Making a Splash on Mars

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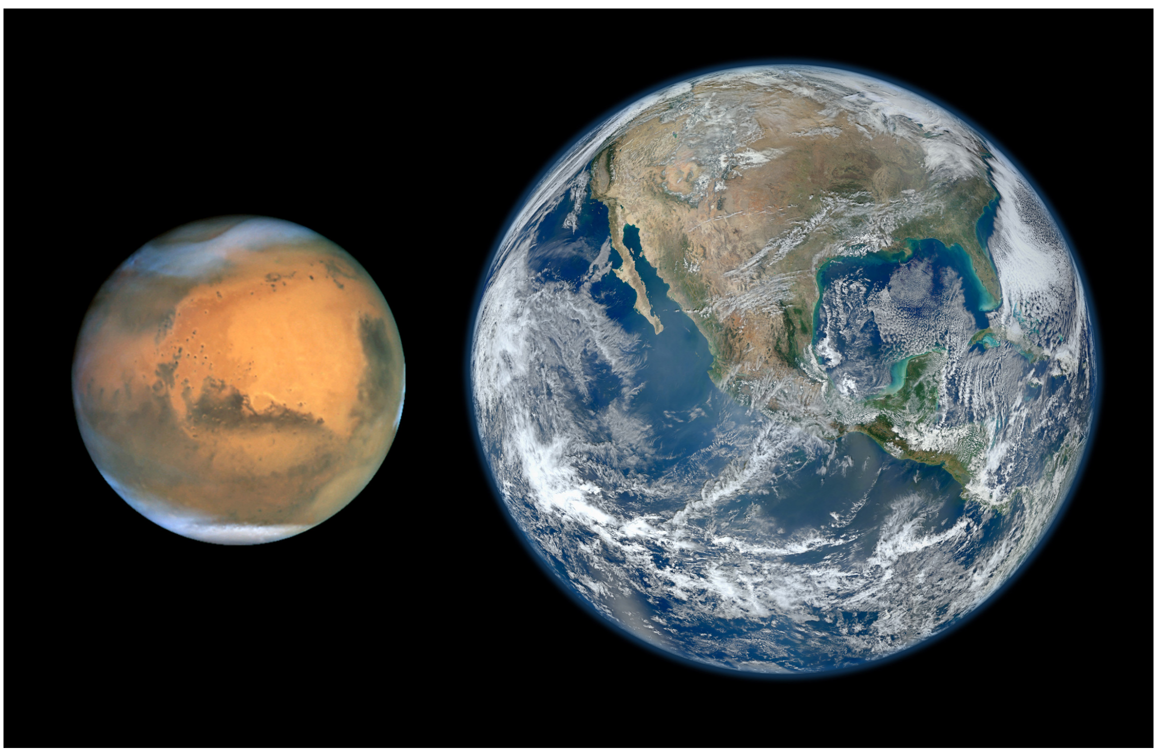
http://science.nasa.gov/science-news/science-at-nasa/2000/ast29jun_1m/

There are trace quantities of water vapor in Mars' atmosphere and substantial amounts of water ice at the Martian poles. There may even be enough frozen water beneath Mars' surface to fill a large ocean if melted.

"We have conditions on Mars that seem to forbid liquid water very close to the surface," said Michael Carr of the U.S. Geological Survey. "At high latitudes, the temperatures are 70 to 100 degrees centigrade below freezing. It's incredibly cold."

The low temperature of Mars conspires with the planet's thin atmosphere (it's 100 times thinner than Earth's) to make water possible in only two forms: solid ice and gaseous vapor. A cup of liquid water transported Star Trek-style to the surface of Mars would freeze or boil (depending on the local combination of temperature and pressure).



Above left, wispy water vapor clouds are seen in the Martian atmosphere. At right, Earth's water vapor clouds cover much of the planet. The planets are sized to scale. Images courtesy of NASA.

"The air pressure is so low on Mars that even in the most favorable spots, where the pressure is higher than average, liquid water is restricted to the range zero to ten degrees Celsius," said Bob Haberle of the NASA/Ames Research Center. "Fresh water on Mars begins to boil at ten degrees Celsius. Here on Earth we can have water anywhere between zero and 100 degrees Celsius—that range is reduced by a factor of ten on Mars."

If the thought of boiling water at ten degrees Celsius seems bizarre, simply consult a high-altitude cookbook for a reality check. On mountaintops where the air pressure is low, water boils at a lower temperature than it does at sea level. (At 9,000 feet a 'three-minute' boiled egg takes about five minutes to fully cook!) Mars simply takes the principles of high-altitude cooking to an extreme.

Although any liquid water exposed to Mars' low-pressure atmosphere is likely to boil, vapor is not the most important repository of Martian H2O. If all the vapor in the present-day atmosphere rained down on one spot, it would barely fill a small pond. On the other hand, the Martian poles contain lots of water in the form of a solid. The north polar cap, composed primarily of water ice, is 1,200 kilometers across and up to three kilometers thick in some places. Even more water ice is thought to lie deep underground.

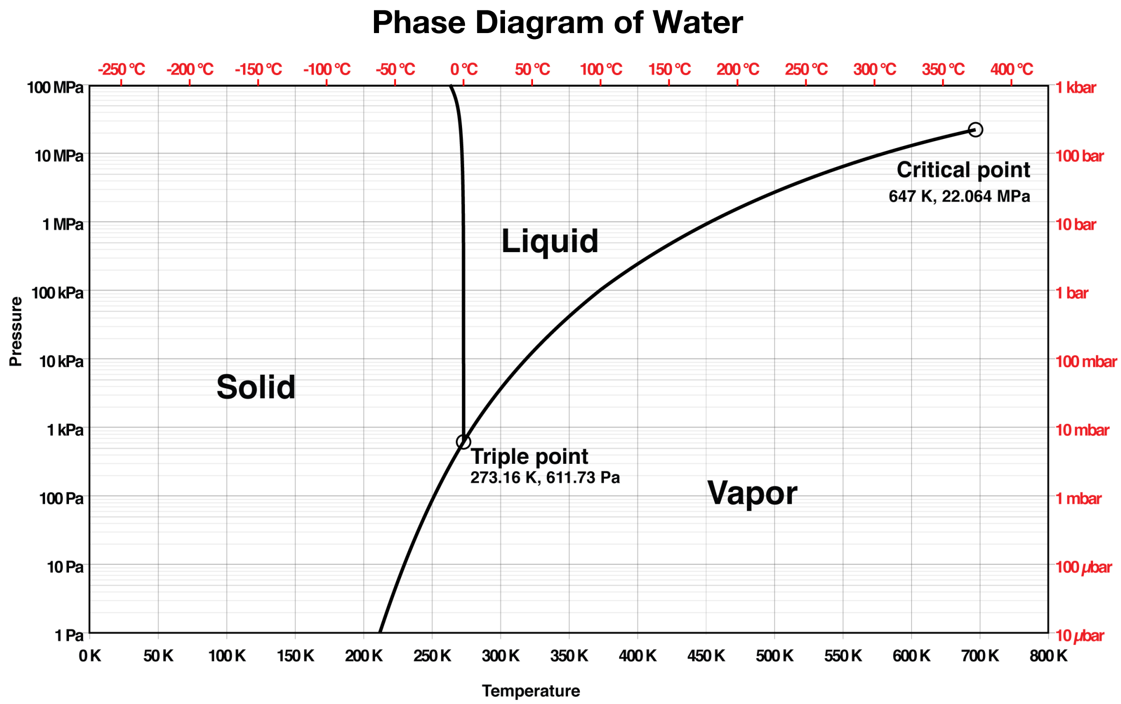
So, the big question is not whether water exists on Mars—it does—but rather, if there is liquid water despite the planet being so cold.

"First of all, you have to remember that the average atmospheric pressure on Mars is very close to the triple point of water," said Richard Hoover, an astrobiologist at the NASA Marshall Space Flight Center. "You only have to increase the pressure a little bit to make liquid water possible."

The 'triple point' is the combination of pressure (6.1 millibars) and temperature (0.01 degrees Celsius) at which water can exist simultaneously in all three states: a solid, a liquid and a gas (see 'Phase Diagram of Water'). On Earth, our experience with the triple point is usually limited to ice skating. The temperature of ice on a skating rink is just a fraction of a degree from the triple point. A little bit of pressure on the solid ice can cause it to transform to a liquid. The weight of a skater applied to the ice along the blade of the skate therefore creates a thin layer of liquid water that lubricates the blade and makes gliding possible.

On Mars the globally-averaged surface pressure of the planet's atmosphere is only slightly less than 6.1 millibars.

"That's the average," said Haberle, "So some places will have pressures that are higher than 6.1 millibars and others will be lower."



Above: A phase diagram of water. The 'triple point' is the temperature and pressure where all three types of water can exist at once. In the diagram, note that liquid water cannot exist below 6.1 millibars. This fact is significant because the atmospheric pressure at the Martian surface hovers just below that value. Any water that might form on a warm afternoon from melting water would quickly disappear in the desiccated Martian atmosphere.

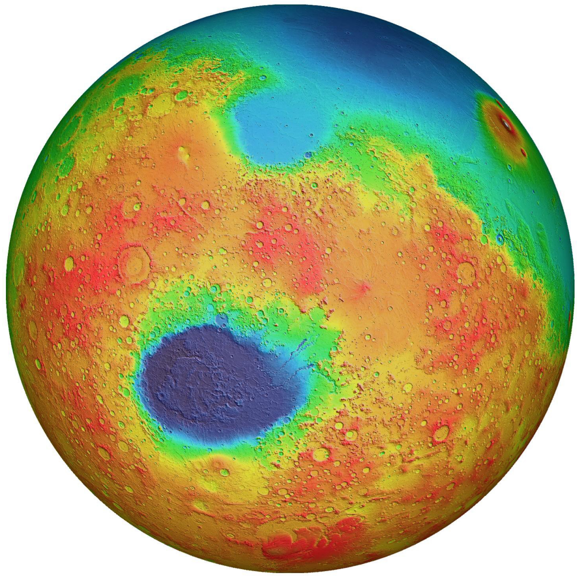
Haberle has developed a sophisticated climate model for Mars based in part on Mars Global Surveyor topography data.

"I used the model to look for regions that meet the minimum requirements for liquid water—above the triple point and below the boiling point," said Haberle. "According to the model, the highest surface pressure, 12.4 millibars, occurs at the bottom of the Hellas Basin (a low-lying area created by an ancient asteroid strike). The problem is that the boiling temperature there is only ten degrees Celsius. It can't get very hot or the water will boil away."

"There are 5 five distinct regions where we might sometimes find surface water: in the Amazonis, Chryse and Elysium Planitia, in the Hellas Basin and the Argyre Basin," Haberle said. "That's not to say that liquid water really does exist in those places, just that it could."

Conditions would be favorable for liquid water only during the Martian day. The temperature falls precipitously at night, so any liquid would re-freeze. At the Viking Lander sites, for example, instruments registered temperatures as high as

-17 degrees Celsius in the air and 27 degrees Celsius in the soil on sunlit summer days. After sunset, thermometer readings plunged back to -60 degrees Celsius or below.



Above: The massive Hellas impact basin in the southern hemisphere of Mars (purple color) is nearly nine kilometers deep and 2,100 kilometers across. The air pressure at the bottom of the basin is about twice the global average. In this false-color image based on measurements from the Mars Global Surveyor laser altimeter, red colors denote high elevations and blue denotes low.

Follow the Salt...

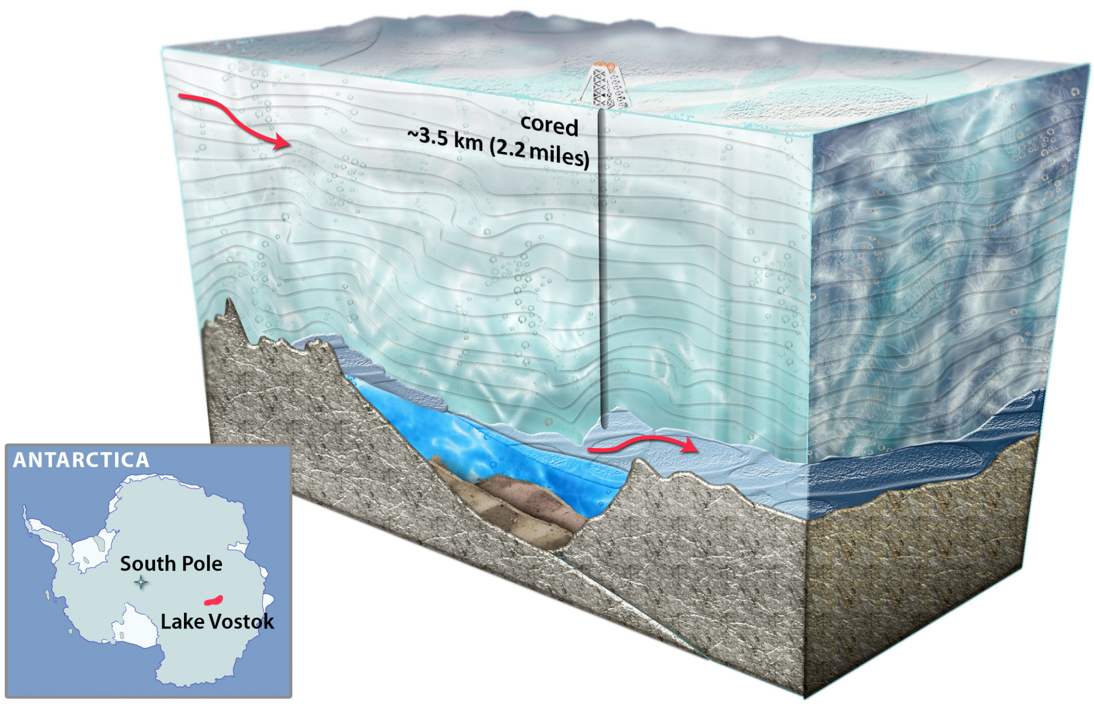
"One thing we have to be careful of is our everyday experience that water always freezes at zero degrees," said Hoover. "It doesn't. Water containing dissolved salts freezes at a significantly lower temperature. Don Juan Pond in Antarctica is a good example. It's a high salinity pond with liquid water at temperatures as low as -24 degrees Celsius."

Research [sic] suggests that ancient Martian oceans—if they existed—contained a mix of salts similar to those in Earth's oceans today. Martian rocks, like those on Earth, react to form salt and clay minerals when exposed to water. On our planet this process gives rise to a variety of brines in the western salt lakes of North America. The detailed chemistry of the brines depends on the composition of local rocks.

On Mars, salty water could be moving through subterranean aquifers. "Ice is a crystal, and it's harder to form crystals when the water is flowing," said Hoover.

There are many places on Earth where liquid water and ice co-exist in sub-zero conditions, said Hoover. The most famous example is Lake Vostok, an expanse of water roughly the size of lake Ontario lying four kilometers beneath the Antarctic ice sheet. The ice sheet acts as a blanket, shielding the lake from Mars-like temperatures at the surface.

Will explorers one day discover oases like Lake Vostok beneath icy terrain on Mars? No one knows. But instead of "Follow the Water," the mantra of future colonists on the red planet might well be "Follow the Salt."



Above: A team of Russian researchers drilled over 3.5 kilometers into Lake Vostok on February 8, 2012. They hope to find previously undiscovered life forms. Image courtesy of NSF.

NASA Spacecraft Data Suggest Water Flowing On Mars

Excerpts from Science News, "NASA Spacecraft Data Suggest Water Flowing On Mars," August 4, 2011 http://www.nasa.gov/home/hqnews/2011/aug/HQ_11-245_Mars_Water_prt.htm

Observations from NASA's Mars Reconnaissance Orbiter (MRO) have revealed possible flowing water during the warmest months on Mars.

"NASA's Mars Exploration Program keeps bringing us closer to determining whether the Red Planet could harbor life in some form," NASA Administrator Charles Bolden said, "and it reaffirms Mars as an important future destination for human exploration."

Dark, finger-like features appear and extend down some Martian slopes during late spring through summer, fade in winter, and return during the next spring. Repeated observations have tracked the seasonal changes in these recurring features on several steep slopes in the middle latitudes of Mars' southern hemisphere.

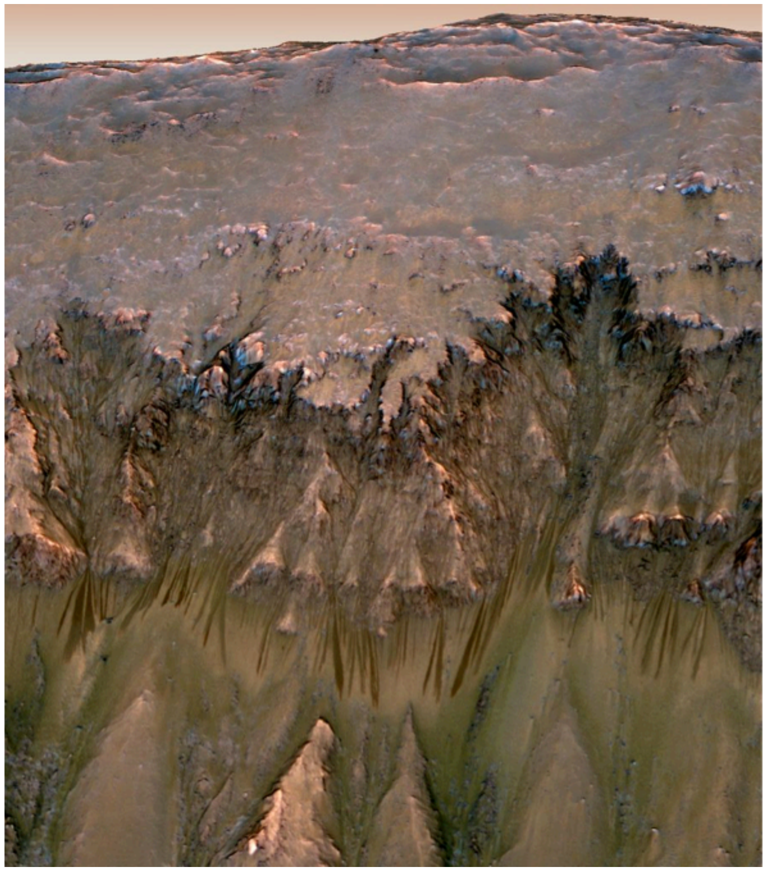
"The best explanation for these observations so far is the flow of briny water," said Alfred McEwen of the University of Arizona, Tucson. McEwen is the principal investigator for the orbiter's High Resolution Imaging Science Experiment (HiRISE).

Some aspects of the observations still puzzle researchers, but flows of liquid brine fit the features' characteristics better than alternate hypotheses. Saltiness lowers the freezing temperature of water.

Sites with active flows get warm enough to sustain liquid water that is about as salty as Earth's oceans, while pure water would freeze at the observed temperatures. Salt deposits over much of Mars indicate brines were abundant in Mars' past. These recent observations suggest brines still may form near the surface today in limited times and places.

There is no direct detection of briny water in the flows. When researchers checked flow-marked slopes with the orbiter's Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), no sign of water appeared. The features may quickly dry on the surface or could be shallow subsurface (below ground) flows.

These results are the closest scientists have come to finding evidence of liquid water on the planet's surface today. Frozen water, however has been detected near the surface in many middle to high-latitude regions. Purported droplets of brine also appeared on struts of the Phoenix Mars Lander. If further study of the recurring dark flows supports evidence of brines, these could be the first known Martian locations with liquid water.



Above: An image combining orbital imagery with 3-D modeling shows flows that appear in spring and summer on a slope inside Mars' Newton crater. Sequences of observations recording the seasonal changes at this site and a few others with similar flows might be evidence of salty liquid water active on Mars today. Image and text courtesy of NASA/JPL-Caltech/Univ. of Arizona