

Recent Evidence for Vast Stores of Land Ice & Permafrost on Mars

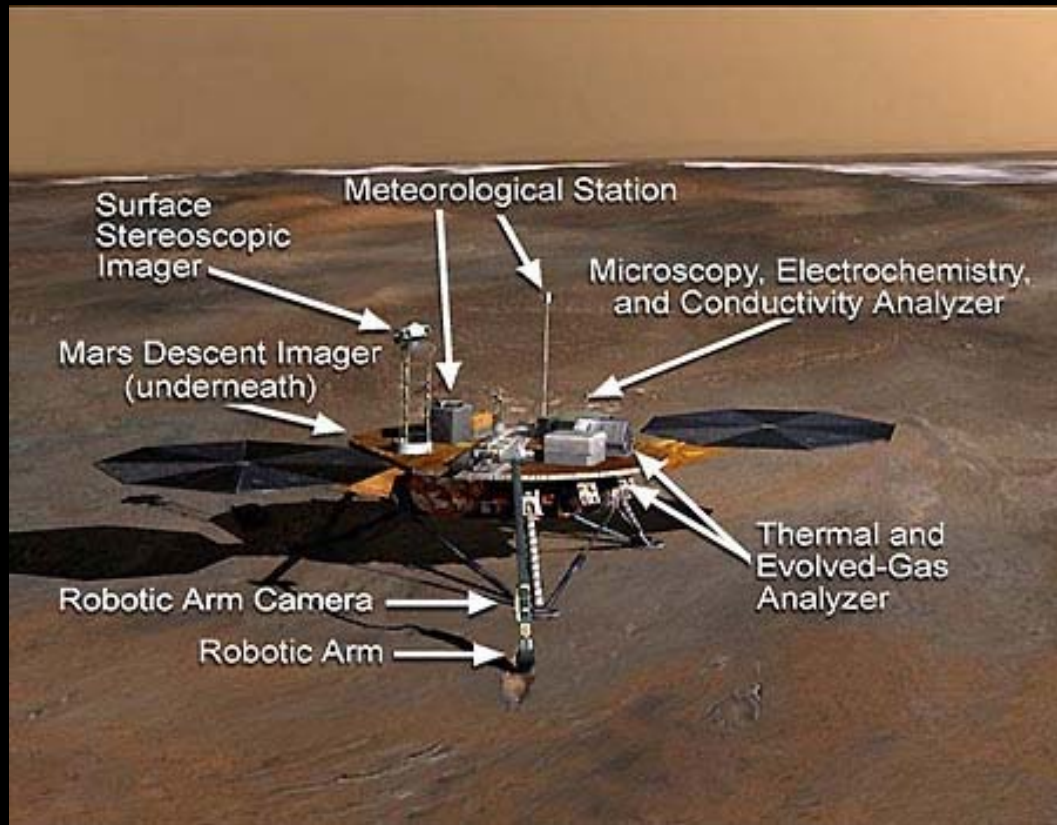
By Charis Smith, Cassie Scruggs, Erol Chandler, & Shawna Fox-Anderson

Ice on Mars

- What are the different types of ice?
- How was the ice identified?
- What can we draw from comparing Mars ice with the ice seen here on Earth?

Phoenix Mars Scout Lander Mission 2007

http://pal2pal.com/BLOGEE/images/uploads/phoenix_lander_labels.jpg



<http://www.hour25online.com/pix/phoenix-martian-surface-with-soil-sample-01.jpg>

Previous Evidence of Water

Viking: Many pictures showing deep river valleys and erosion formations that are typical of flowing water. Large amounts of water. Many samples, that showed the presence of sulfates.

Mars Pathfinder: Climate research that showed very difficult for there to be water on surface, but chance of water below surface.

Mars Odyssey: Find mass amounts of water just below the surface using a gamma ray spectrometer.

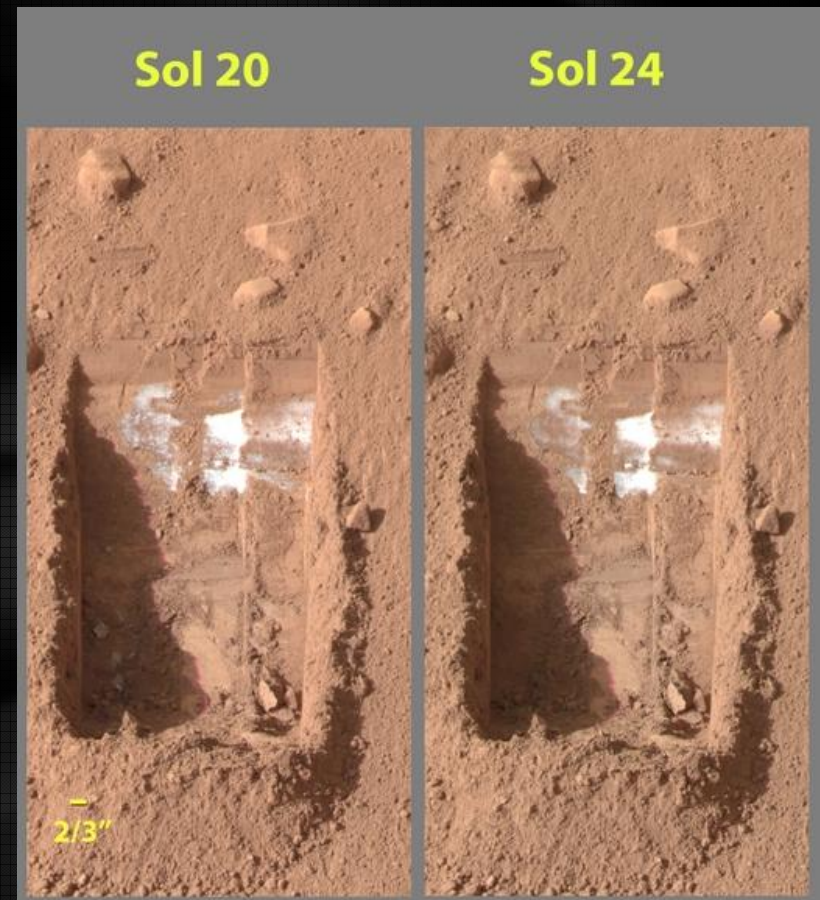
Missions Goals

- 1) Study the geologic history of water.
- 2) Evaluate past or potential planetary habitability in the ice-soil boundary

Data/Analysis

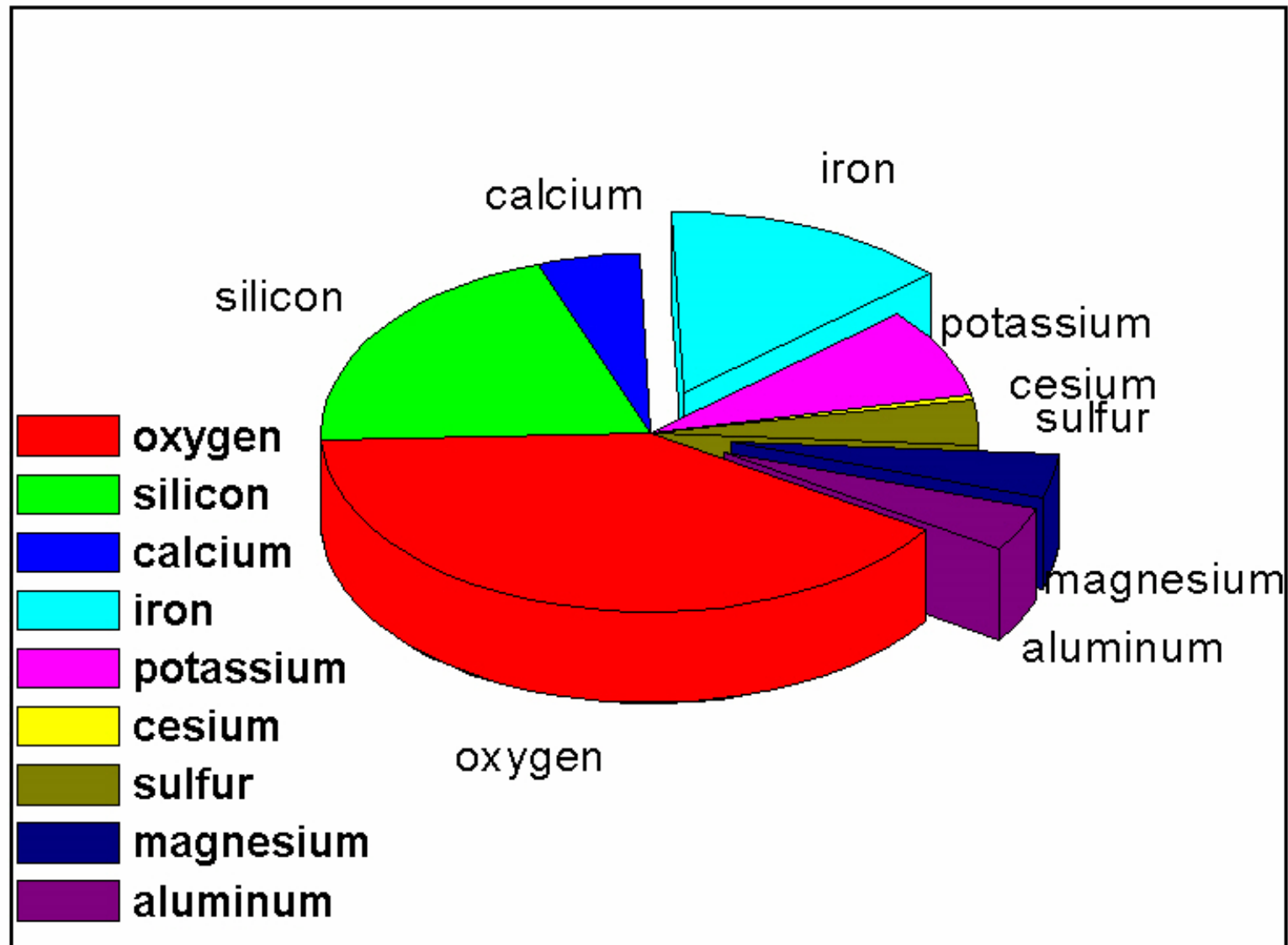
Loss of water over 4 days by sublimation.

There is very little atmospheric pressure so water would not sit on surface, and it would not go through a liquid phase.



http://www.nasa.gov/mission_pages/phoenix/images/press/sol_020_024_change_dodo_v3.html

Results from Mars Soil

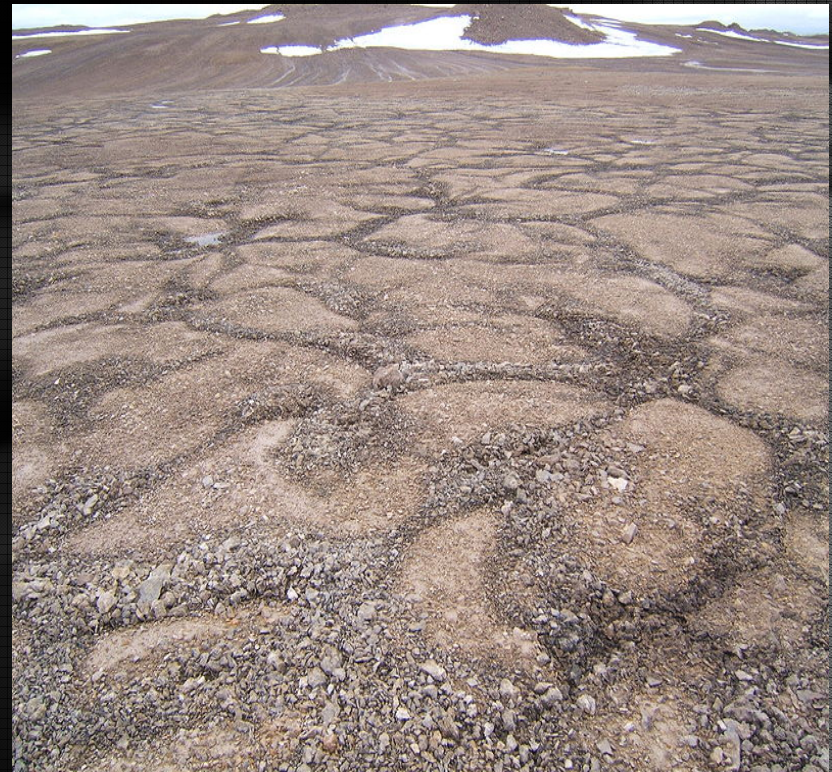


Comparative Physical Surfaces

Surface of Mars



Surface of Antarctica

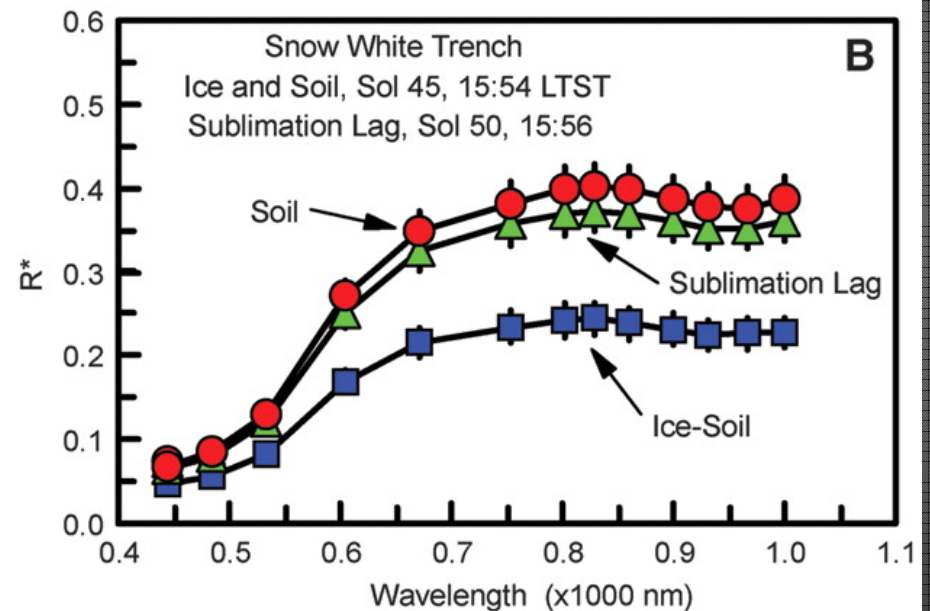
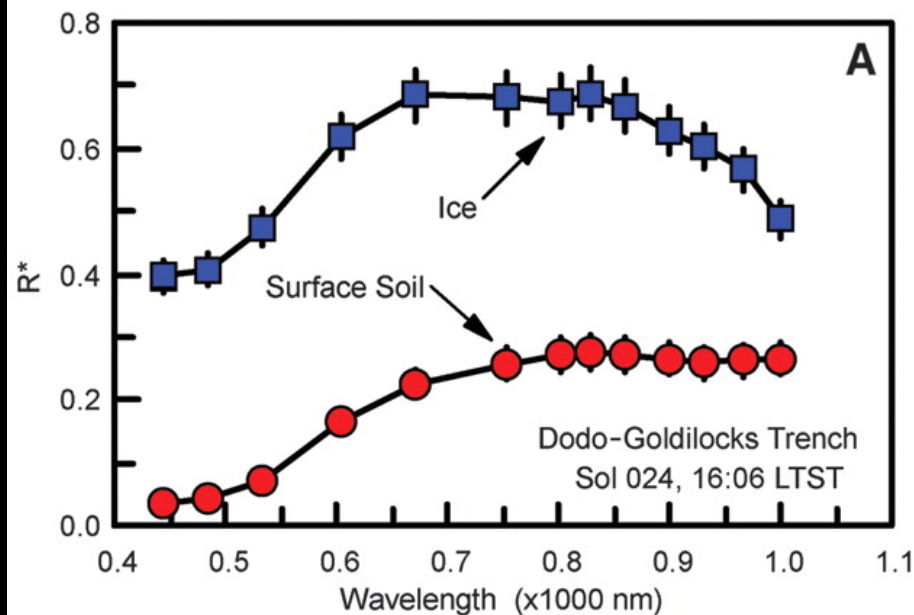


The light detection and ranging instrument on the Phoenix mission observed water-ice clouds in the atmosphere of Mars that were similar to cirrus clouds on Earth.



A Bit More Evidence

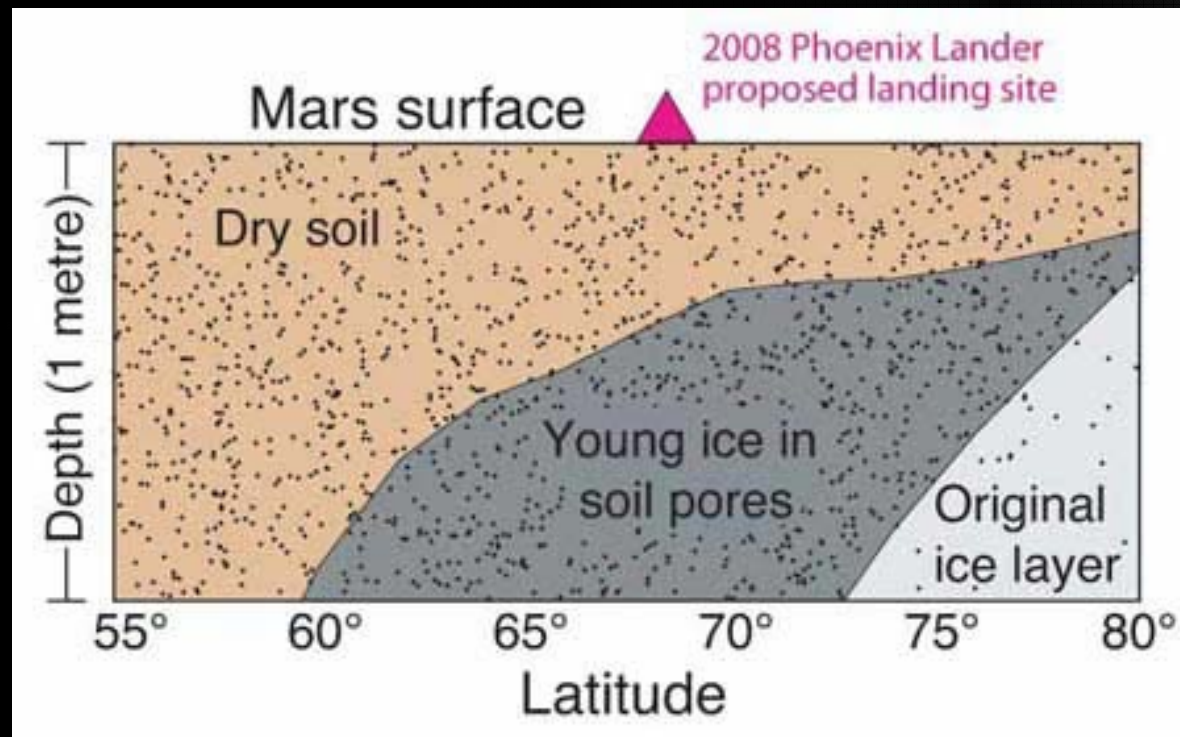
Spectra reveal two different concentrations of ice mixed with soil. Error bars indicate 1 σ . (A) The Dodo-Goldilocks trench matches high-albedo ice with a minor soil component (<2%) compared with nearby ice-free soil exposed in the trench bottom. (B) The spectra in the Snow White trench correspond to low-albedo ice with a major soil component, and nearby ice-free surface soil exposed in the trench bottom and to the sublimation lag developed 5 sols later at the same location as the ice.



Ice found on Mars

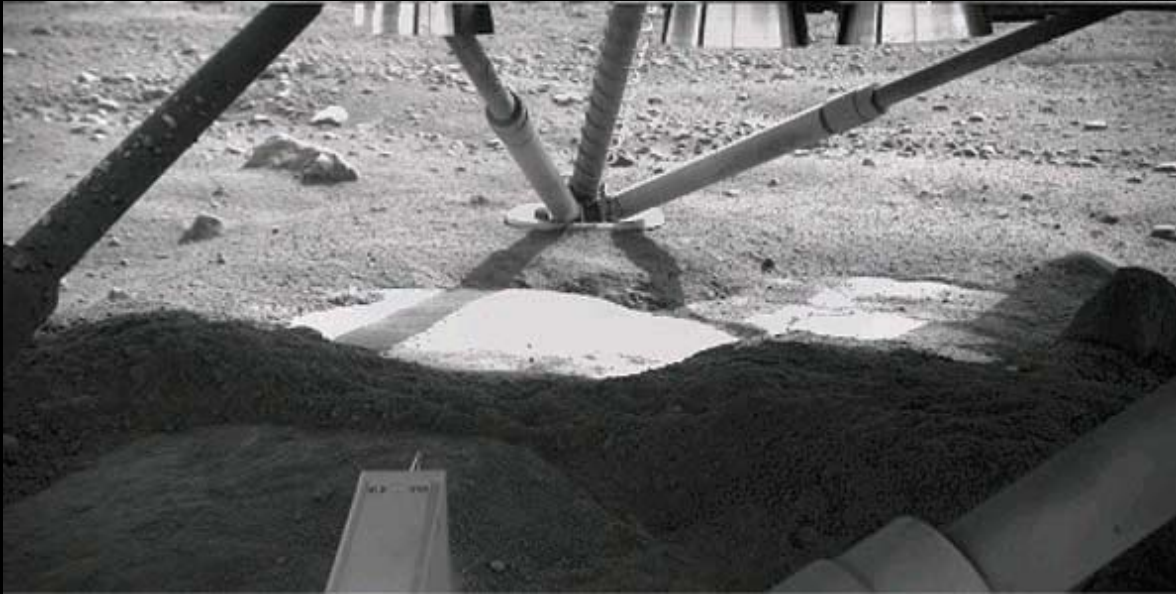
Types of Ice Found

Ice Sheets and Permafrost



<http://www.ifa.hawaii.edu/info/press-releases/Norbert-9-07/IceAgesOnMars.html>

Ice Sheets



Science 325, 58 (2009);
P. H. Smith, *et al.*
H₂O at the Phoenix Landing Site



<http://www.telegraph.co.uk/news/worldnews/northamerica/2168254/NASAs-Phoenix-Lander-finds-ice-on-Mars.html>

Permafrost



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How did the Ice form on Mars?

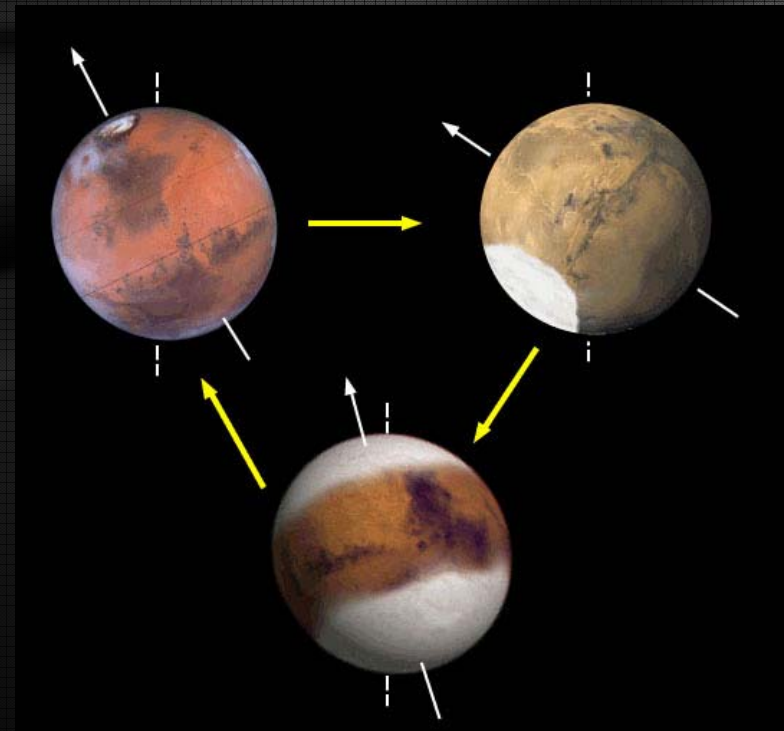
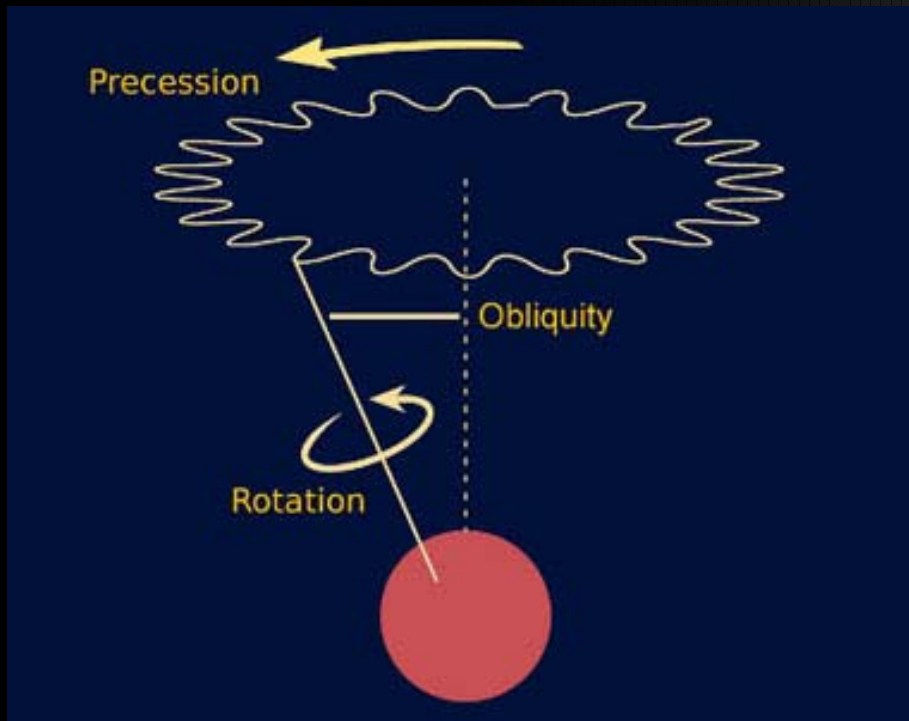
There are two possible mechanisms for the emplacement of the ice:

- (1) precipitation from the atmosphere
- (2) diffusion and condensation of atmospheric vapor in regolith pores.

Comparing formation of ice on Earth and Mars

Large Ice Sheets

Changes in the obliquity of Mars tilt influences the size of the Martian polar caps



Mars • Global Dust Storm



June 26, 2001



September 4, 2001

Hubble Space Telescope • WFPC2

NASA, J. Bell (Cornell), M. Wolff (SSI), and the Hubble Heritage Team (STScI/AURA) • STScI-PRC01-31

<http://www.astronomynotes.com/solarsys/pics/Mars-dustHST.jpg>

Relating the Formation of Ice on Earth to the Ice Found on Mars



Polar ice sheets on Mars



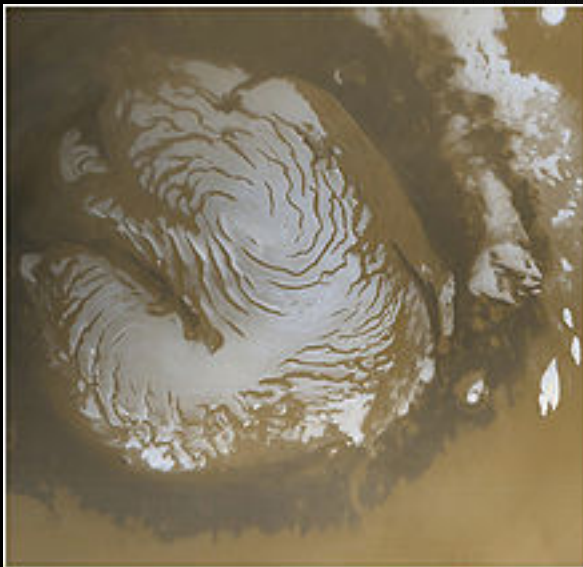
Polar ice sheet in the arctic

<http://www.satnews.com/cgi-bin/story.cgi?number=529322933>

Formation of Ice Sheets on Earth

- Polar ice caps: Frozen water that forms near the poles of the planet.
 - Due to being on the axis of the planet. Photographed from Viking 2, but we do see same types of formations on Earth.

Mars Polar Caps



http://en.wikipedia.org/wiki/File:Martian_north_polar_cap.jpg

Earth Ice Caps (Greenland)



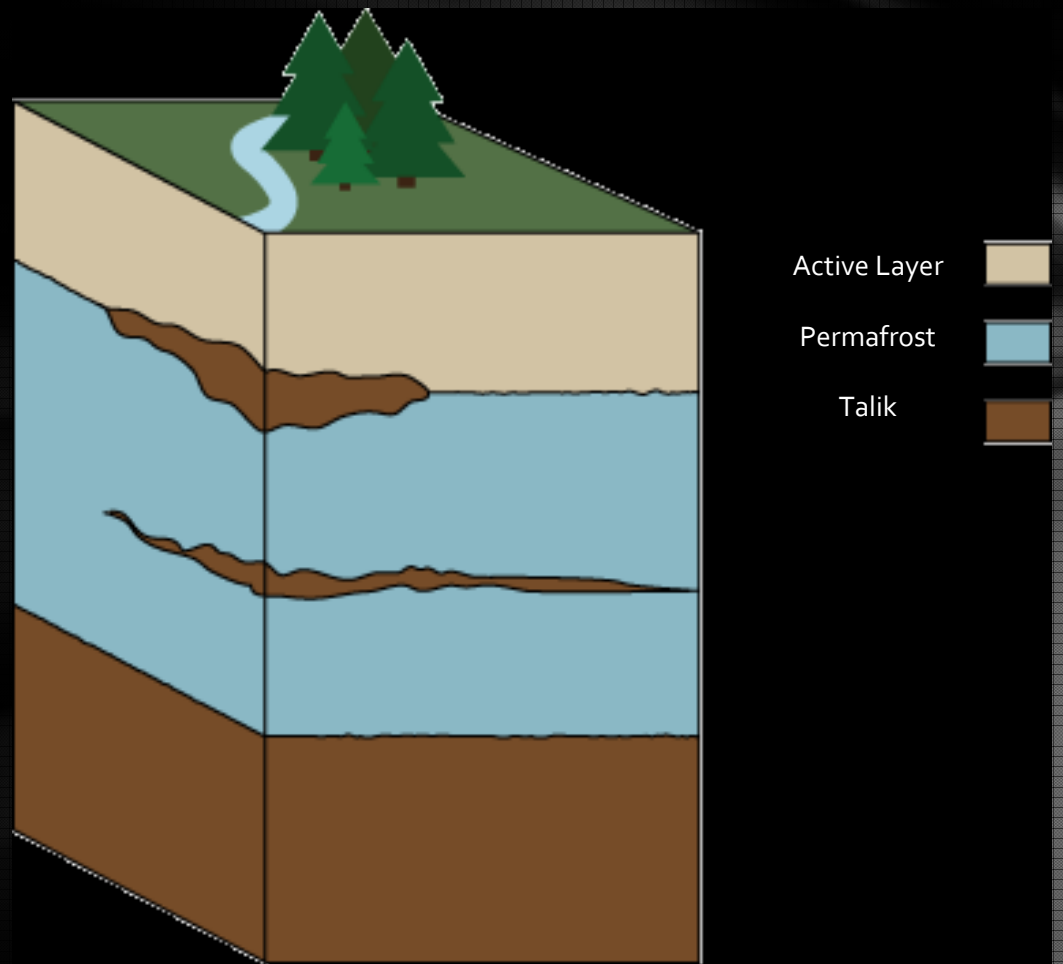
<http://en.wikipedia.org/wiki/File:Vatnaj%C3%B6kull.jpeg>

Permafrost

Permanently frozen ground that remains below 0°C for a minimum of 2 years

Ranges from 1 meter to 1000 meters thick

Forms when ground cools significantly in winter to produce a frozen layer that persists throughout the following summer



What Causes Permafrost To Form or Thaw?

Permafrost can last for thousands of years

- It is often close to its melting point (Williams & Smith, 1989)

Temperature, distribution & thickness directly relates the grounds thermal regimen

as a result is affected by precipitation, vegetative cover, organic material, hydrology, erosion, and human & natural disturbances (forest fires or cities)



http://s.ngm.com/2007/12/permafrost/img/permafrost_feature.jpg

Permafrost Comparison

Earth

- Permafrost: Layer of ice that is underneath the surface. Much evidence for permafrost was built from the Phoenix Mission.
- On earth forms slowly.
~about 500,000 years for deep permafrost.
- Between .6 and 2 meters deep

MARS

- On Mars was found very close to the surface: about 4-5 cm deep.
- Gamma Ray Spectrometer show large amounts which resembles on Earth
- Surface physical characteristics are very similar

Permafrost Comparison Cont.

Ice sheets and Permafrost are phenomenon seen on Earth and Mars



Polygonal ground formations in the Arctic



Polygonal ground formations on Mars

Ice formation Theories for the ice seen on Mars today

It is hypothesized that the different types of ice form based on the obliquity of Mars' axis.

When more tilted then precipitation occurs closer to the tropics resulting in wide spread ice sheets and as the tilt decreases the ice sheets retreat toward the poles. As the tilt decreases the atmosphere becomes less humid resulting less precipitation. With a less humid climate Permafrost is formed in place of large ice sheets. The Permafrost is formed from the interaction of atmospheric vapor and soil. Atmospheric vapor can freeze inside the soil and form "pore-ice," which is mainly soil with some ice in pore spaces.

Relating the Formation of Ice on Earth to the Ice Found on Mars

- Ice Sheets and permafrost are all observable phenomena on Earth.
- The ice found on Mars can be categorized into these different types of ice found on Earth.
- By being able to observe and test these types of ice on Earth, we can use the same methods to determine the composition of the ice found on Mars, as well as how it came to be there.