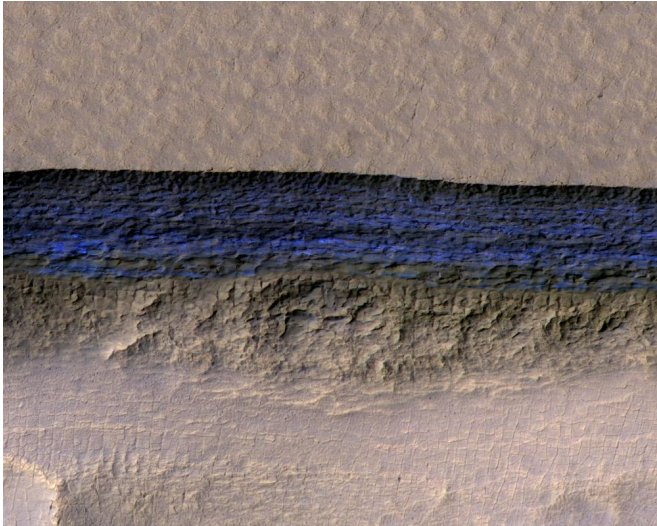


# Steep slopes on Mars reveal structure of buried ice

11 January 2018



A cross-section of a thick sheet of underground ice is exposed at the steep slope (or scarp) that appears bright blue in this enhanced-color view from the High Resolution Imaging Science Experiment (HiRISE) camera on NASA's Mars Reconnaissance Orbiter. The view covers an area about 550 yards (500 meters) wide. Figure 1 includes a 100-meter (109-yard) scale bar. North is toward the top. The upper third of the image shows level ground that is about 140 yards (130 meters) higher in elevation than the ground in the bottom third. In between, the scarp descends sharply, exposing about 260 vertical feet (80 vertical meters) of water ice. Color is exaggerated to make differences in surface materials easier to see. The presence of exposed water ice at this site was confirmed by observation with the same orbiter's Compact Reconnaissance Imaging Spectrometer for Mars (CRISM). Credit: NASA/JPL-Caltech/UA/USGS

Researchers using NASA's Mars Reconnaissance Orbiter (MRO) have found eight sites where thick deposits of ice beneath Mars' surface are exposed in faces of eroding slopes.

These eight scarps, with slopes as steep as 55 degrees, reveal new information about the internal

layered structure of previously detected underground ice sheets in Mars' middle latitudes.

The ice was likely deposited as snow long ago. The deposits are exposed in cross section as relatively pure [water ice](#), capped by a layer one to two yards (or meters) thick of ice-cemented rock and dust. They hold clues about Mars' climate history. They also may make frozen water more accessible than previously thought to future robotic or human exploration missions.

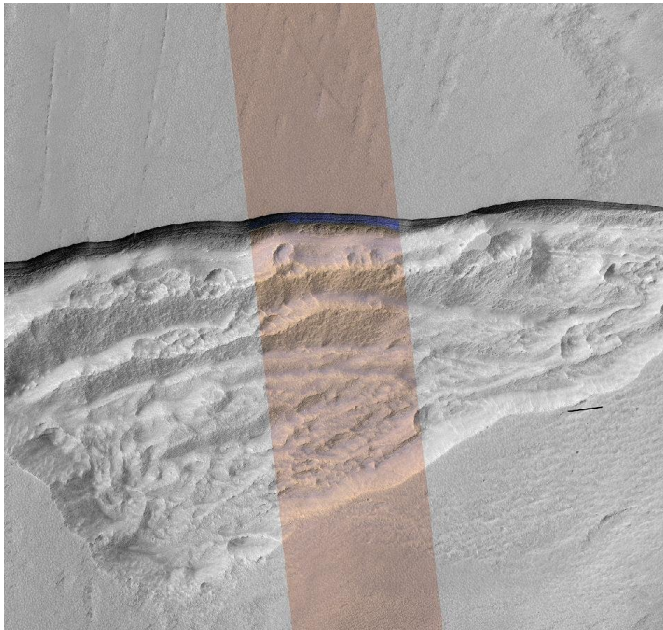
Researchers who located and studied the scarp sites with the High Resolution Imaging Science Experiment (HiRISE) camera on MRO reported the findings today in the journal *Science*. The sites are in both northern and southern hemispheres of Mars, at latitudes from about 55 to 58 degrees, equivalent on Earth to Scotland or the tip of South America.

"There is shallow ground ice under roughly a third of the Martian surface, which records the recent history of Mars," said the study's lead author, Colin Dundas of the U.S. Geological Survey's Astrogeology Science Center in Flagstaff, Arizona. "What we've seen here are cross-sections through the ice that give us a 3-D view with more detail than ever before."

## Windows into underground ice

The scarps directly expose bright glimpses into vast underground ice previously detected with spectrometers on NASA's Mars Odyssey (MRO) orbiter, with ground-penetrating radar instruments on MRO and on the European Space Agency's Mars Express orbiter, and with observations of fresh impact craters that uncover subsurface ice. NASA sent the Phoenix lander to Mars in response to the Odyssey findings; in 2008, the Phoenix mission confirmed and analyzed the buried water ice at 68 degrees north latitude, about one-third of the way to the pole from the northernmost of the

eight scarp sites.



At this wedge-shaped pit on Mars, the steep slope (or scarp) at the northern edge (toward the top of the image) exposes a cross-section of a thick sheet of underground water ice. The image is from the High Resolution Imaging Stereo Experiment (HiRISE) camera on NASA's Mars Reconnaissance Orbiter. The gray-scale portions on left and right are from a single waveband in the red-light portion of the visible spectrum. The middle section, in enhanced color, combines data from red, near-infrared and blue-green wavebands. The scene covers an area about three miles (five kilometers) wide. Figure 1 includes a one-kilometer scale bar. One kilometer is about six-tenths of a mile. The ice-exposing scarp at the northern edge of the pit has a steepness of about 45 to 55 degrees, plunging from the relatively level ground outside the pit. Credit: NASA/JPL-Caltech/UA/USGS

The discovery reported today gives us surprising windows where we can see right into these thick underground sheets of ice," said Shane Byrne of the University of Arizona Lunar and Planetary Laboratory, Tucson, a co-author on today's report. "It's like having one of those ant farms where you can see through the glass on the side to learn about what's usually hidden beneath the ground."

Scientists have not determined how these particular

scarps initially form. However, once the buried ice becomes exposed to Mars' atmosphere, a scarp likely grows wider and taller as it "retreats," due to sublimation of the ice directly from solid form into water vapor. At some of them, the exposed deposit of water ice is more than 100 yards, or meter, thick. Examination of some of the scarps with MRO's Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) confirmed that the bright material is frozen water. A check of the surface temperature using Odyssey's Thermal Emission Imaging System (THEMIS) camera helped researchers determine they're not seeing just thin frost covering the ground.

Researchers previously used MRO's Shallow Radar (SHARAD) to map extensive underground water-ice sheets in middle latitudes of Mars and estimate that the top of the ice is less than about 10 yards beneath the ground surface. How much less? The radar method did not have sufficient resolution to say. The new ice-scarp studies confirm indications from fresh-crater and neutron-spectrometer observations that a layer rich in water ice begins within just one or two yards of the surface in some areas.

### Astronauts' access to Martian water

The new study not only suggests that underground water ice lies under a thin covering over wide areas, it also identifies eight sites where ice is directly accessible, at latitudes with less hostile conditions than at Mars' polar ice caps. "Astronauts could essentially just go there with a bucket and a shovel and get all the water they need," Byrne said.

The exposed ice has scientific value apart from its potential resource value because it preserves evidence about long-term patterns in Mars' climate. The tilt of Mars' axis of rotation varies much more than Earth's, over rhythms of millions of years. Today the two [planets](#) tilts are about the same. When Mars tilts more, climate conditions may favor buildup of middle-latitude ice. Dundas and co-authors say that banding and color variations apparent in some of the scarps suggest layers "possibly deposited with changes in the proportion of ice and dust under varying climate conditions."

This research benefited from coordinated use of multiple instruments on Mars orbiters, plus the longevities at Mars now exceeding 11 years for MRO and 16 years for Odyssey. Orbital observations will continue, but future missions to the surface could seek additional information.

"If you had a mission at one of these sites, sampling the layers going down the scarp, you could get a detailed climate history of Mars," suggested MRO Deputy Project Scientist Leslie Tamppari of NASA's Jet Propulsion Laboratory, Pasadena, California. "It's part of the whole story of what happens to [water](#) on Mars over time: Where does it go? When does ice accumulate? When does it recede?"

**More information:** C.M. Dundas at U.S. Geological Survey in Flagstaff, AZ et al., "Exposed subsurface ice sheets in the Martian mid-latitudes," *Science* (2018). [science.sciencemag.org/cgi/doi ... 1126/science.aao1619](https://science.sciencemag.org/cgi/doi/10.1126/science.aao1619)

Provided by NASA

APA citation: Steep slopes on Mars reveal structure of buried ice (2018, January 11) retrieved 27 September 2020 from <https://phys.org/news/2018-01-deep-glaciers-mars.html>

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