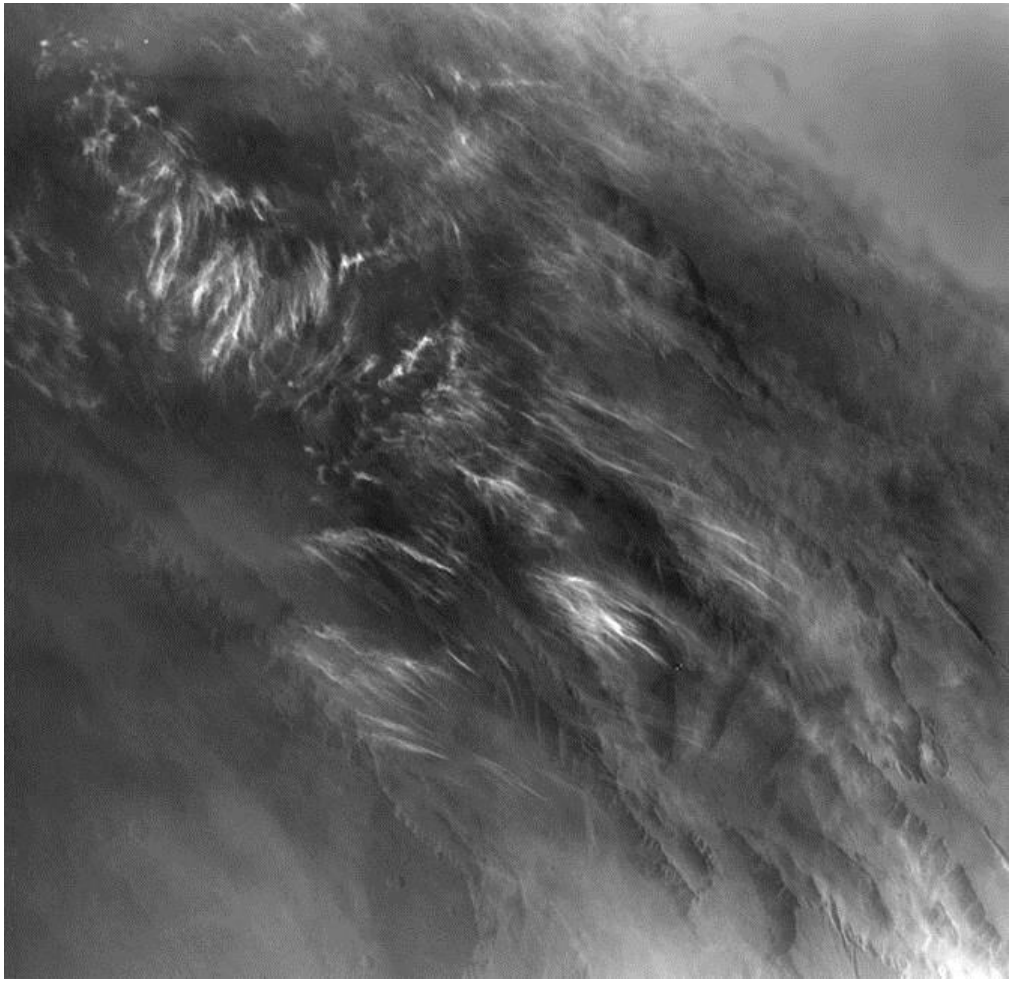
Martian seasons

Dust season



Martian weather

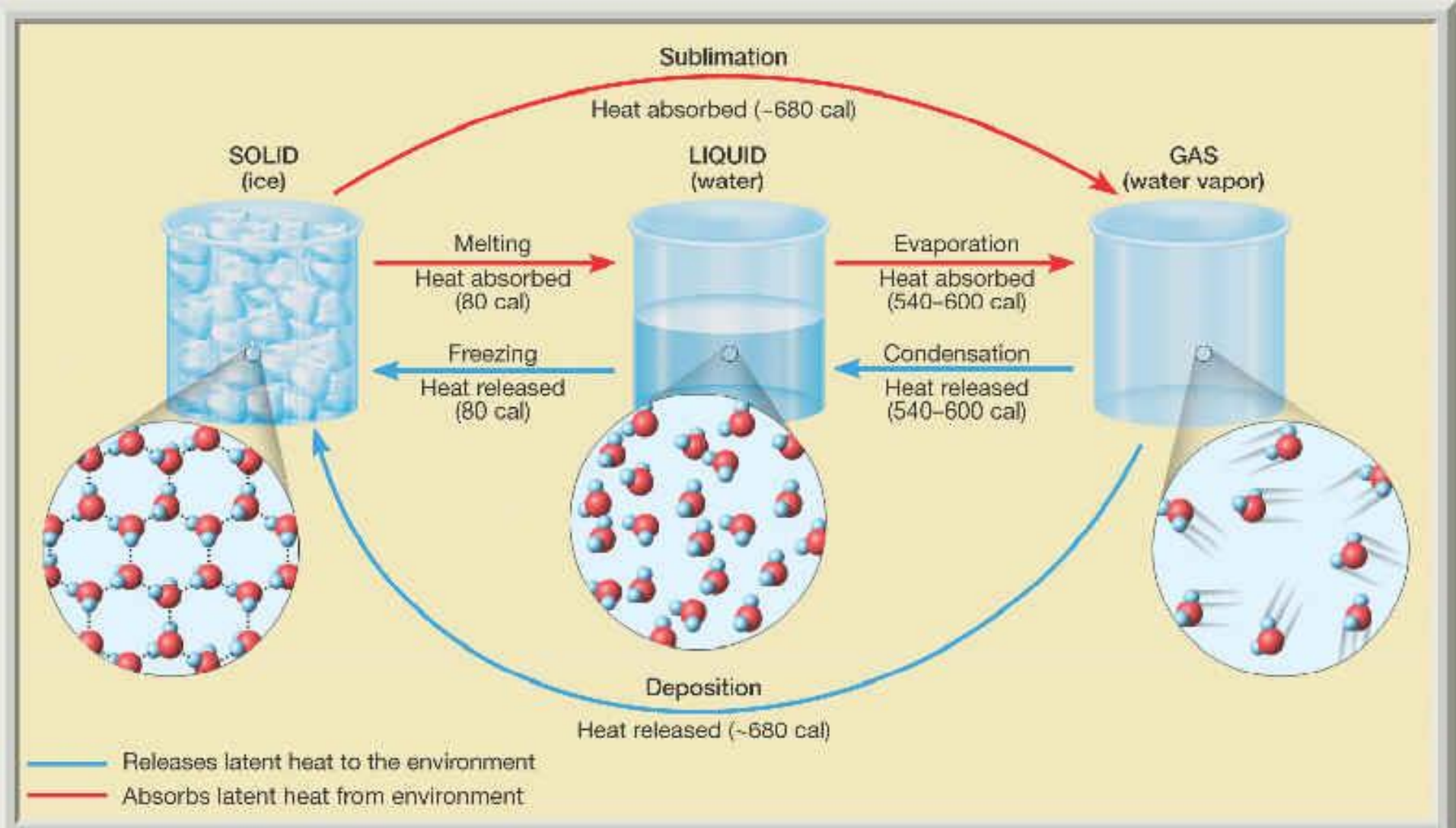
- Fairly Predictable
- Phoenix observed precipitation
- But evaporated before reaching ground



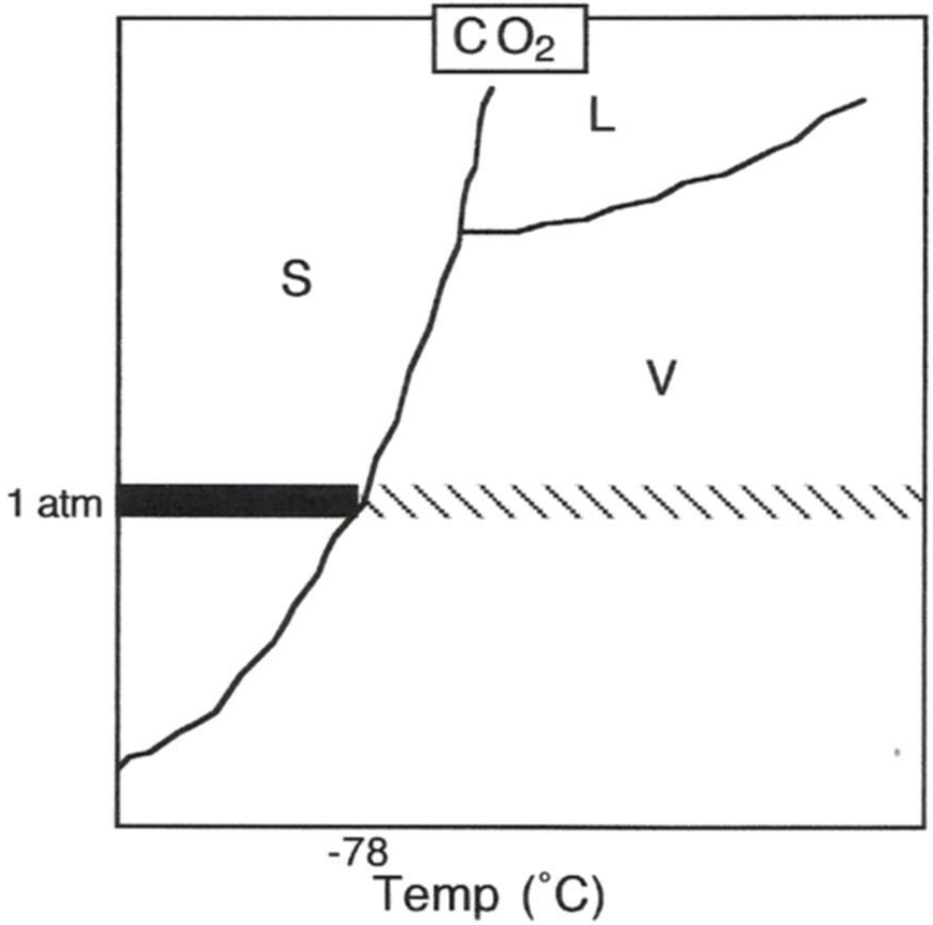
1976 Viking 1 orbiter

2008 Phoenix lander

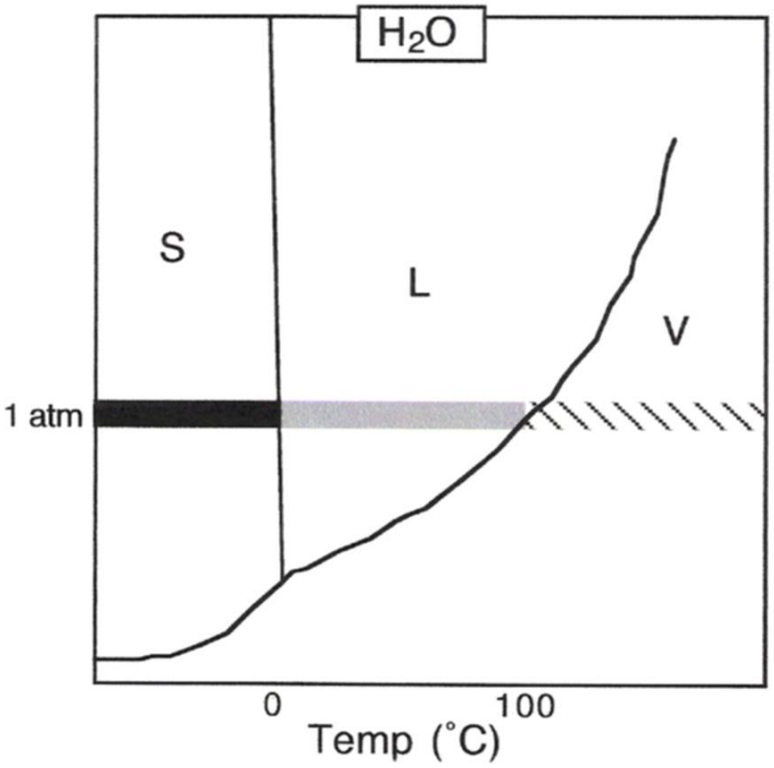
The three phases

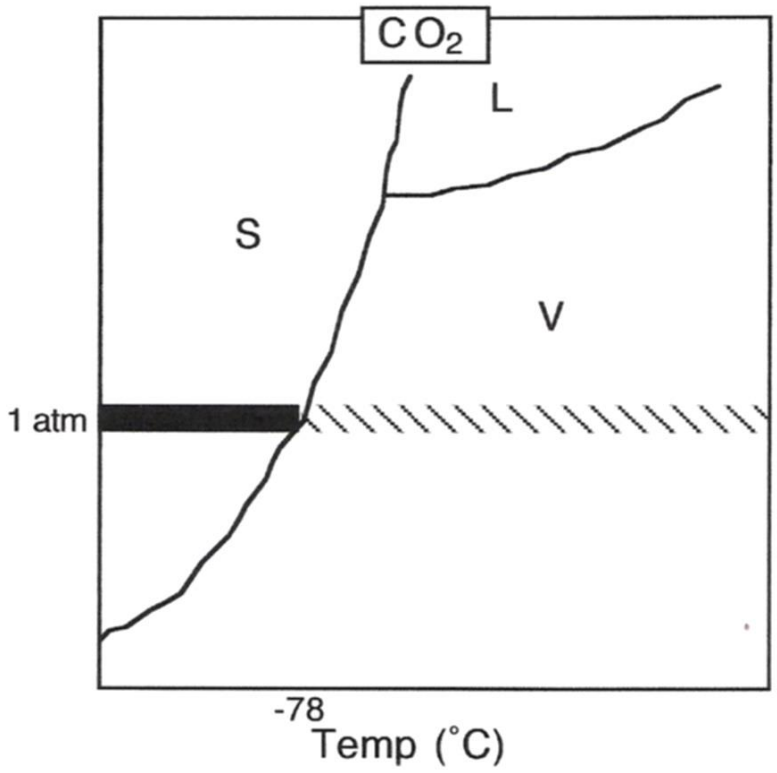


Phase diagram: carbon dioxide



Water vs. carbon dioxide

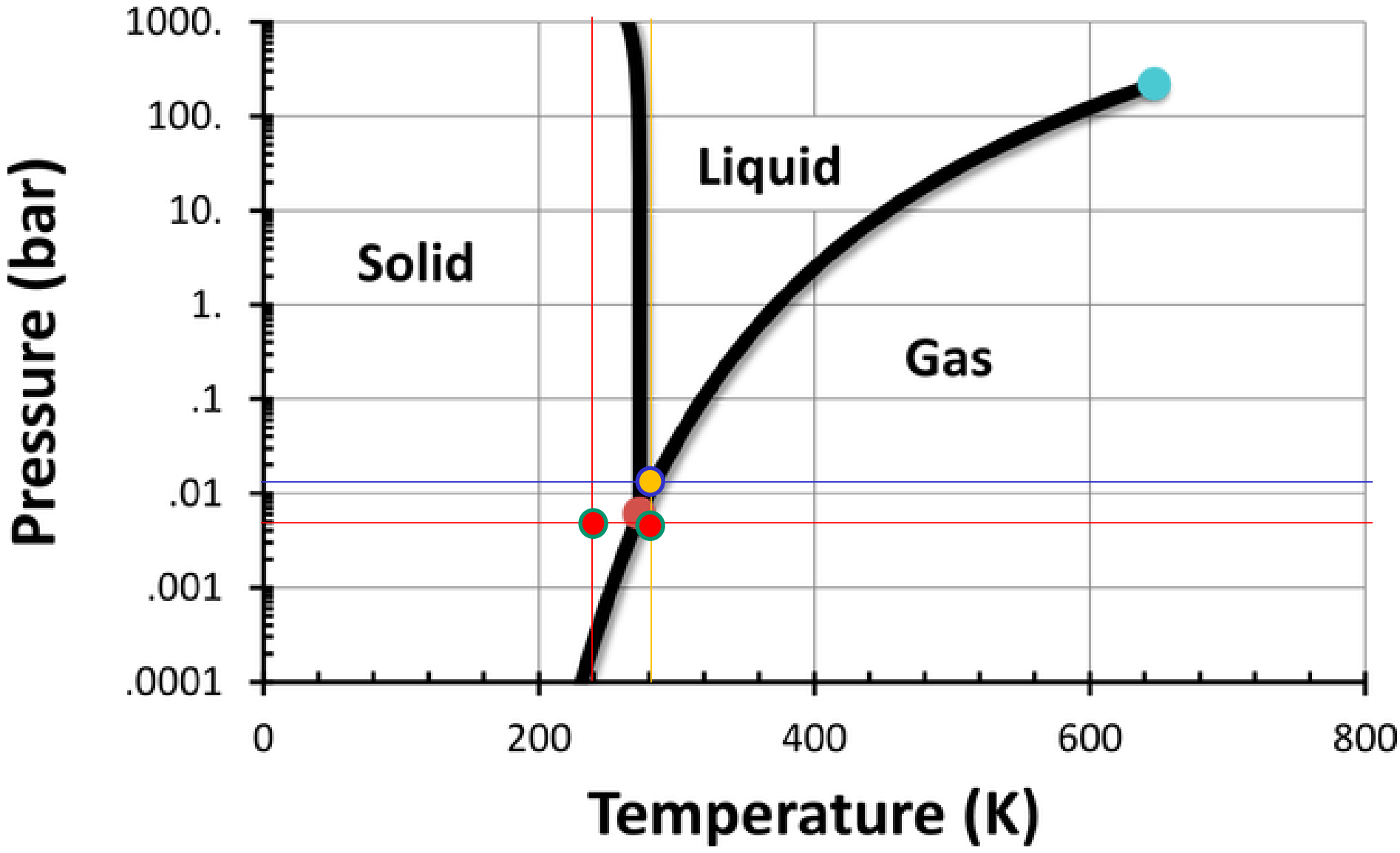




Phase changes possible

A. When temperature changes
B. When pressure changes
C. When temperature and/or pressure change

Phase diagram of water



Phase changes possible

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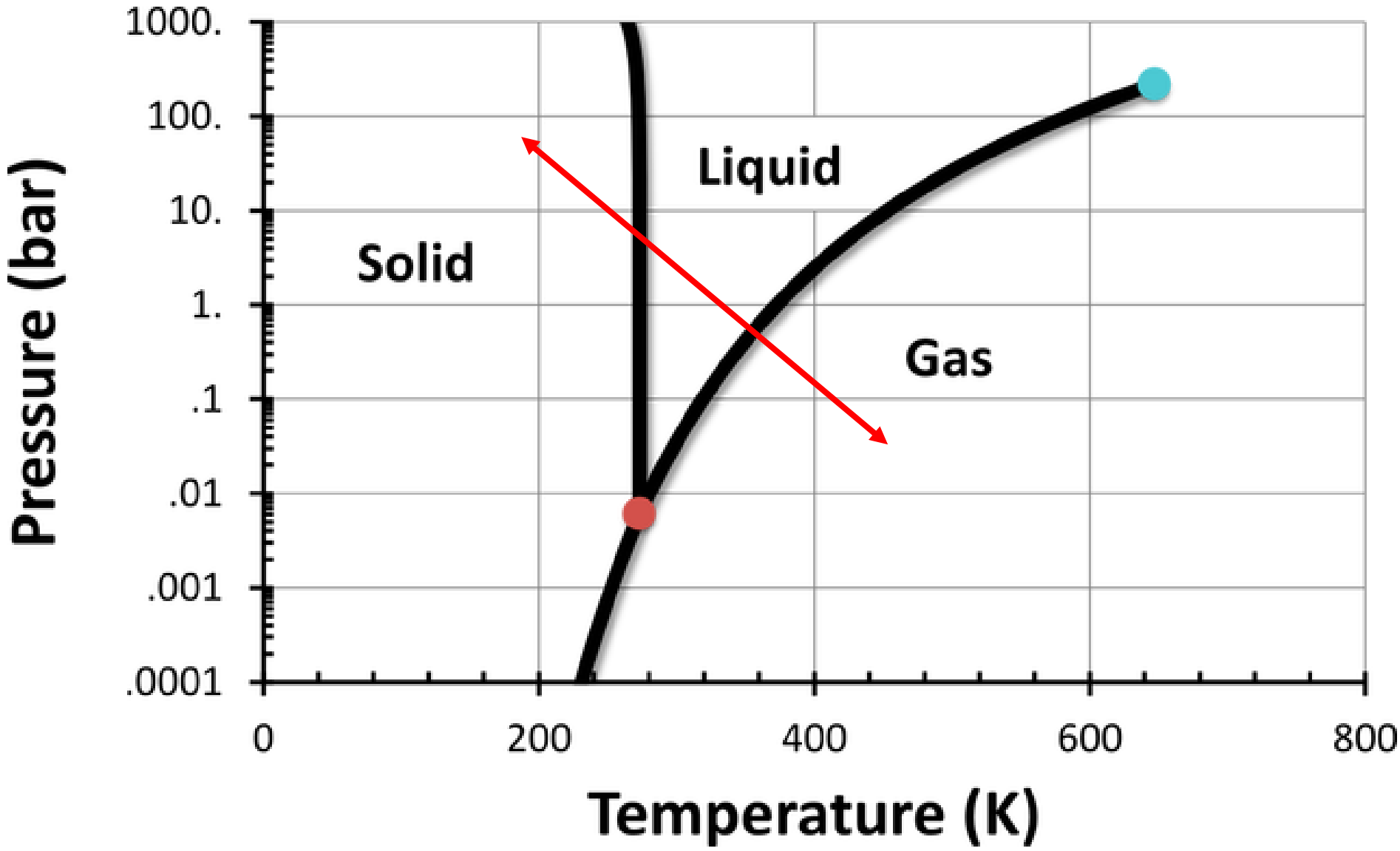
Phase diagram of water



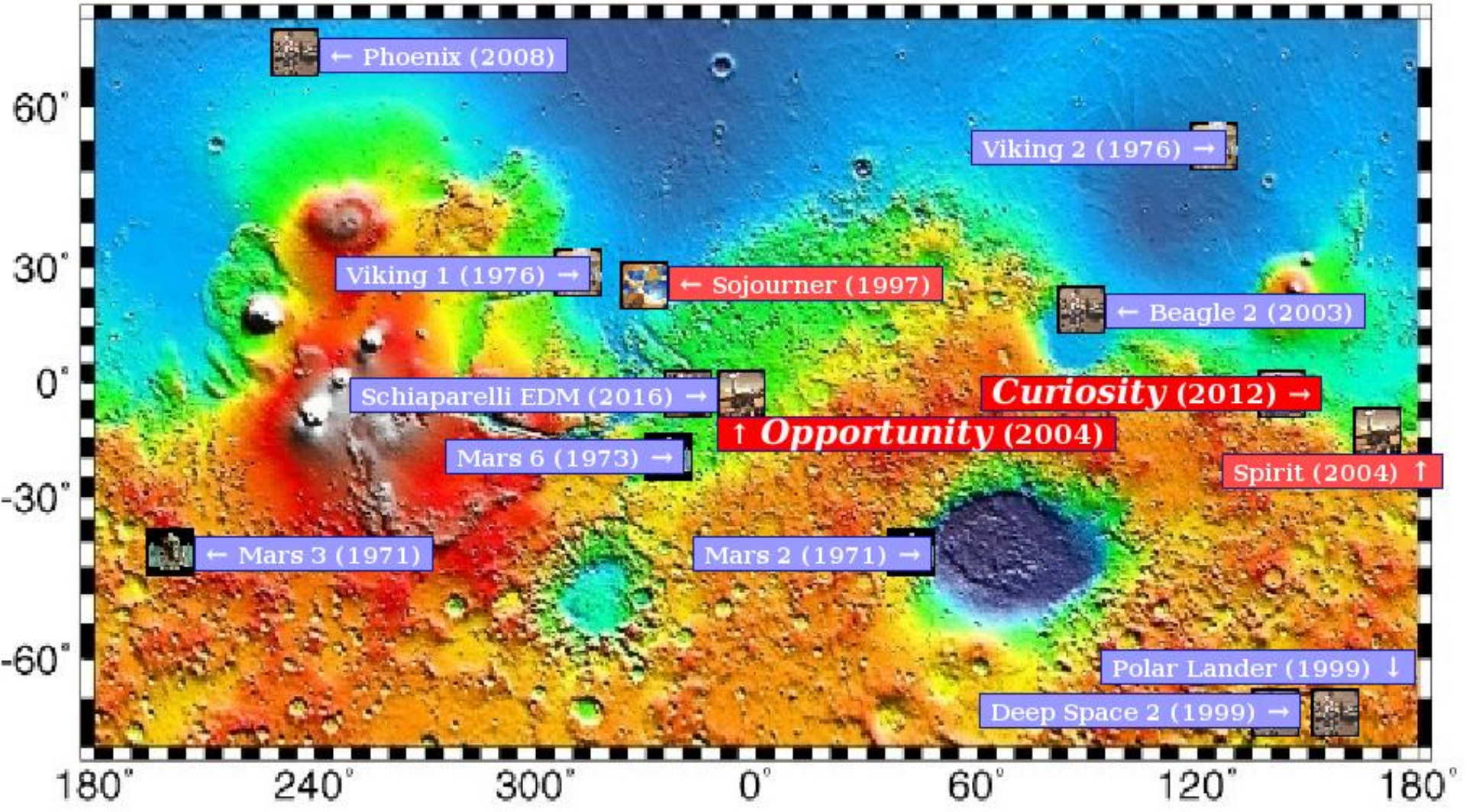
Phase changes possible

A. When temperature changes

B. When pressure changes

C. When temperature and/or pressure change

Modern topographic map of Mars

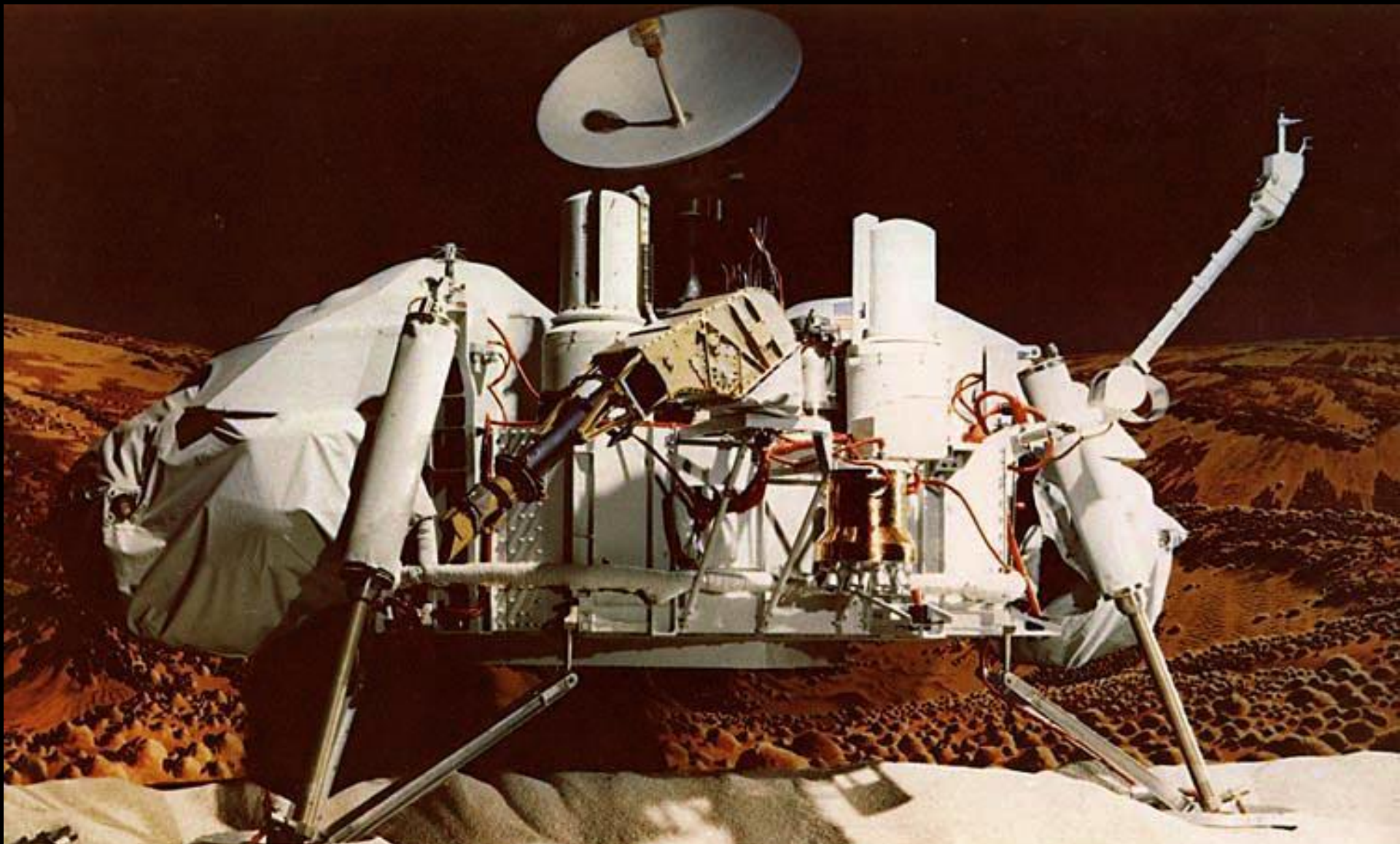


Viking 2 far north; Phoenix even more! Northern planes…

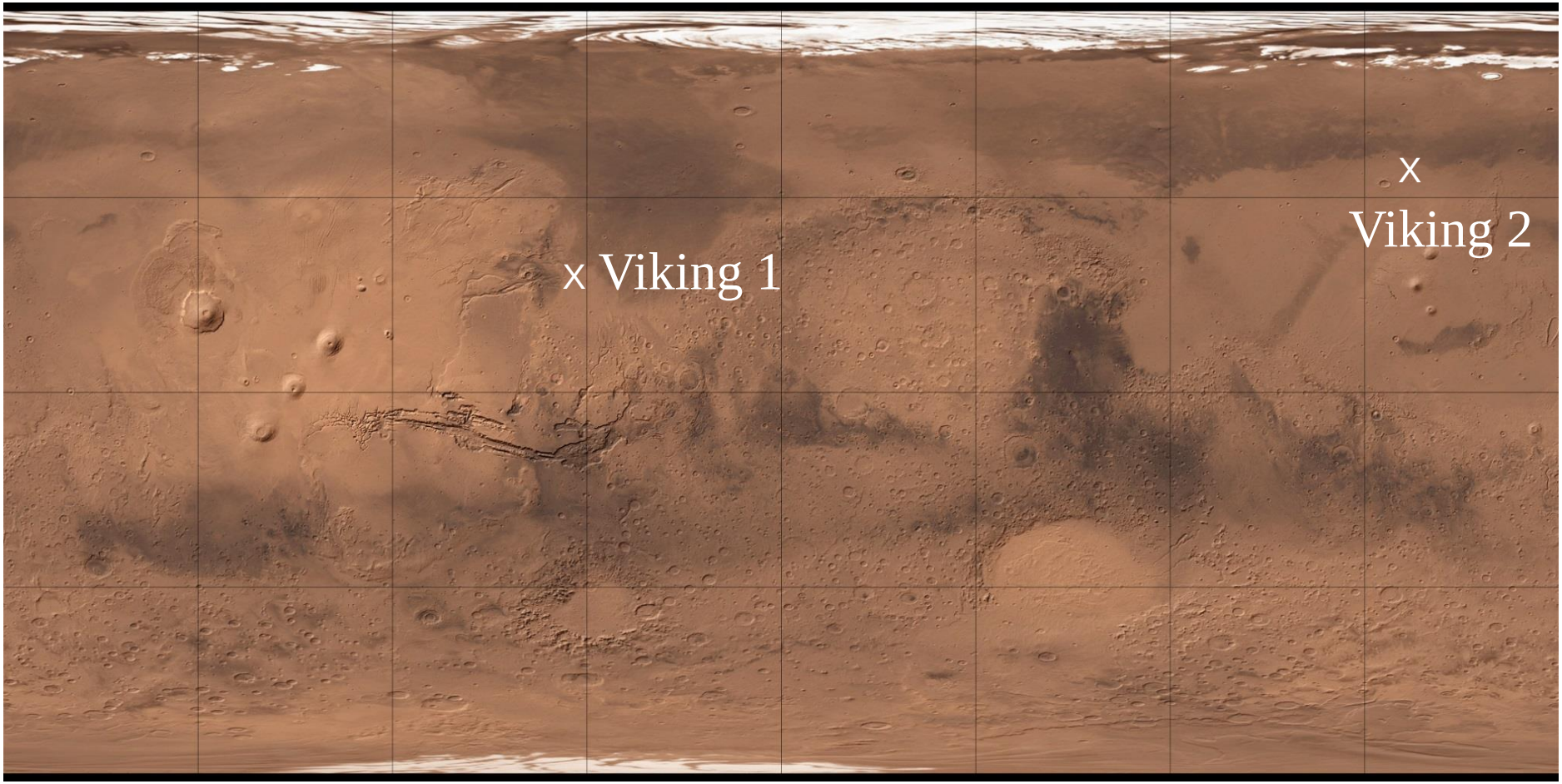
Martian life claims: 3 categoroies

- Viking 1+2 landers
  - Microbes in the soil perform metabolism on supplied organics
- Methane in martian atmosphere
  - Methanogenes?
- Martian meteorites
  - Fossil evidence

The Viking labs (1976)

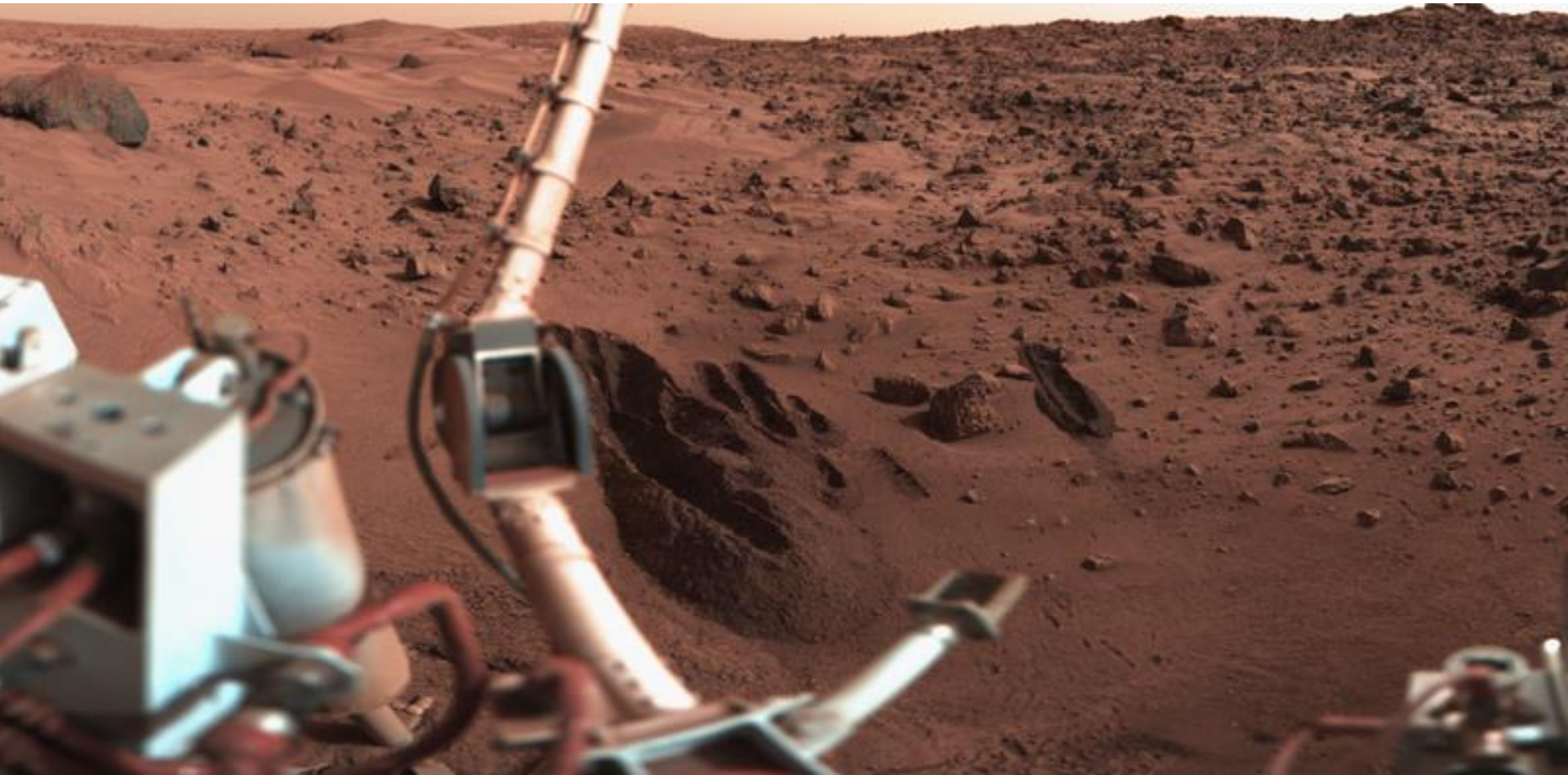


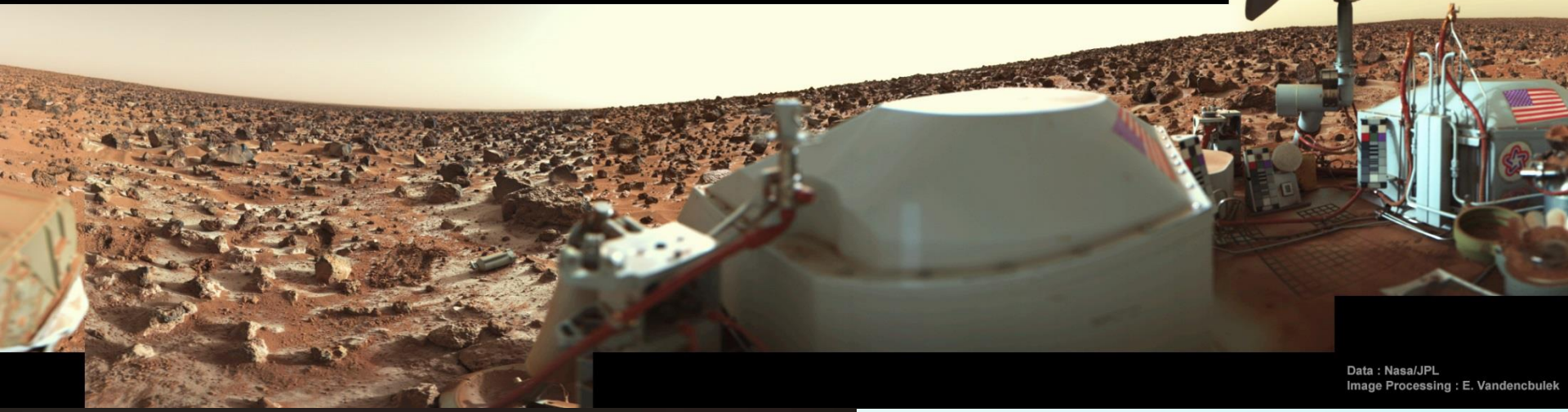
Syrtis Major, Olympus Mons, etc



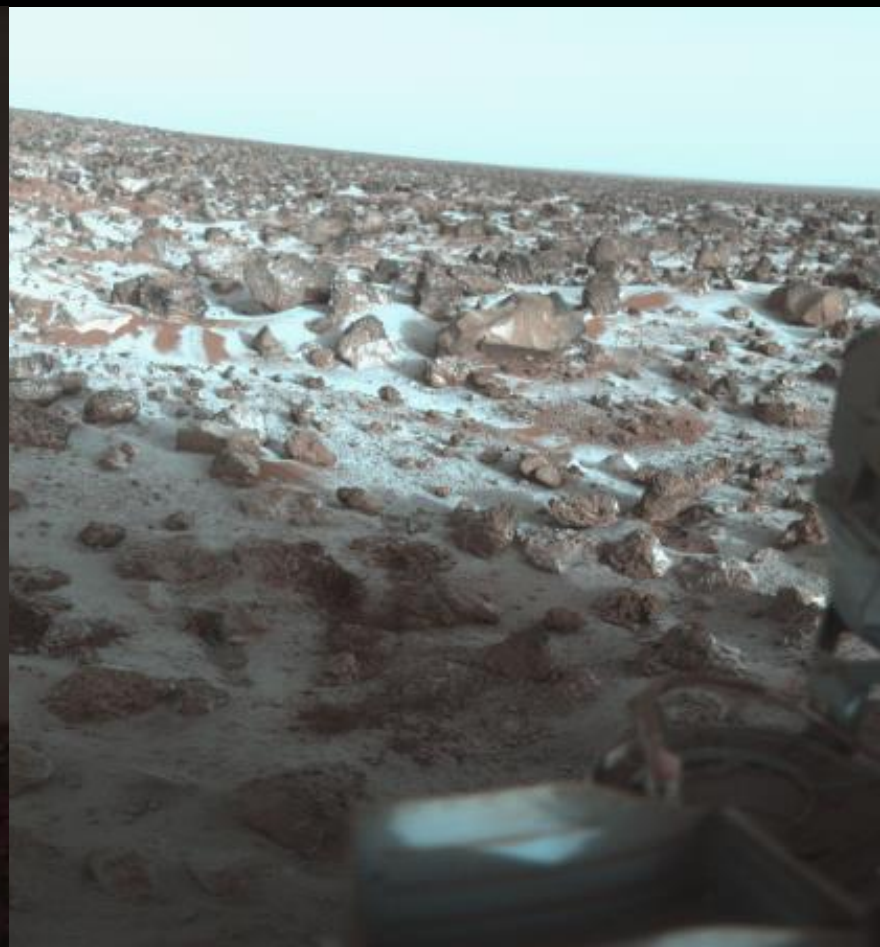
Viking results of 1976

- Lots of pictures, not much change
- Sometimes winds, condensation, precipitation, clouds





Data : Nasa/JPL
Image Processing : E. Vandencbulek

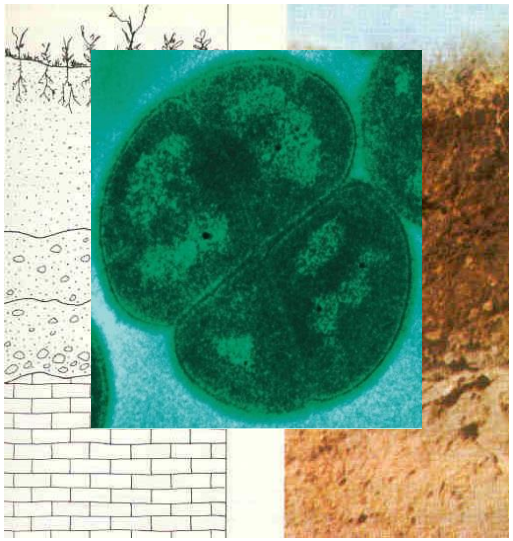


Martian sky

- Black (not much air)
  - Except when dust: brown
- Sunsets blue
  - Blue gets transmitted

The Label Release Experiment

- Supply “nutrients” (amino acids, etc)
- Control experiment



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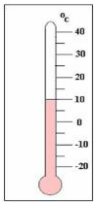
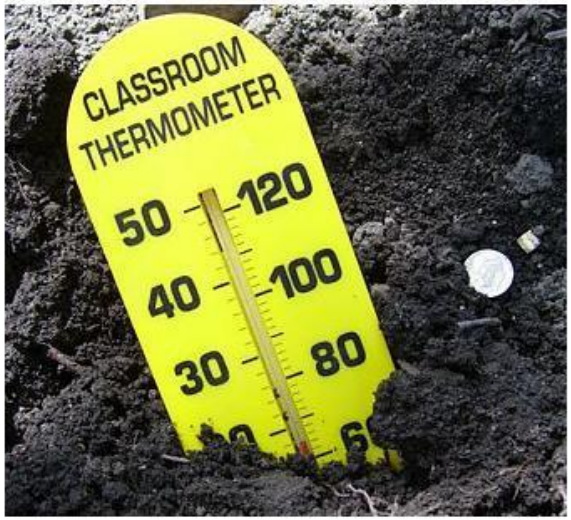


= CO_2+…

Control Experiment

- Soil heated to 140 C, later 40 – 50 C
- To sterilize soil



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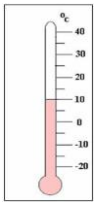

= nothing

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Review Article

The Case for Extant Life on Mars and Its Possible Detection by the Viking Labeled Release Experiment

Gilbert V. Levin[1] and Patricia Ann Straat[2]

Abstract

The 1976 Viking Labeled Release (LR) experiment was positive for extant microbial life on the surface of Mars. Experiments on both Viking landers, 4000 miles apart, yielded similar, repeatable, positive responses. While the authors eventually concluded that the experiment detected martian life, this was and remains a highly controversial conclusion. Many believe that the martian environment is inimical to life and the LR responses were nonbiological,

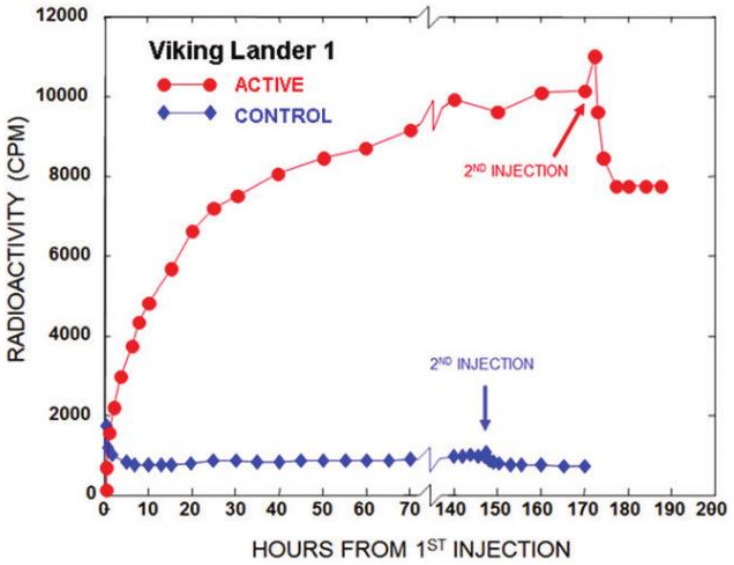

FIG. 2. LR response to first and second nutrient injection in VL1 cycle 1 (active) and VL1 cycle 2 (160°C control). [Adapted from Levin and Straat, 1976b]

Quote from Sagan

- … the more extraordinary the claim, the more extraordinarily well-tested the evidence must be.
- The person making the extraordinary claim has the burden of proving to the experts at large that his or her belief has more validity than the one almost everyone else accepts…

Methane and Life on Mars

Gilbert V. Levin*[a] and Patricia Ann Straat**[b]
[a]Beyond Center, College of Liberal Arts and Sciences, Arizona State University, Tempe, AZ, USA 85287
[b]Retired, National Institutes of Health, Bethesda, MD, USA, 20892

ABSTRACT

Mumma *et al.* [1] have confirmed earlier detections of methane in the Martian atmosphere, finding it localized and correlated with atmospheric water vapor. They determined that, because of the short half-life of methane, a continual replenishment is required to account for its presence. They also conclude that the dynamics of methane on Mars require a methane sink in the soil. It is suggested here that both phenomenon could be accounted for by an ecology of methane-producing and methane-consuming microorganisms. Such ecologies exist on Earth, where, generally, anaerobic methanogens live at depth and aerobic methanotrophs live at or near the surface. On Mars, with its essentially anaerobic atmosphere, both types of microorganisms could co-exist at or near the surface. It is possible that the Viking Labeled Release (LR) experiment detected methanogens in addition to other microorganisms evolving carbon dioxide since the LR instrumentation would detect methane, carbon dioxide, or any other carbon gas derived from one of the

Phoenix lander discovered perchlorates

- Explains why no (not much) organics are found
- Might also explain results of Viking Experiments

Perchlorates: $KClO_4$

APPLIED AND ENVIRONMENTAL MICROBIOLOGY, July 2005, p. 3928–3934 Vol. 71, No. 7
0099-2240/05/$08.00+0 doi:10.1128/AEM.71.7.3928–3934.2005

Reduction of Perchlorate and Nitrate by Microbial Communities in Vadose Soil

Mamie Nozawa-Inoue,* Kate M. Scow, and Dennis E. Rolston

Department of Land, Air, and Water Resources, University of California, Davis, California

Received 22 September 2004/Accepted 7 February 2005

Perchlorate contamination is a concern because of the increasing frequency of its detection in soils and groundwater and its presumed inhibitory effect on human thyroid hormone production. Although significant perchlorate contamination occurs in the vadose (unsaturated) zone, little is known about perchlorate biodegradation potential by indigenous microorganisms in these soils. We measured the effects of electron donor (acetate and hydrogen) and nitrate addition on perchlorate reduction rates and microbial community composition in microcosm incubations of vadose soil. Acetate and hydrogen addition enhanced perchlorate reduction, and a longer lag period was observed for hydrogen (41 days) than for acetate (14 days). Initially, nitrate suppressed perchlorate reduction, but once perchlorate started to be degraded, the process was stimulated by nitrate. Changes in the bacterial community composition were observed in microcosms enriched with perchlorate and either acetate or hydrogen. Denaturing gradient gel electrophoresis analysis and partial sequencing of 16S rRNA genes recovered from these microcosms indicated that formerly reported perchlorate-reducing bacteria were present in the soil and that microbial community compositions were different between acetate- and hydrogen-amended microcosms. These results indicate that there is potential for perchlorate bioremediation by native microbial communities in vadose soil.

Next time

- Water on Mars
- RGS 99 - 109