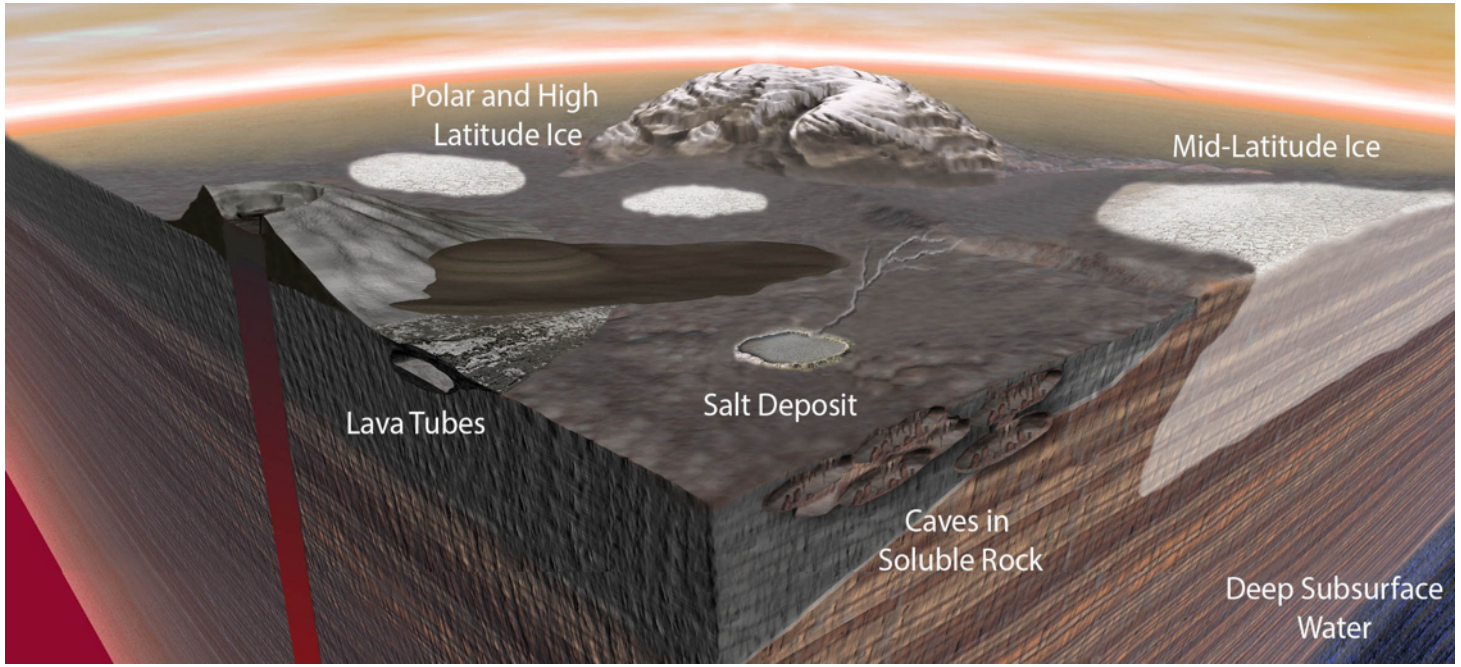
We Should Search for Extant Life on Mars in this Decade

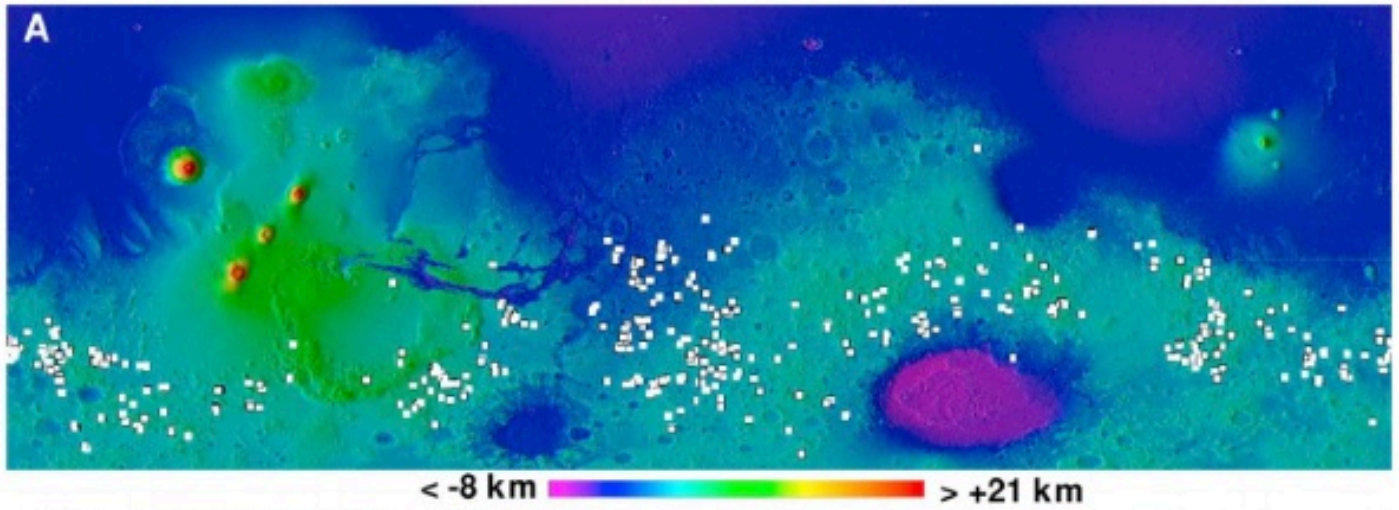
Recent workshop: Mars Extant Life: What's Next? identified 4 types of potentially habitable environments on Mars warranting a search for extant life on Mars. (Carrier *et al.* Astrobiology 2020)



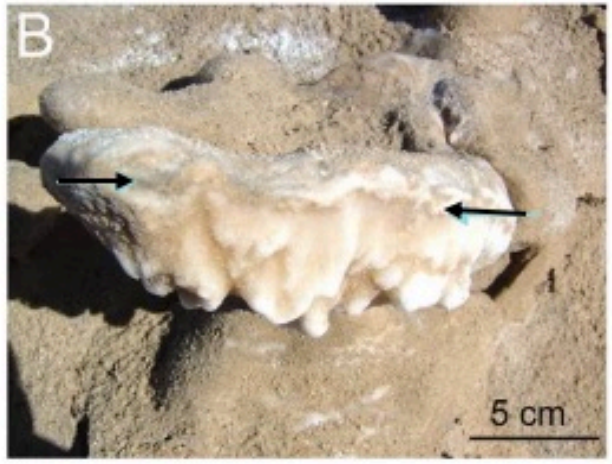
4 potential habitats for life on Mars:

- Salts and brines
- Ground Ice (mid and high latitudes)
- Caves
- Deep subsurface liquid water aquifers

Salts



Chloride salt deposits (white) on Mars. At least 640 sites identified.
(map from Osterloo *et al. JGR 115 E10012,*2010)



Salts in Atacama desert host endolithic cyanobacteria that obtain water from atmospheric humidity via deliquescence (Davila *et al*. Astrobiology (10) 617, 2010).

Viable microbial colonies can survive for 10^8 Yrs in fluid inclusions in salt crystals.

Deliquescence from atmospheric humidity can produce brine on Mars

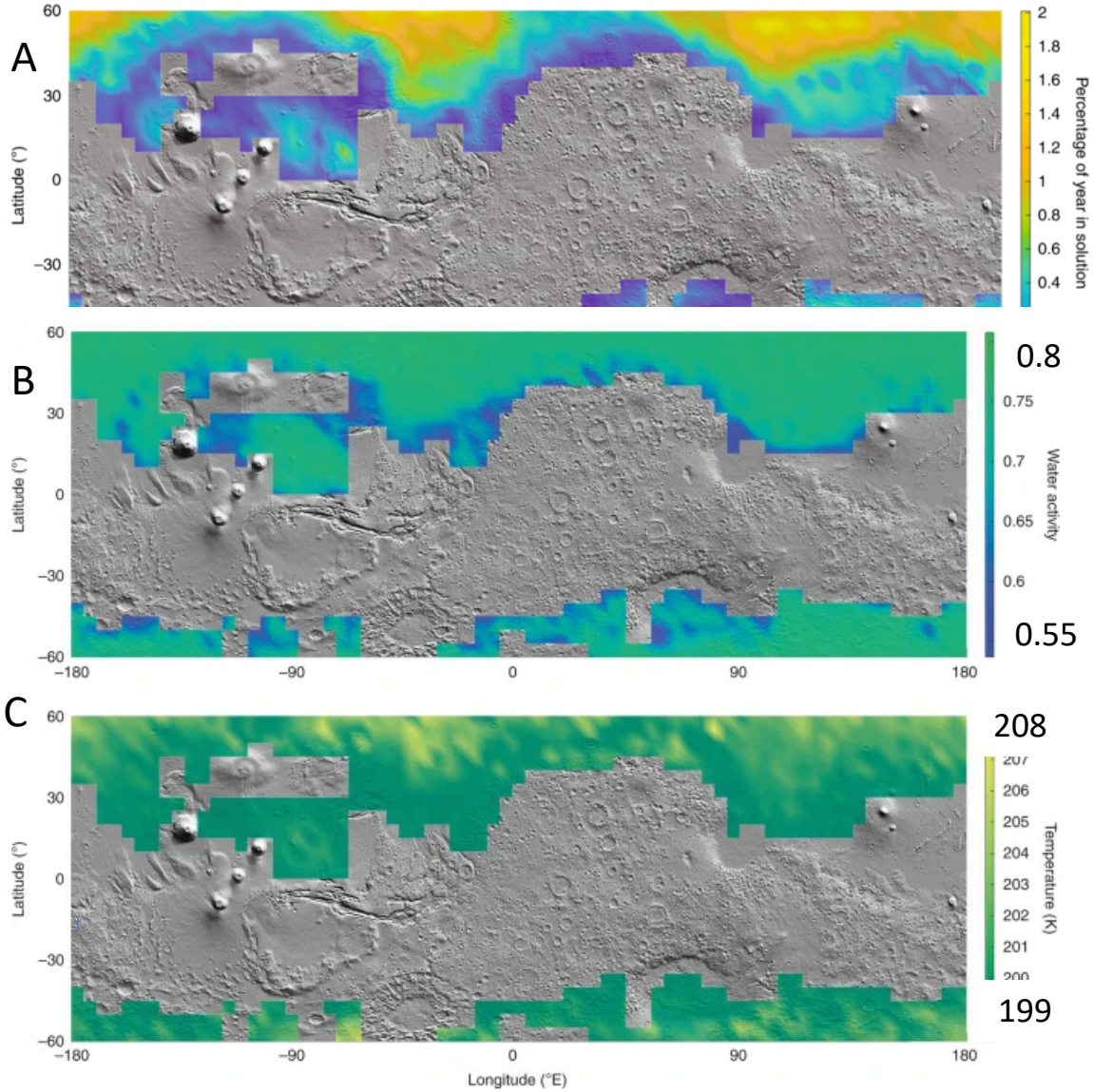
Calcium perchlorate brines can form on contemporary Mars over large regions. (Rivera-Valentine *et al*. Nature Astronomy (4) 756, 2020.)

Brines are stable for up to 6 hrs per sol during summer, but they form at night when the temperature is very low (T<210K).

Mars special regions study (Rummel *et al. Astrobiology* (14)887, 2014) posit both Aw>0.55 and T>255 needed at the same time for Mars to support terrestrial life. So these brines are not "special regions".

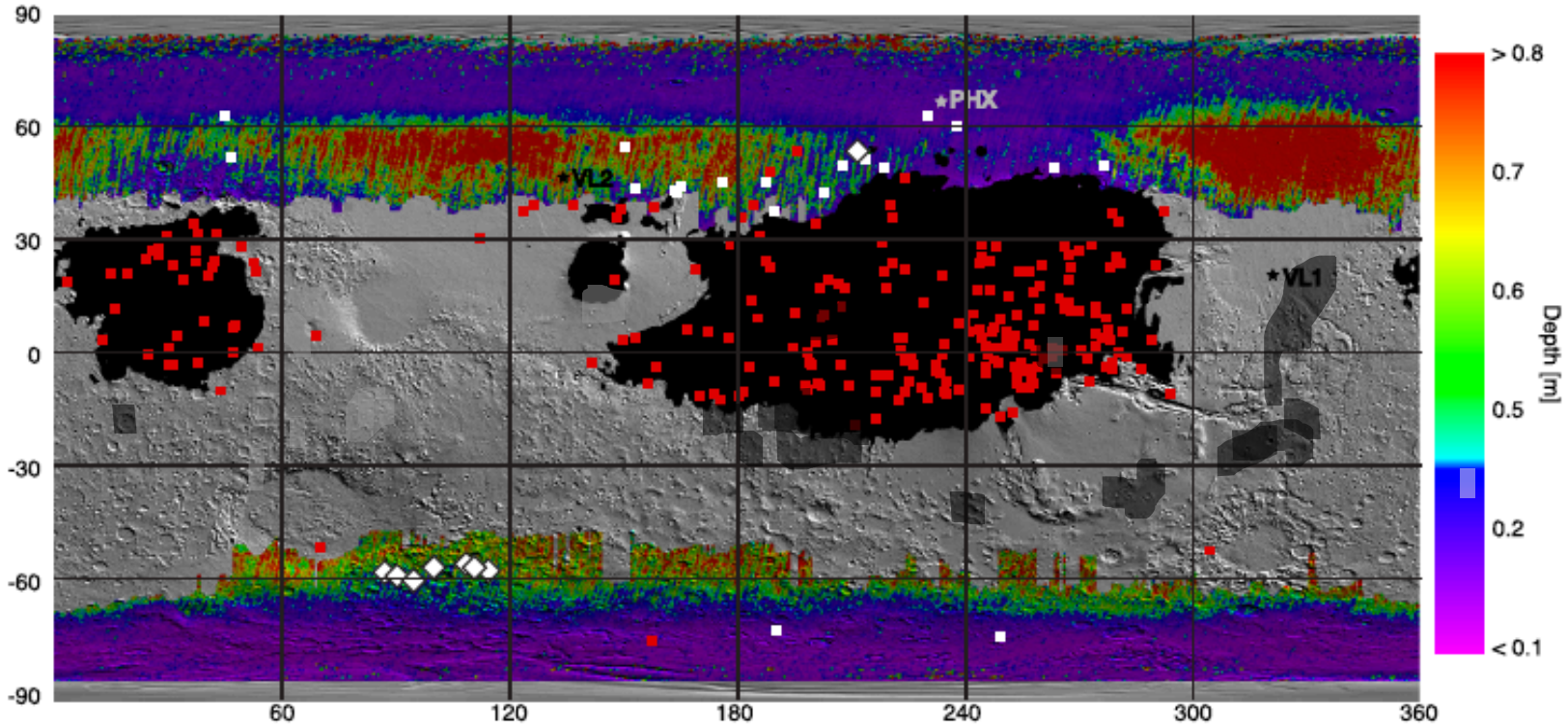
The special region limits are based on growth observed in terrestrial microbes in laboratory cultures. The growth and metabolism limits of terrestrial biota need further study.

Martian biota might have evolved means to sequester water when liquid water is available and use it when temperatures are higher, or even to grow in the low temperature when water activity is high.



A. Duration (% of year) when $CaClO_4$ brines can form on Mars from deliquescence. B. Water activity of brine. C. Temperature of brine (Credit Rivera-Valentine *et al*. Nature Astronomy (4), 756, 2020.)

Ground Ice



Global map showing the location and depth to ground ice across Mars.

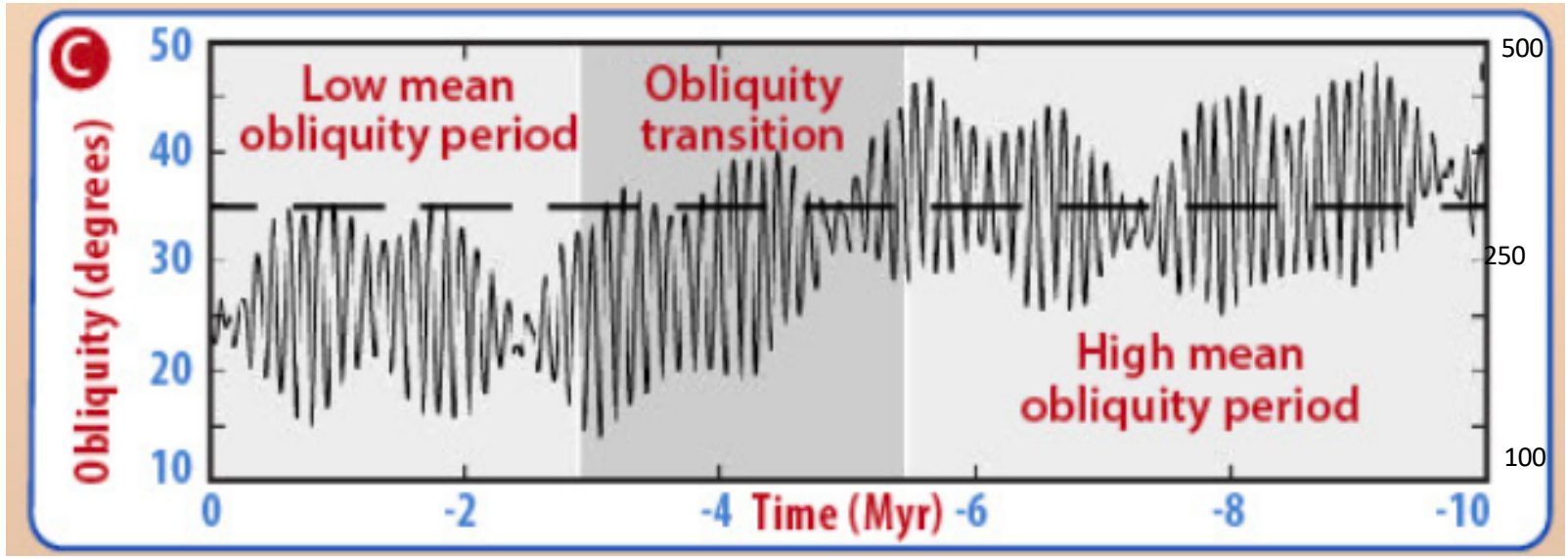
- All latitudes above 40° N have ground ice within 1 m of the surface
- White squares are the locations of fresh craters revealing white ice.
- Black areas are obscured by dust.

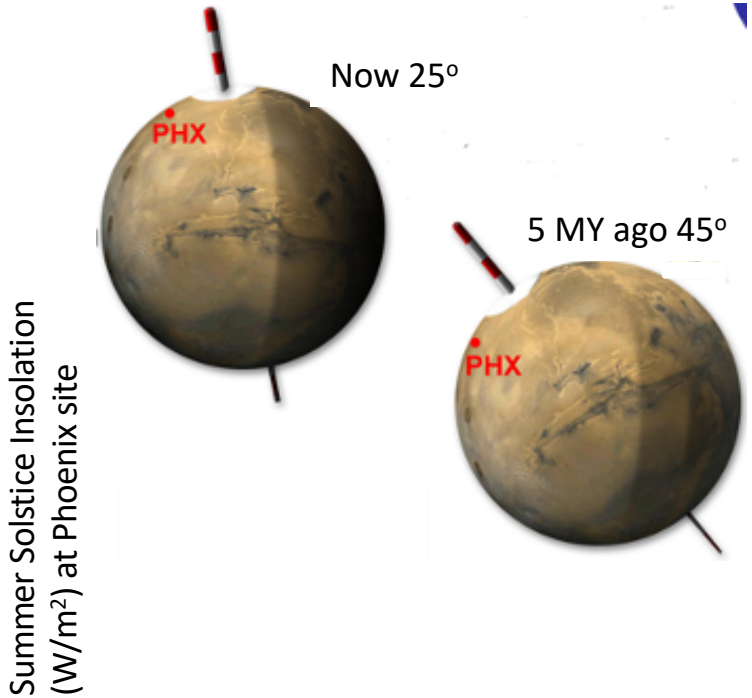
Map from Piqueux et al. Geophys Res. Lett. (46)14920, 2019.

Calcium perchlorate brine can form continuously at the ice table in midlatitudes suggesting it may be habitable for martian life.

Orbital Forcing Drives Climate Change on Mars

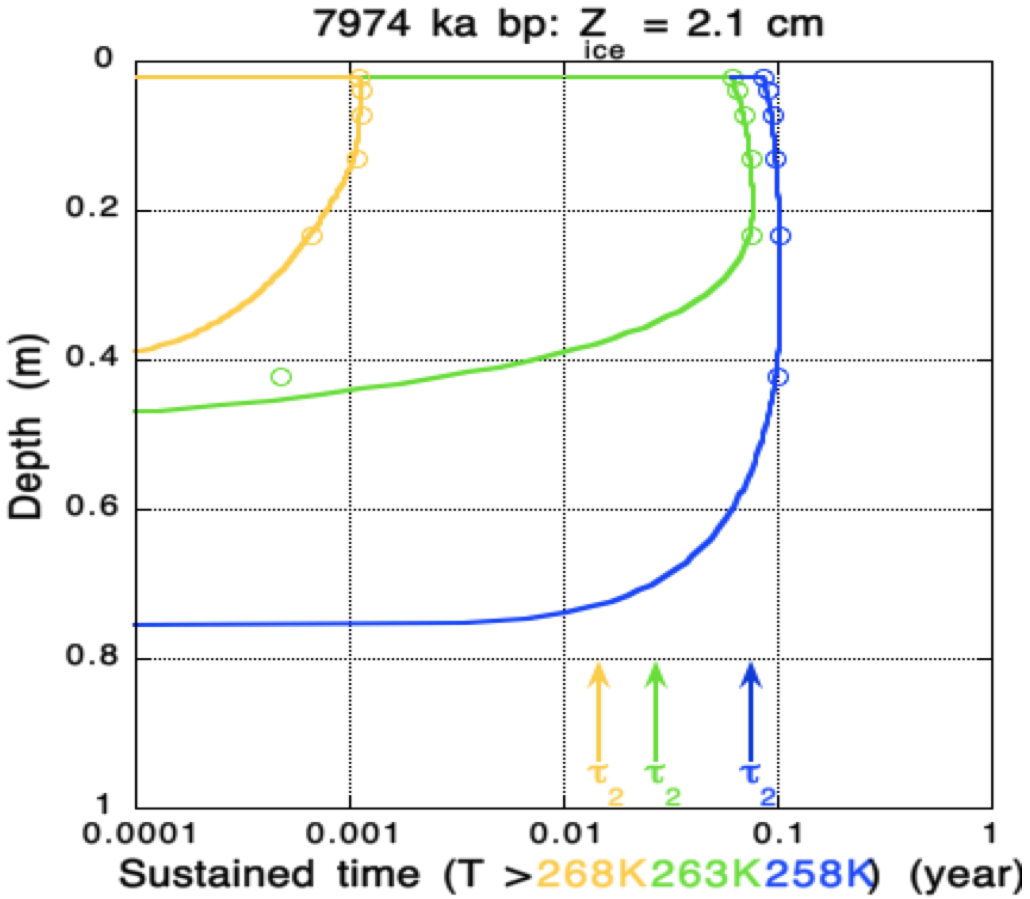
Obliquity changes rapidly over time. Insolation at high latitudes increases at high obliquity.

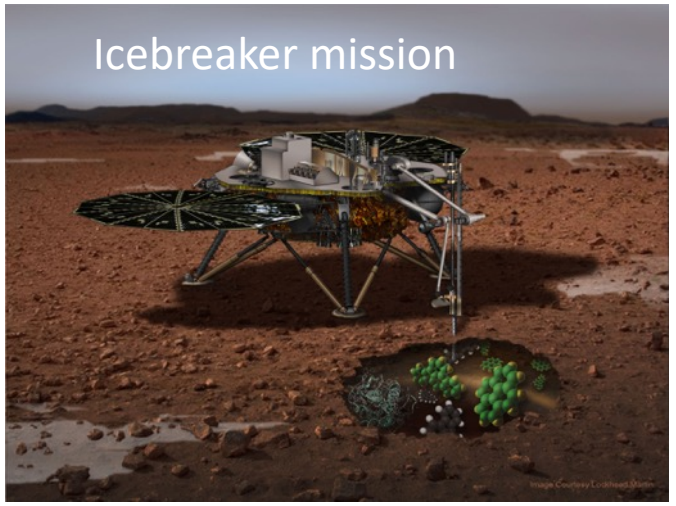




High latitude ground ice is significantly warmer in summer for obliquity above 35°. This is the average obliquity. Last 4 MY is much colder than average.

Subsurface Ice at Phoenix Landing Site (68N) is warm enough to support life at high obliquity down to 1m depth



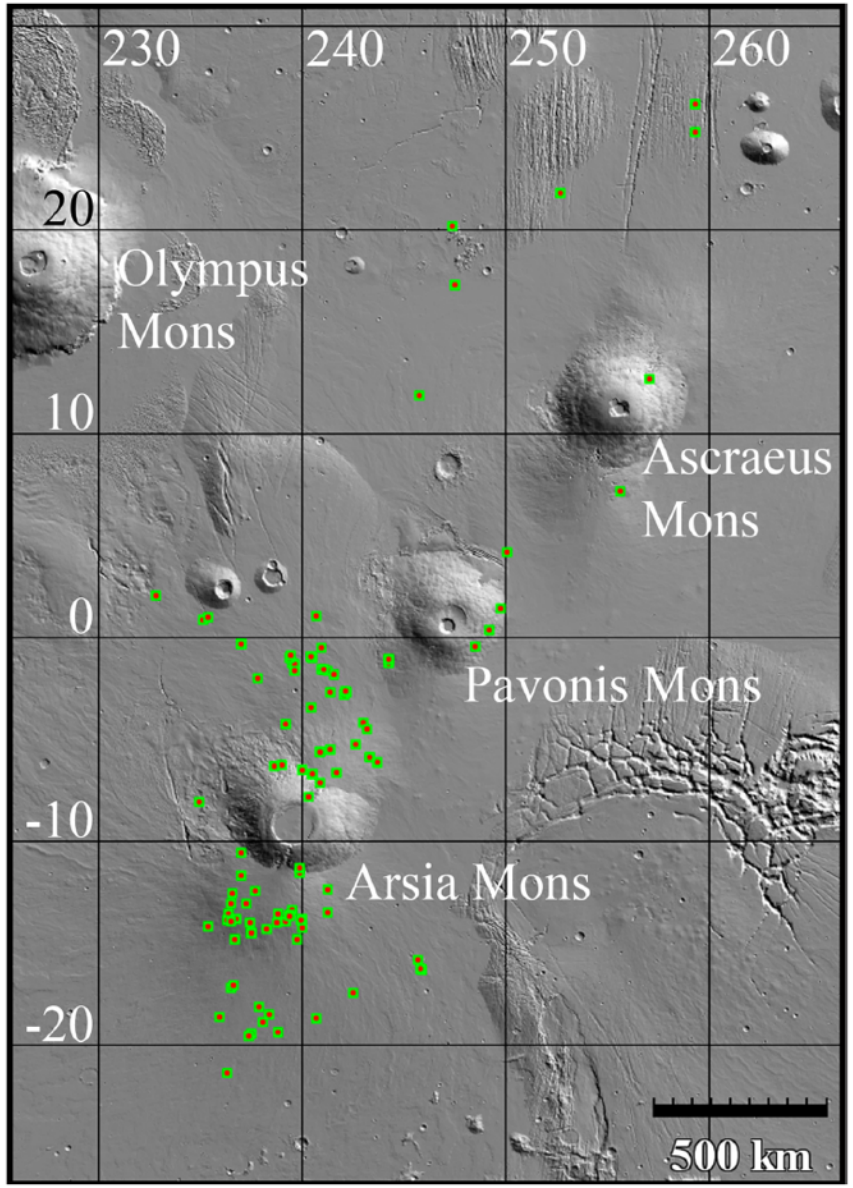


By drilling to 1 m samples that represent the entire range of habitable conditions in Northern ground ice can be analyzed (McKay *et al. Astrobiology (13) 334,* 2013)

Honeybee robotics 1 m TRIDENT drill used on rover in Atacama Chile to feed samples to life detection instruments in 2019 field test. Same drill will be flown to the Moon on VIPER rover.

At 45^{o} obliquity T allowing metabolism (-20^{o}C) extends to ~1m **(**A. Zent, Icarus (196) 385, 2008).

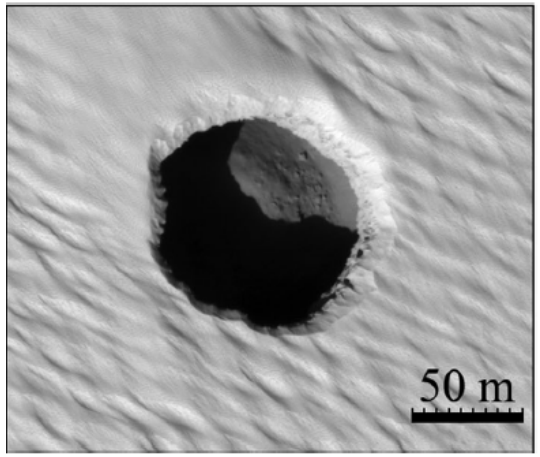
Caves



Map from Cushing *et al.* JGR (120) 123, 2015

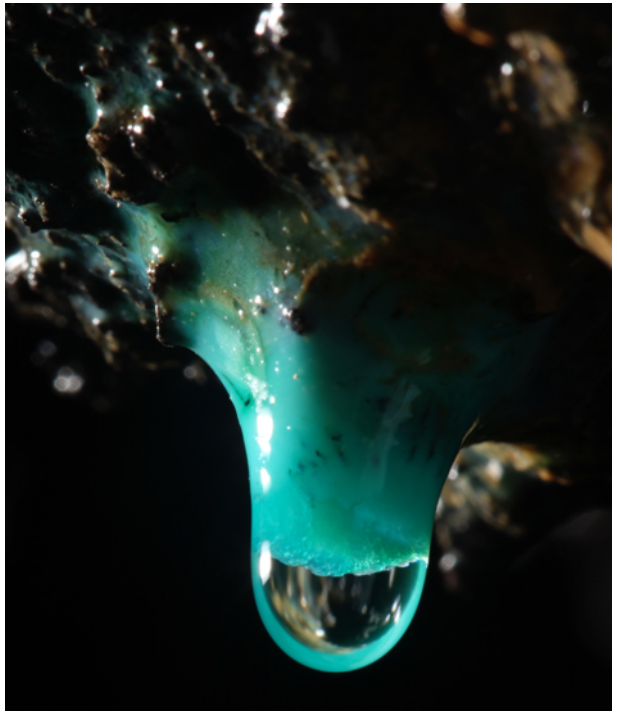
Caves can provide habitable environments: Warmer, wetter, sheltered from UV and cosmic radiation.

Windows into the subsurface "skylights" are found on Mars

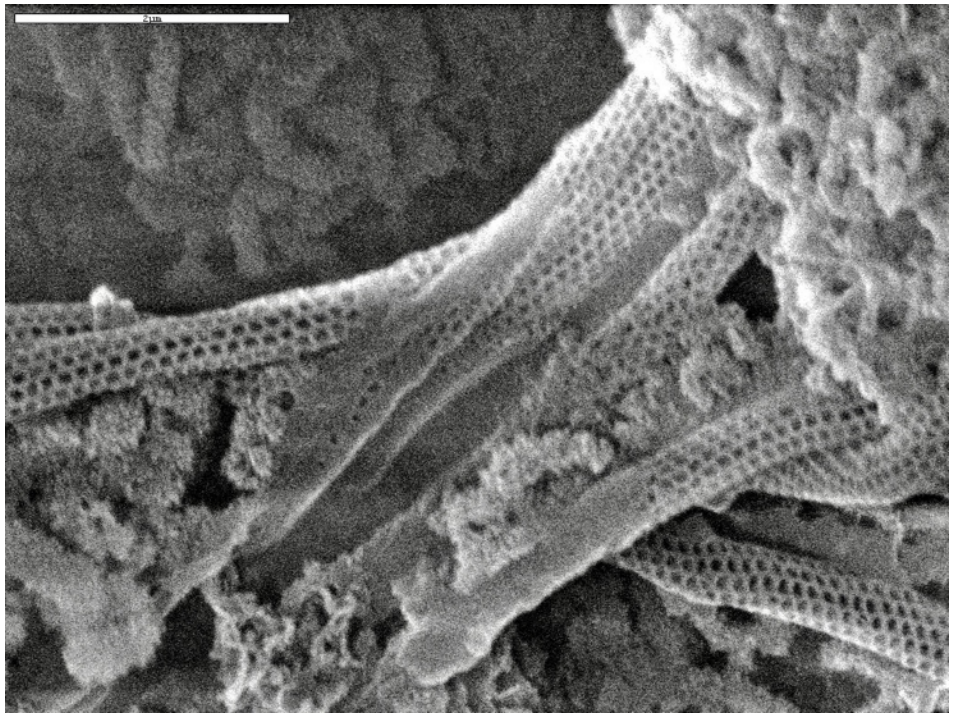


Over 1000 cave entrances mapped on Mars. Many are associated with Tharsis volcanism.

Cave Microbes



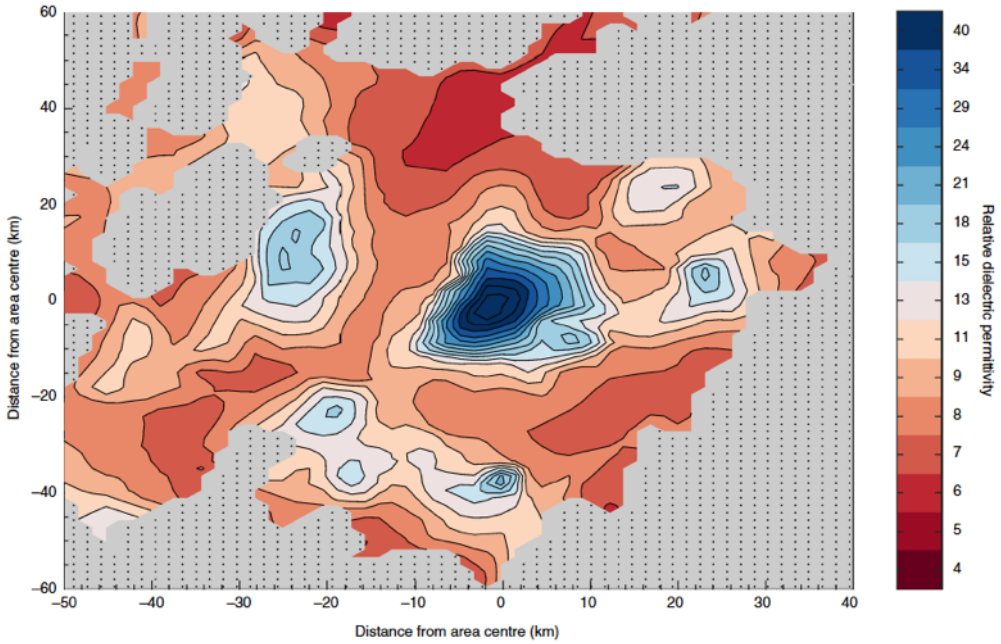
Microbes in caves form mineral deposits.



SEM images show unique morphologies in these mineral fossils.

Drones are an important technology to evaluate the habitability of caves.

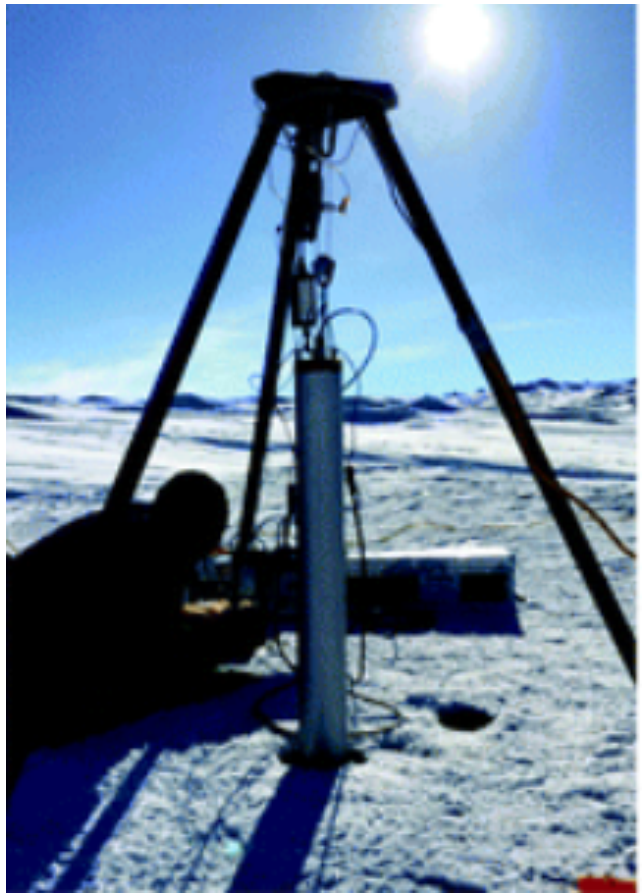
Deep Subsurface



MARSIS Radar data interpreted as evidence of subsurface ”lake” 1 km beneath S. polar layered terrain on Mars (Lauro *et al.* Nature Astronomy Sept. 2020).

Seems to be too cold for even brine to exist without geothermal hot spot.

Low mass deep drilling required to access the deep subsurface environment.



Honeybee Robotics wireline system drilled 110 m in Greenland Ice in recent 2019 field campaign (Bhartia et al. 2019 AGU fall meeting).

Conclusions

Its been 44 years since Viking, isn't it time we resume the search for extant life on Mars?

- Salts and ice can be sampled with current robotic technology (rovers and drills). These near surface targets are critical to assess for extant life before people land on Mars.

- Caves could be accessed with drones to assess habitability (Temperature and Humidity)

- Deep subsurface aquifers will require deep drilling systems to access.

- Life detection instrument development is needed.