• 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)
Martian seasons

Orbital period
- 687 days = 1.9 yr

Rotation period
- 1^d37^m22^s

Solar day = sol
- 1^d39^m35^s

Summers/winters in north/south?
## Martian seasons

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<th>Summer</th>
<th>Winter</th>
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<td>North</td>
<td>Cooler</td>
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<td>caps sublimate less</td>
<td>Caps freeze less</td>
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South more extreme

- Caps evaporate
- 1/3 more CO$_2$ gas
- Lots of wind
- Dust storm season!

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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

- **Solid** (ice)
  - Melting: Heat absorbed (80 cal)
  - Freezing: Heat released (80 cal)

- **Liquid** (water)
  - Evaporation: Heat absorbed (540–600 cal)
  - Condensation: Heat released (540–600 cal)

- **Gas** (water vapor)
  - Sublimation: Heat absorbed (~680 cal)
  - Deposition: Heat released (~680 cal)

- Sublimation: Absorbs latent heat from environment
- Deposition: Releases latent heat to the environment
Phase diagram: carbon dioxide

From 1700 K to 20 K

Refractory minerals: $T_{50} > 1100$ K
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

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

• 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)

Gas chromatograph-mass spectrometer (GCMS)

No organics detected (less than on the moon!)

Decisive reason why conclusion: no life
Syrtis Major, Olympus Mons, etc
Viking results of 1976

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

\[ + \quad = \quad \text{CO}_2 + \ldots \]
Control Experiment

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

+ nothing
The Case for Extant Life on Mars and Its Possible Detection by the Viking Labeled Release Experiment

Gilbert V. Levin¹ and Patricia Ann Straat²

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,
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* and Patricia Ann Straat**

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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: $\text{KClO}_4$

Reduction of Perchlorate and Nitrate by Microbial Communities in Vadose Soil

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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