An Examination of the Possibility of

Flowing Liquid Water on Mars

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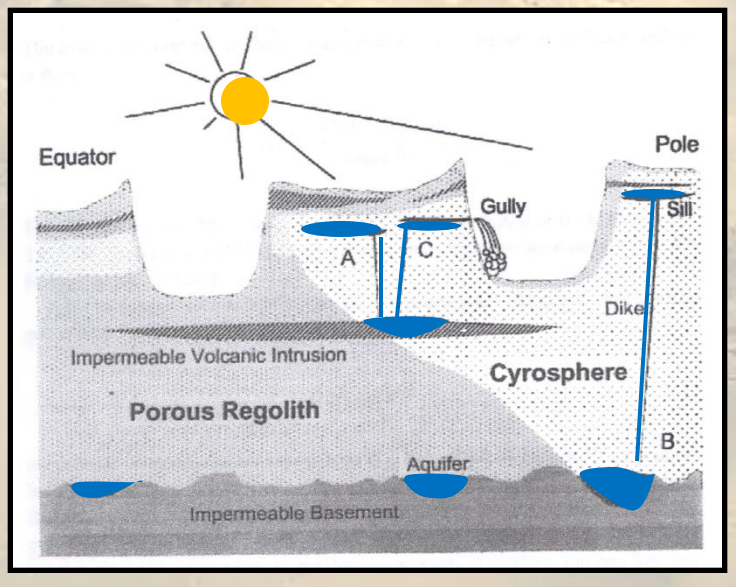
Source Paper

Cryovolcanism and the Recent Flow of Liquid Water on Mars by Eric J. Gaidos

- Presupposes set of geological conditions that would lead to surface eruption of underground water.

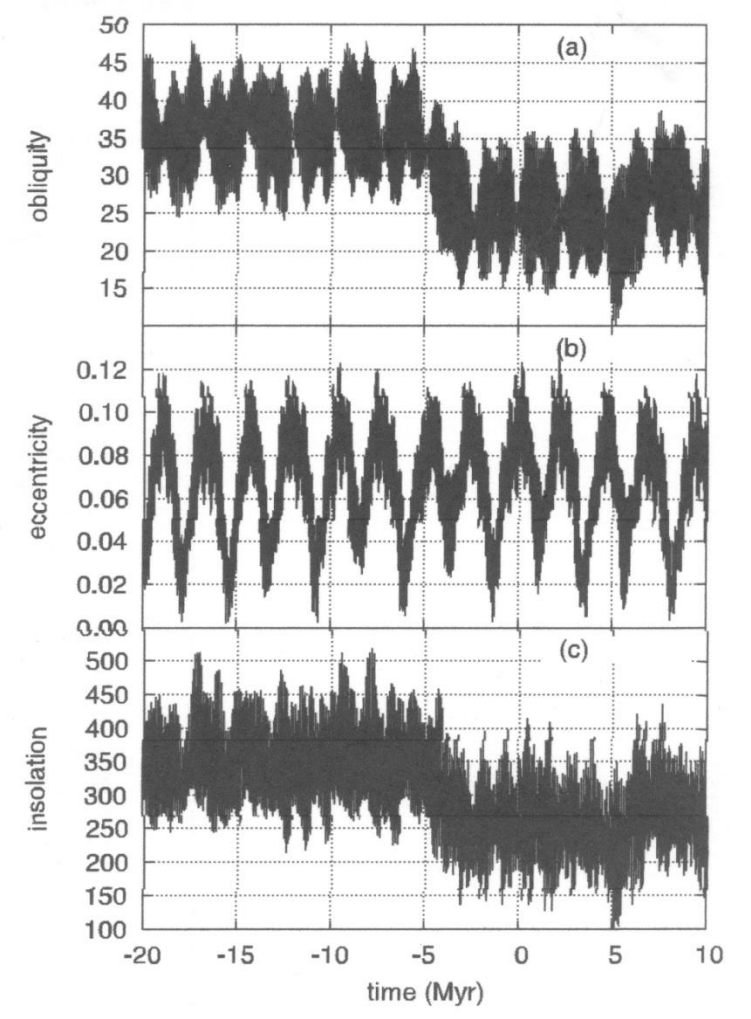
- Complicated circumstances and process

- One of many papers on the subject of flowing liquid water



Mars Obliquity

- Obliquity as high at 47 degrees
  - Vaporizing the water at N. Pole
  - Coldest near equator
- Eccentricity as high as .12
  - Increasing the distance from sun at aphelion
- After high obliquity, Mars received less energy from the sun
  - Preserving non-polar ice fields

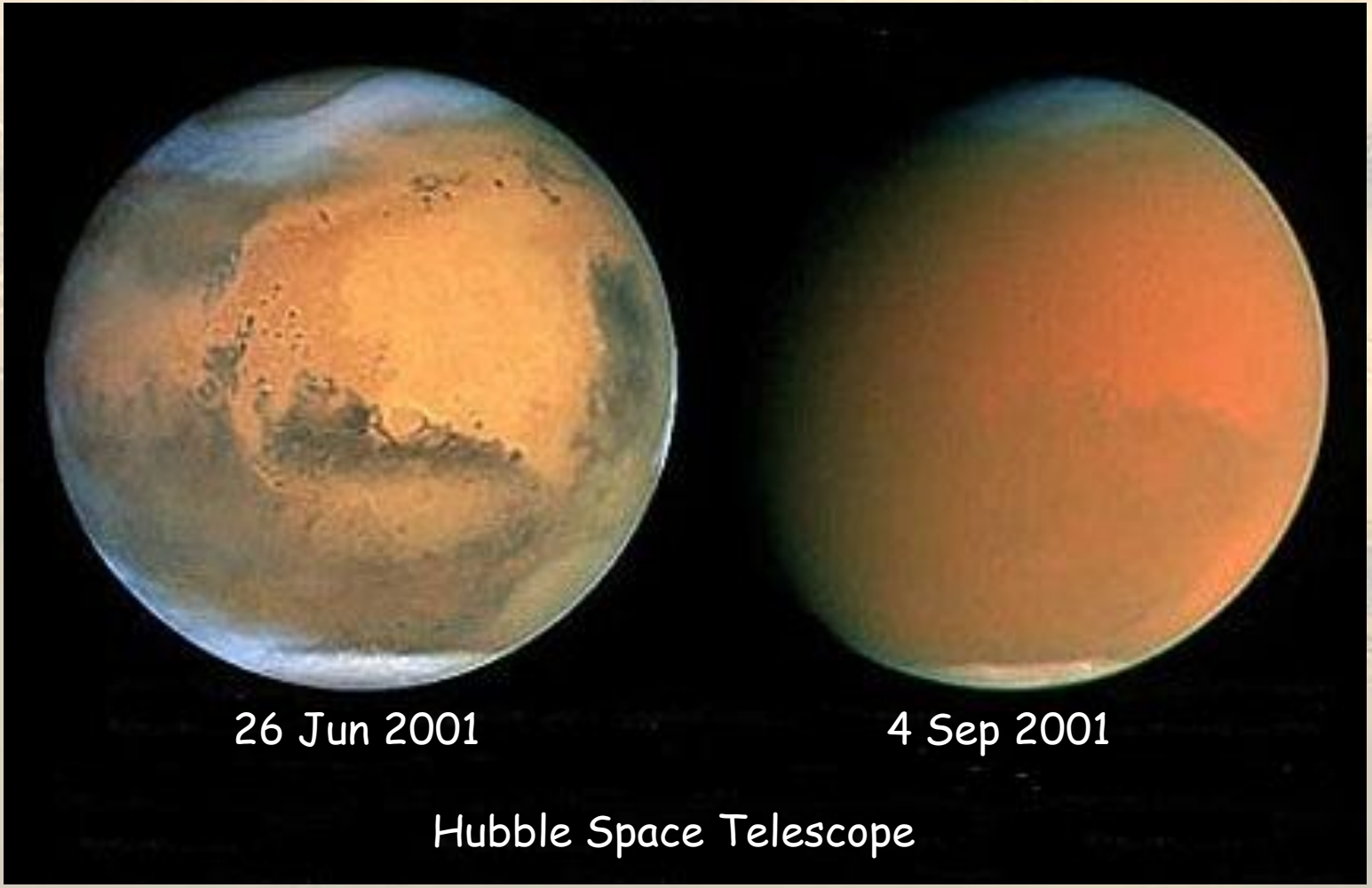


Sources of Water on Mars

- North Pole
- South Pole
- (Black) Glaciers
- (Black) Ice Sheets
- (Black) Lakes
- Permafrost
- Hot Springs
- Underground Water/Ice

- Alternatives to flowing water
  - Dry flows
  - CO_2 crystals or Liquid CO_2
  - Ice crystals

Martian Dust Storms

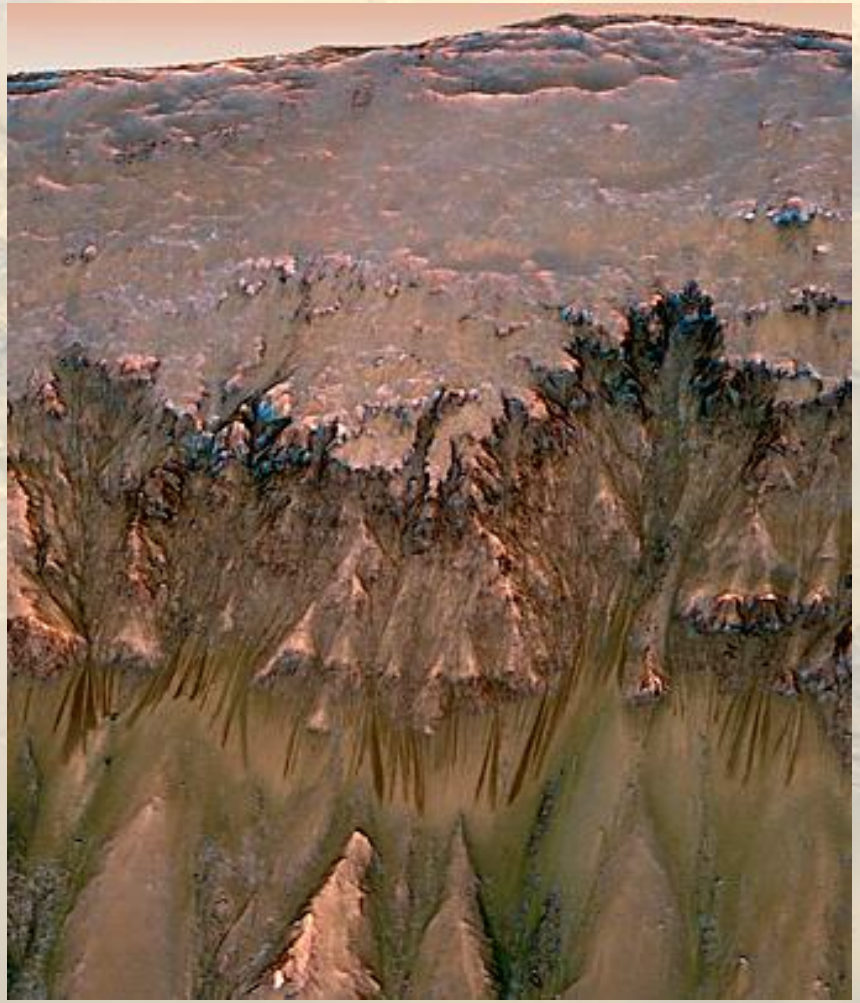


Thermal Properties of Soil

- Dirty coverings on ice generally cause the snow to melt faster due to greater thermal absorption
  - Until the covering gets thick enough to act as an insulating blanket
- One Earth, 20cm of soil can hold the subsurface at the average of the day/night temperatures +/- 2C
- The summertime temperature on Mars is +15C to - 120C. The average temperature would be approximately -55C (218K)

Recent Flowing Water on Mars

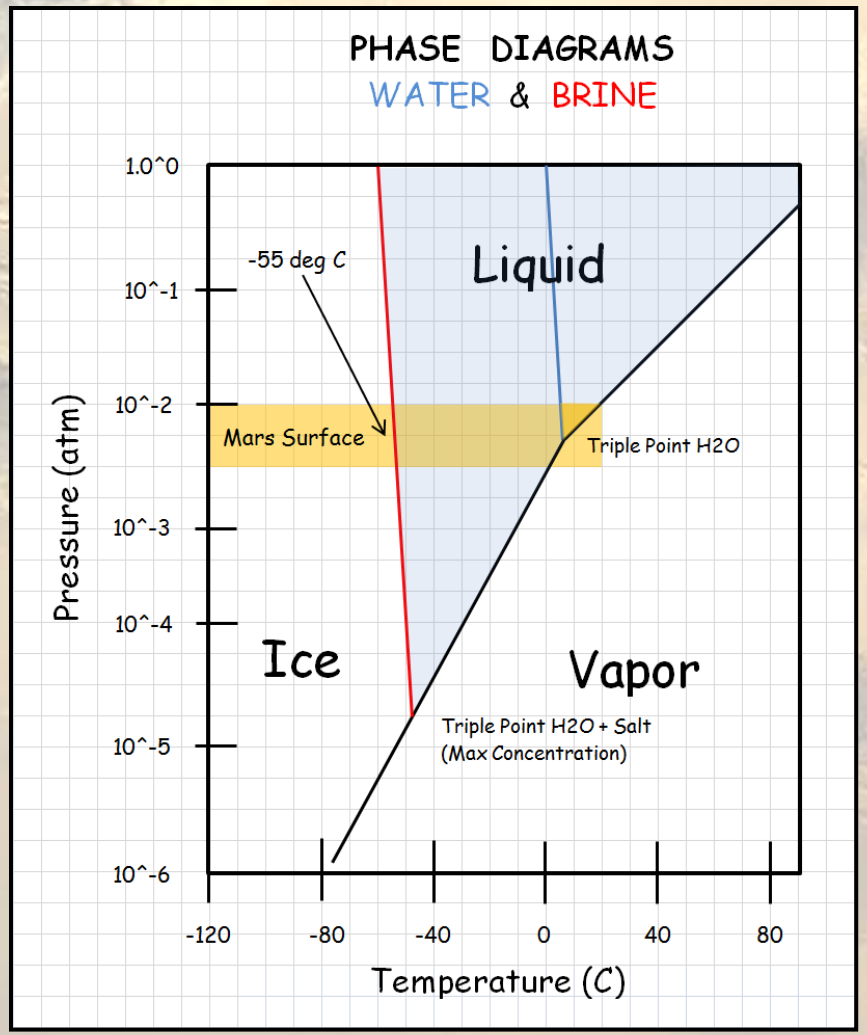
- Repeatable
  - Observed reoccurring for 3 years
- Seasonal
  - During the warm season in southern hemisphere
- Sloping terrain
- Pole-facing slopes
- Multiple outlets
- Multiple locations



Triple Point of Water & Brine

- The absorption of salts drastically lowers the boiling point of water making it liquid at a much lower temperature and pressure

- Salts are known to be present in Martian soil (NaCl, MgCl, CaCl)



Carbon Dioxide/Salt *Clathrate*

- Carbon dioxide reacts with salt water to form a solid phase carbon dioxide clathrate

- Decomposition of this phase produces carbon dioxide gas in equilibrium with water - like carbonated salt water

- Melting will begin at the carbon dioxide-brine eutectic point

  - Eutectic Point: **Boiling point of** a mixture of several components, which melts sharply below the melting point of any individual component

- **The decomposition of a calthrate brine produces brine + a large volume of gas "capable of considerable mechanical energy"**

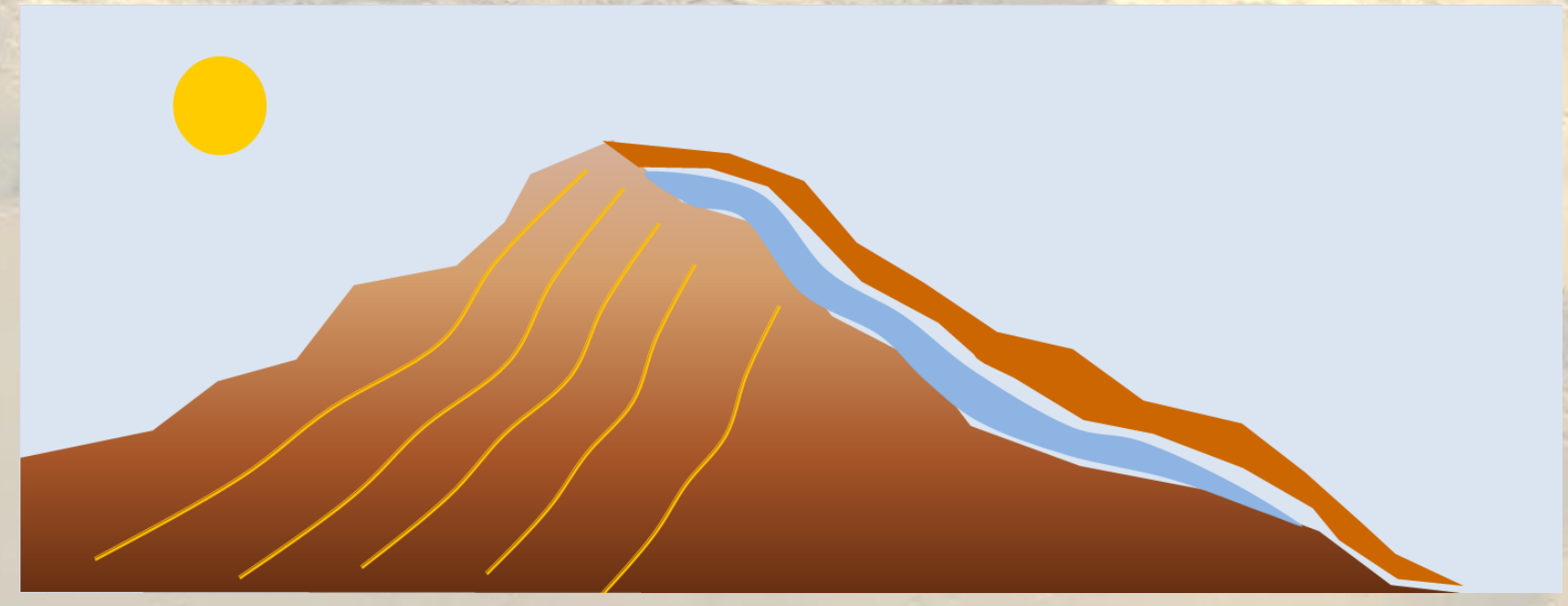
Hypothesis

- Water source: Black glaciers or huge insulated ice deposits
- Liquid: Water, Brine or brine & Carbon-dioxide clathrate

- Process:
  - When the southern hemisphere heats up, the underside of the ice flow reaches its melting point. Briny water, above its triple point fills the lower part of the cavity which is blocked with an ice plug.
  - Carbon dioxide comes out of solution and pressurizes the under-ice cavities
  - Gravity and CO_2 pressure force water out between sloped ridge surface and black ice cover
  - When the water is drained, the pressure is relieved, the drainage holes are plugged with frozen water
  - The process then begins all over.

Protected Ice Sheet

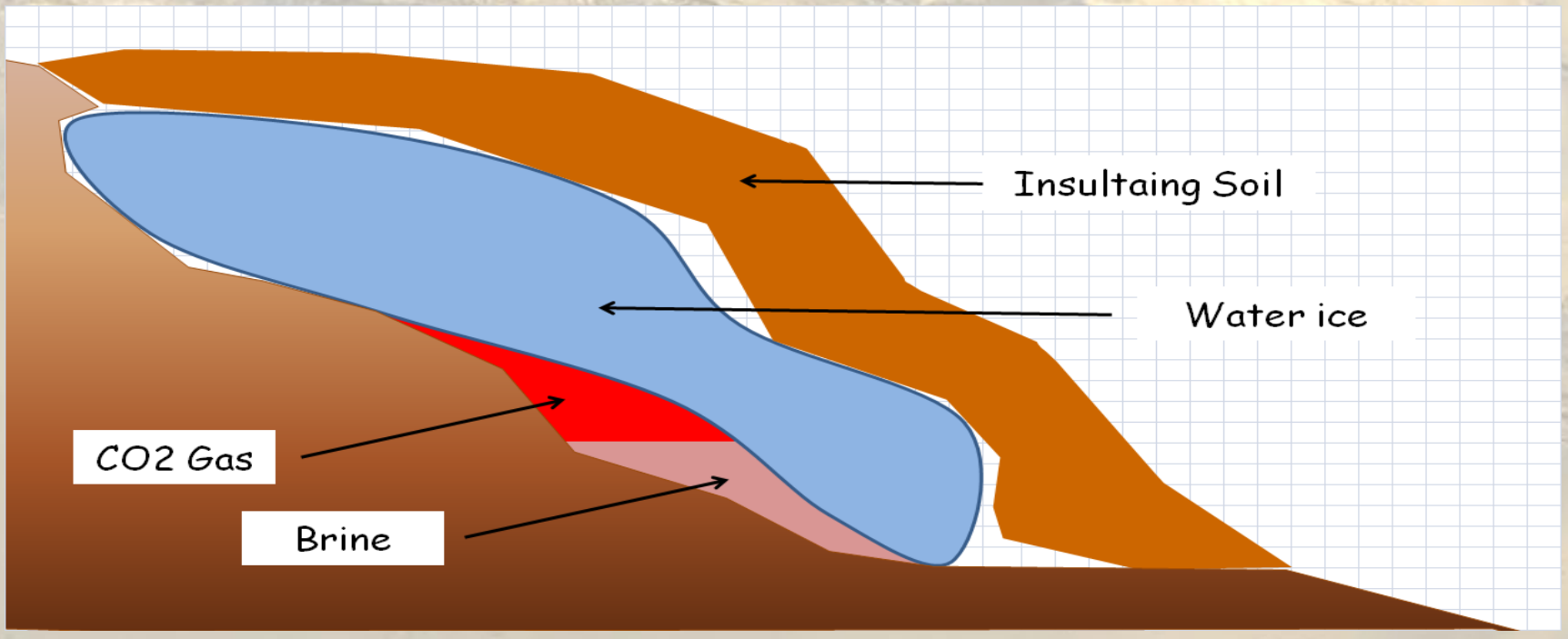
- Sun heats sunward side of ridge
- Ridge transmits heat to underside of ice field



Water Flowing Under Ice Sheet

Build-up of Pressure

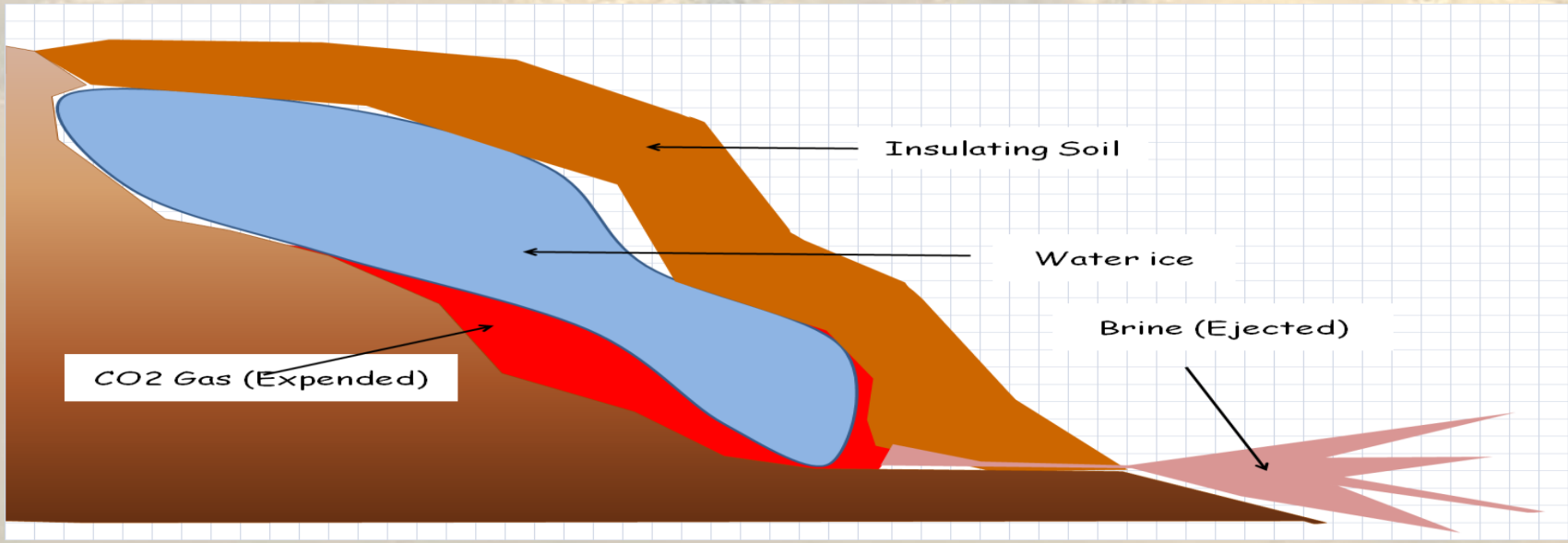
- Heat melts water ice/brine and releases CO_2 gas which remain trapped while weight of brine and pressure of gas build up



Ejection of Brine

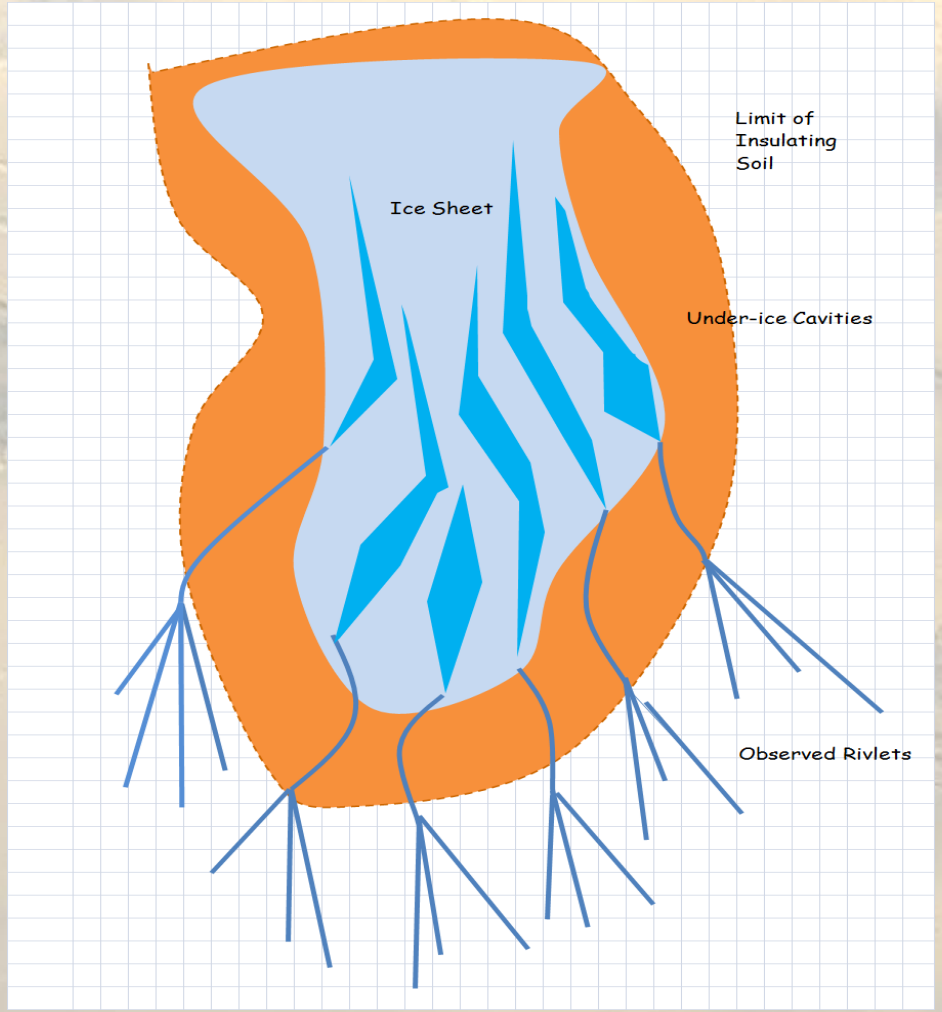
- Pressure of gas and brine push through the crust and into the open to flow until evaporated

- Upon release of pressure, exit to atmosphere is re-blocked by ice and process begins to repeat

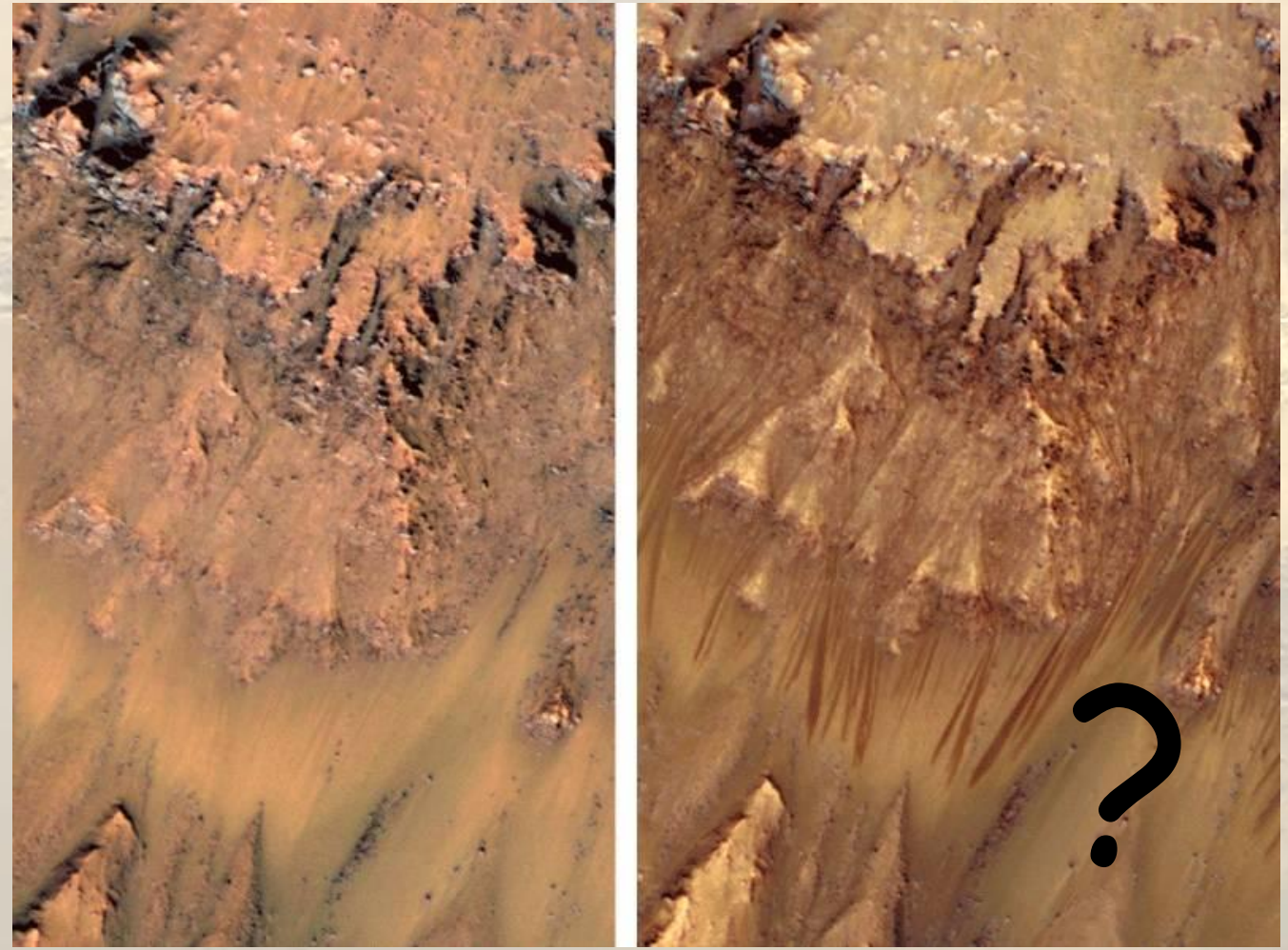


Flowing Water on Mars

- Brine gushes out of regolith covering with enough mass and volume to form gullies and alluvial fan formations before evaporating in low pressure atmosphere



Questions?



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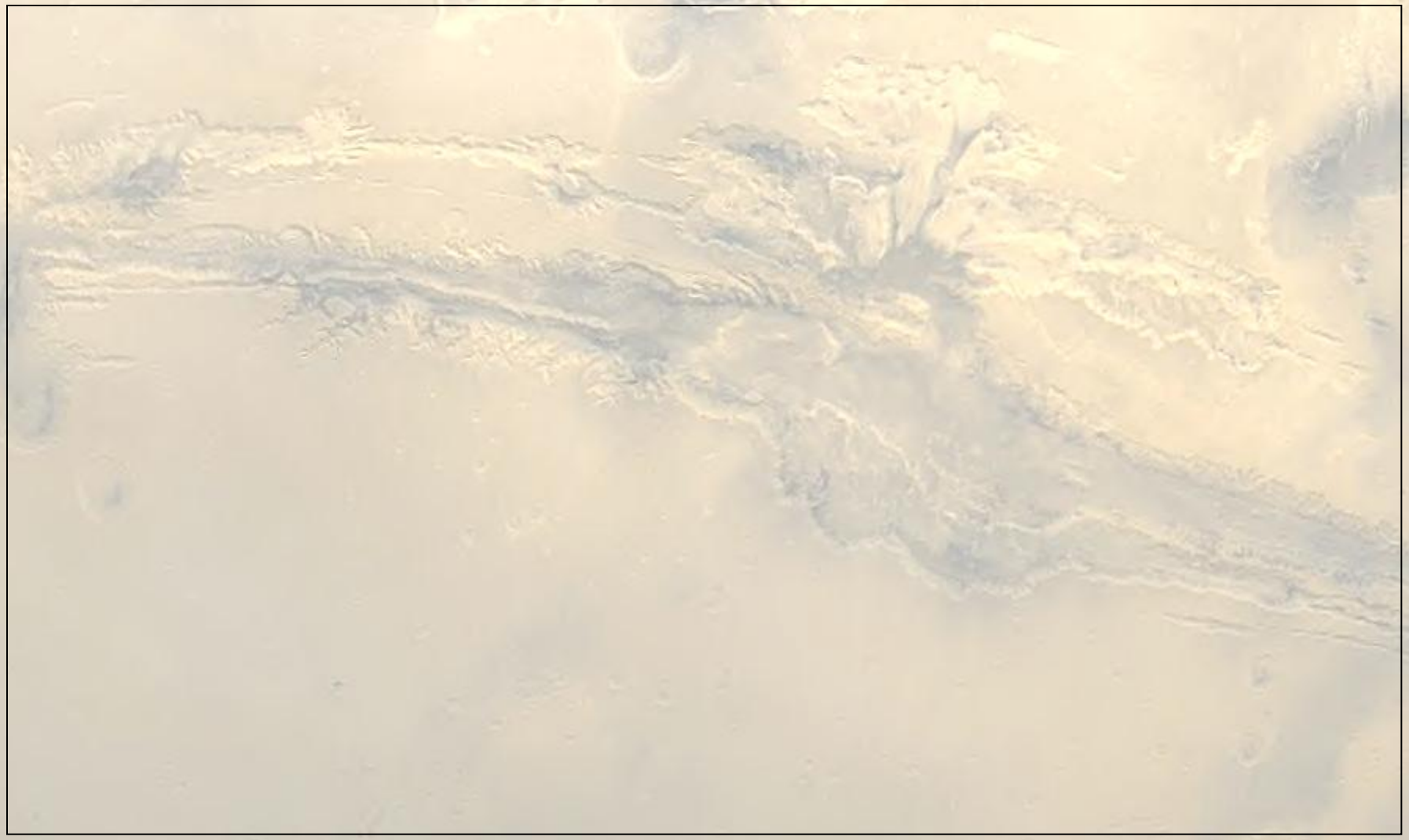
Additional Slides

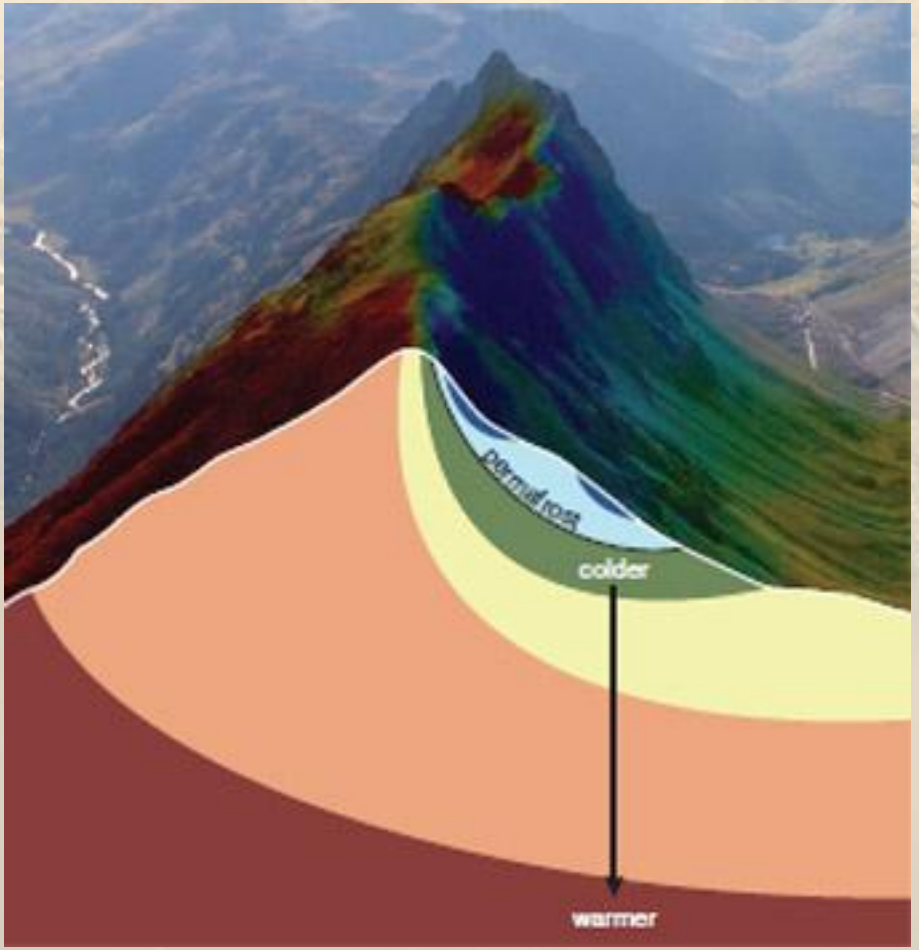


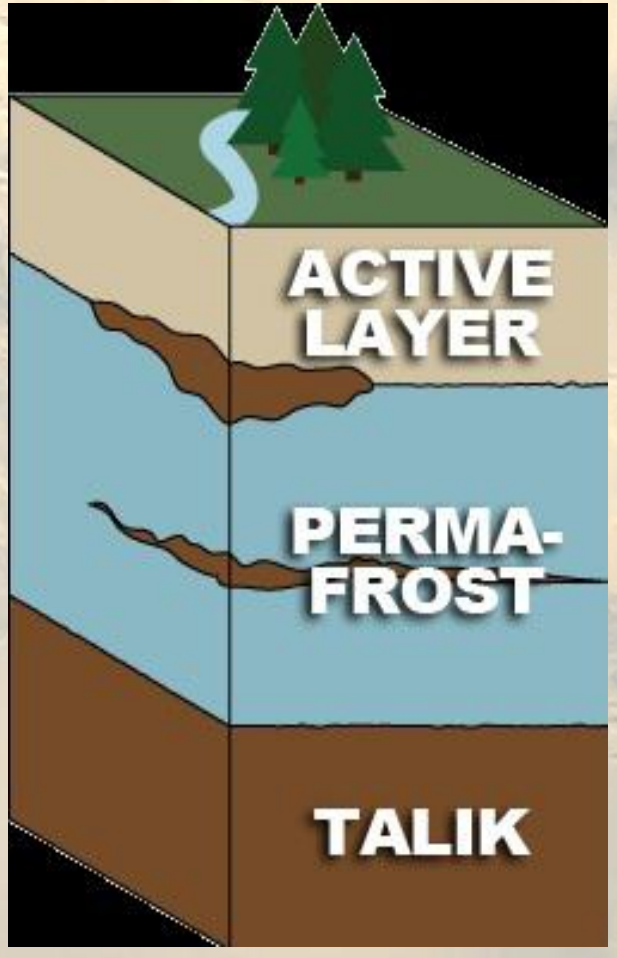
Why Finding Water is Important

- Locate potential life forms on Mars

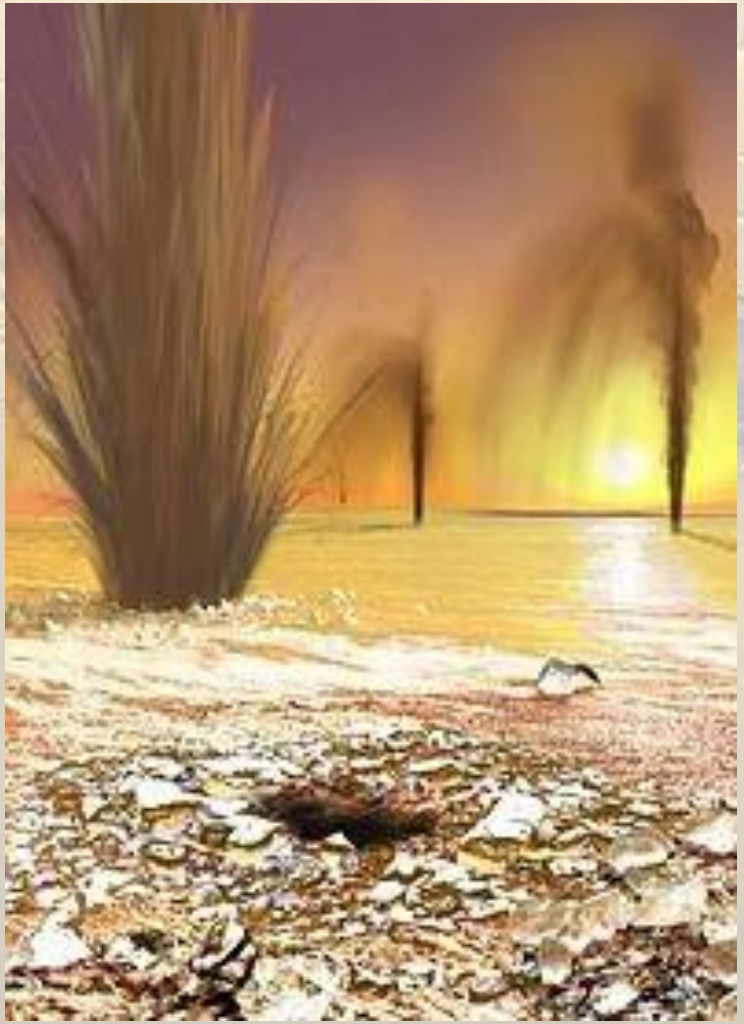
- Support a long-term manned Mars exploration program
  - Drinking/bathing/laundry/food preparation
  - Source of oxygen
    - For breathing
    - For fuel cells to power ground equipment
    - For rocket propellant oxidizer
  - Source of hydrogen
    - For fuel cells
    - To combine with atmospheric CO_2 to produce methane for rocket fuel (CH_4)

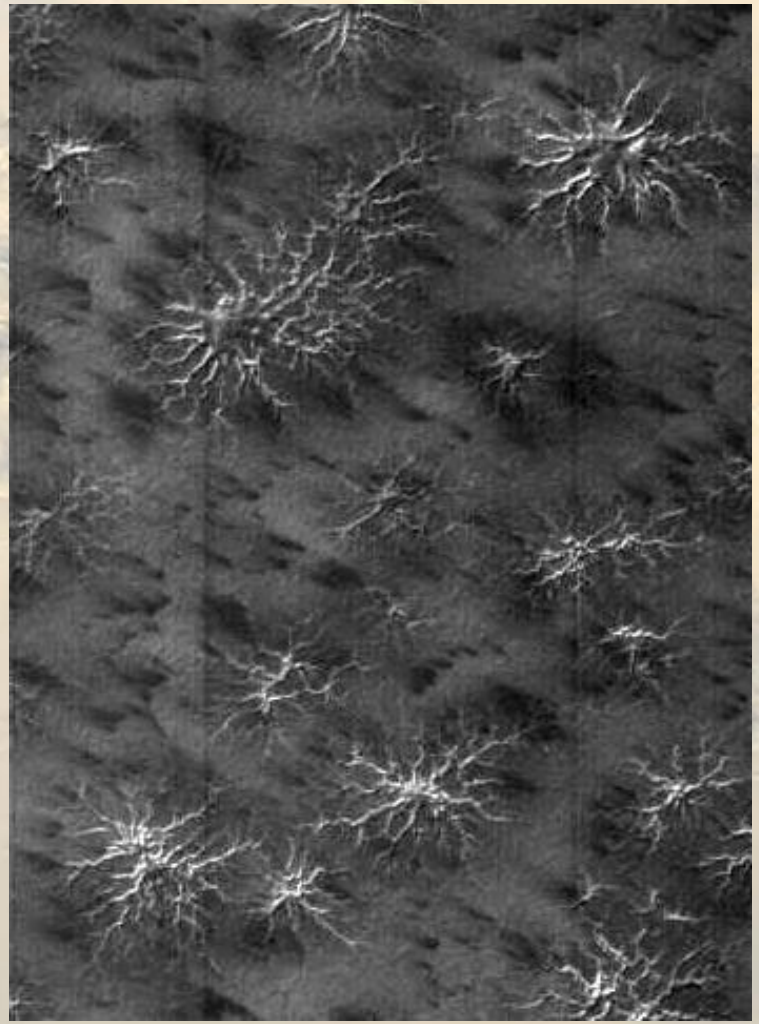
Permafrost



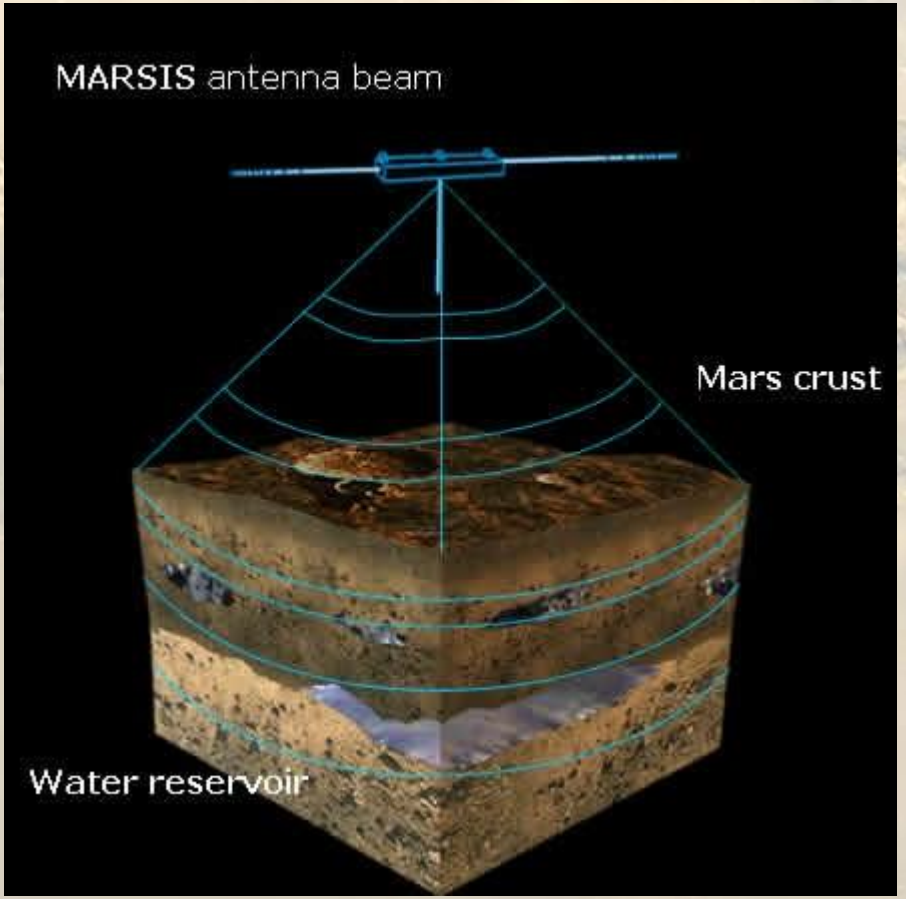


Geysers on Mars





Underground Water

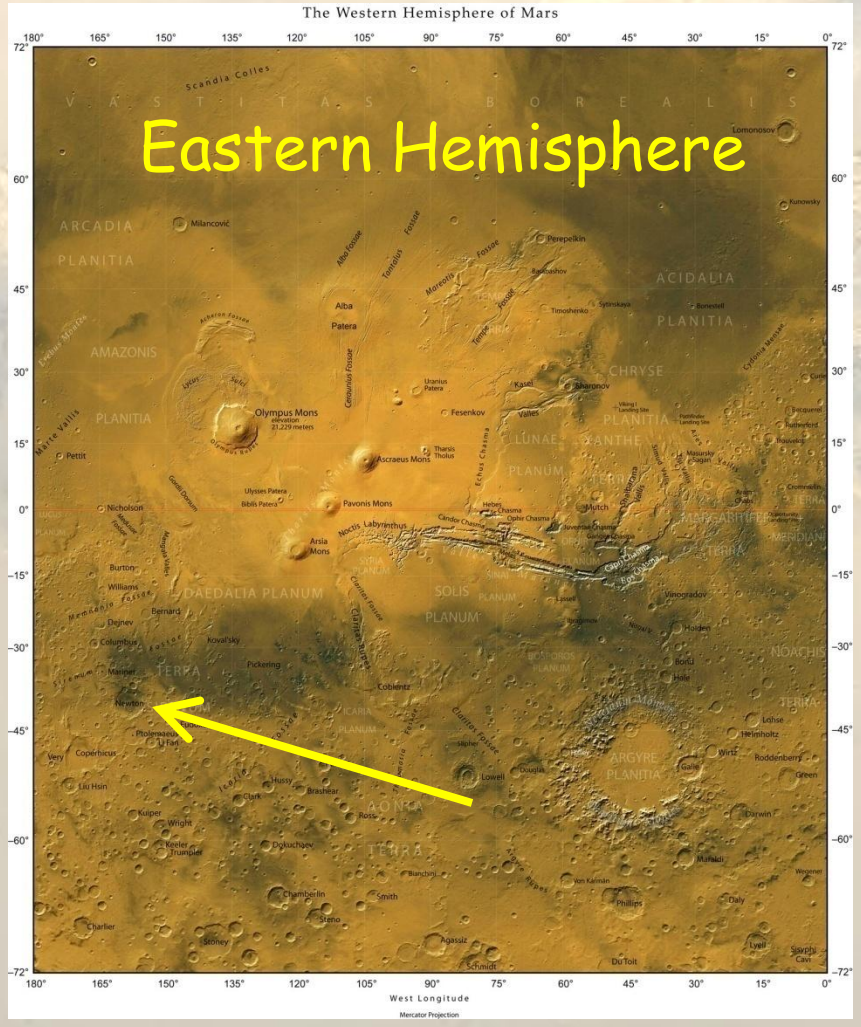


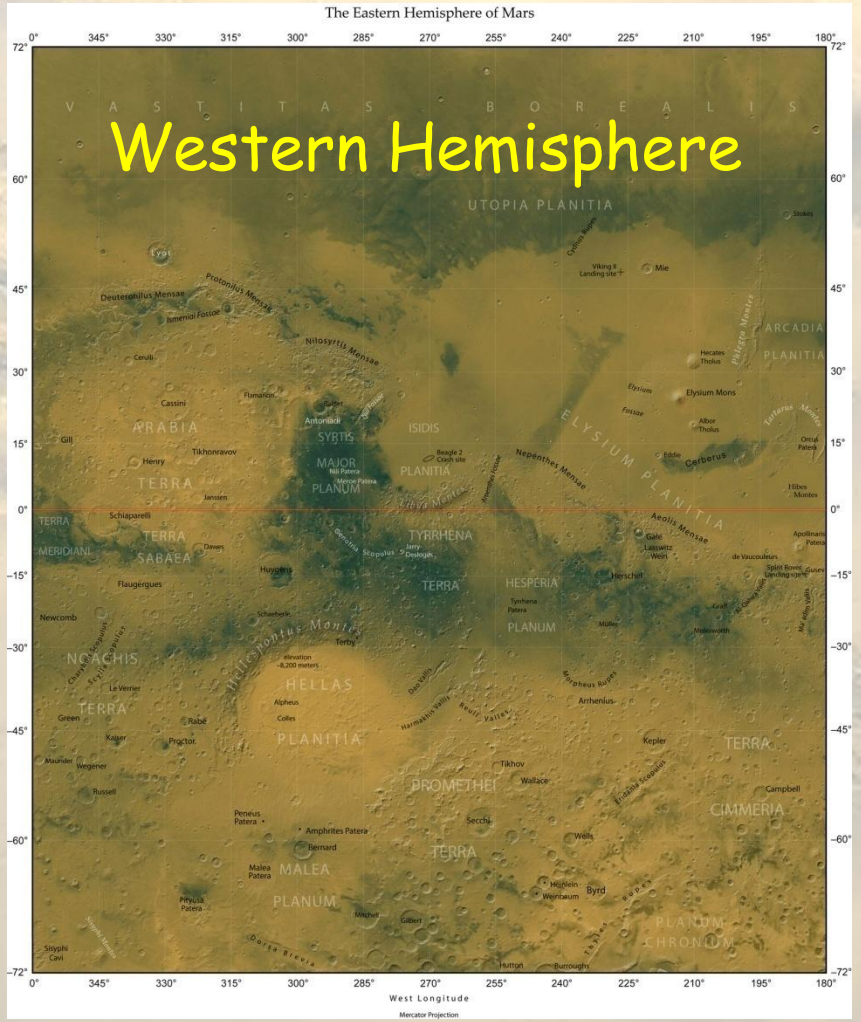
Black Glaciers / Ice Sheets

- On Earth:
  Partially covered by avalanches, forests, etc.

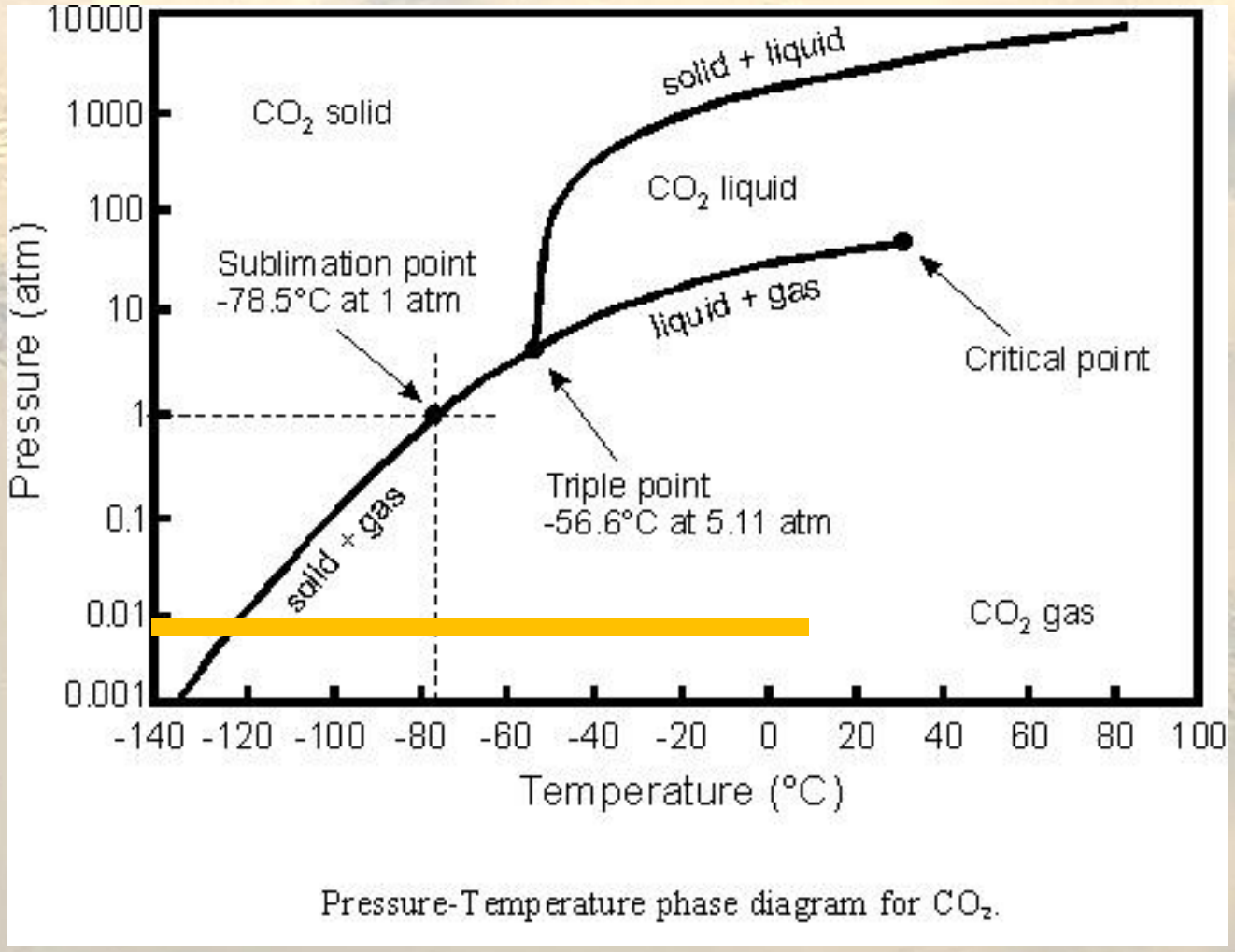
- On Mars:
  Completely covered with Martian soil from wind & storms for millions of years

Newton Crater



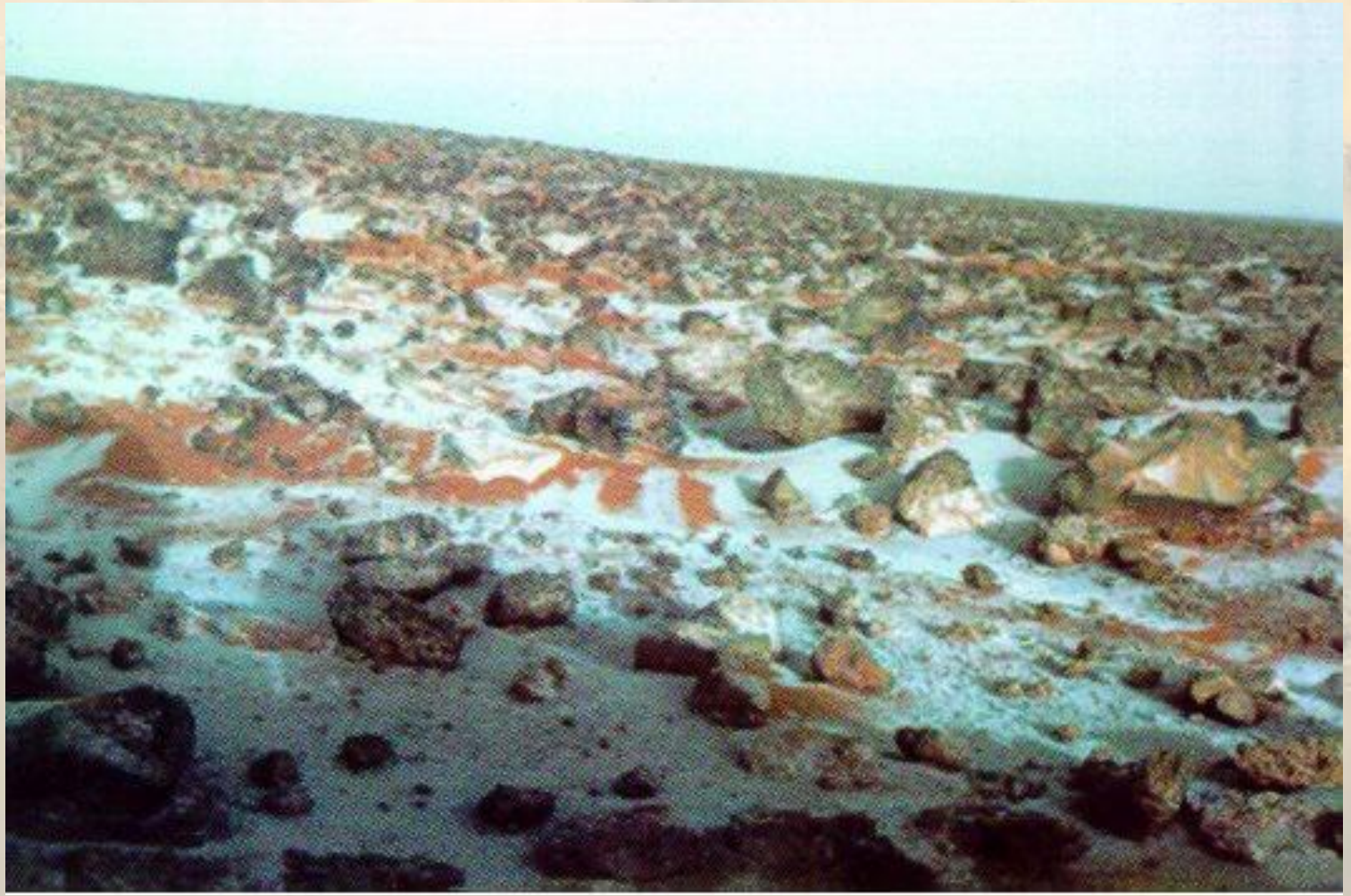


Phase Diagram – CO_2



Pressure-Temperature phase diagram for CO_2.

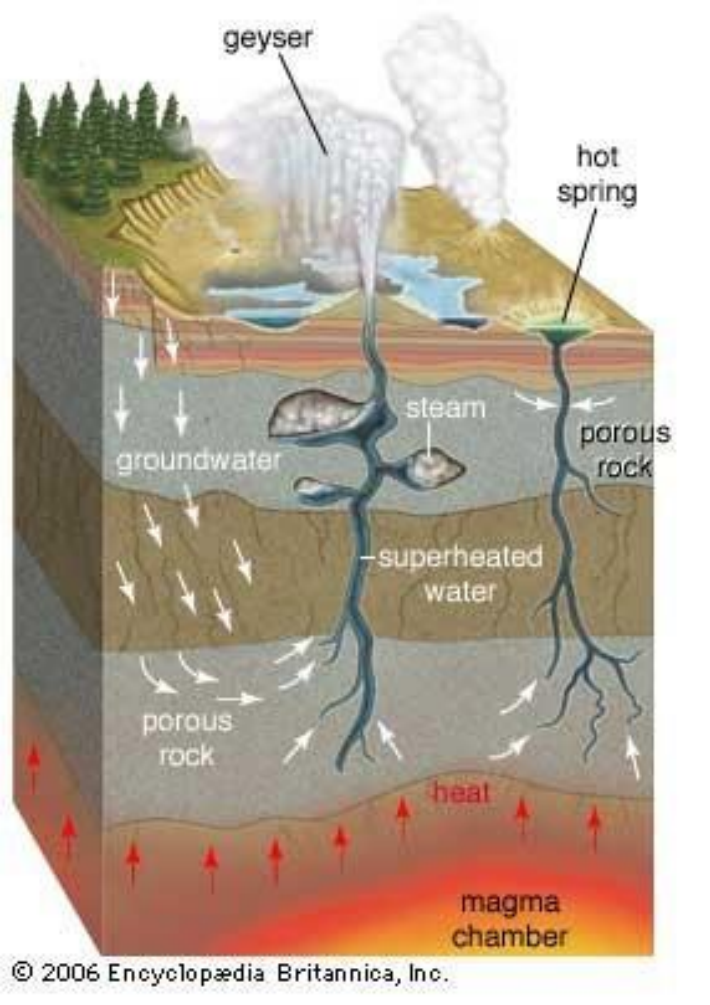
Frost on Surface of Mars



Old Faithful

- Completely unique set of circumstances that results in a singularly unique event

- Closest similar events are steam vents and hot springs



Running Water / Freezing Conditions

Ice Sheet