Planetary scientists solve 40-year-old mysteries of Mars' northern ice cap

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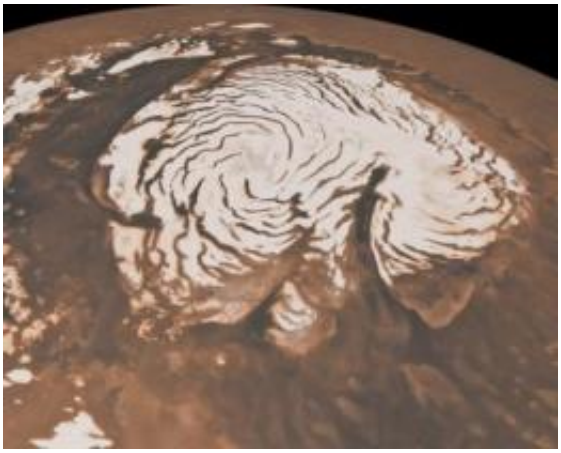


This is a view of the north polar region of Mars from orbit. The ice-rich polar cap (quasi-circular white area at center) is about 1,000 km across. It is bisected by a large canyon, Chasma Boreale, on the right side. Dark, spiral-shaped bands are troughs. Chasma Boreale is about the length of the Grand Canyon in the US and up to 2 km deep. Credit: NASA/Caltech/JPL/E. DeJong/J. Craig/M. Stetson

Scientists have reconstructed the formation of two curious features in the northern ice cap of Mars—a chasm larger than the Grand Canyon and a series of spiral troughs—solving a pair of mysteries dating back four decades while finding new evidence of climate change on Mars.

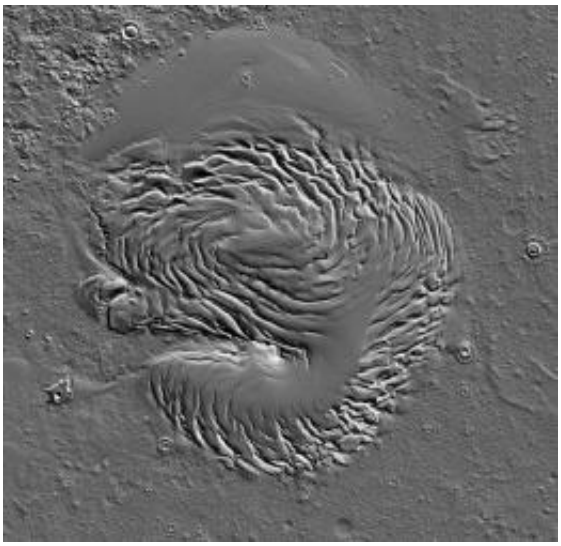
In a pair of papers to be published in the journal *Nature* on May 27, Jack Holt and Isaac Smith of The University of Texas at Austin's Institute for Geophysics and their colleagues describe how they used radar data

collected by NASA's Mars Reconnaissance Orbiter to reveal the subsurface geology of the red planet's northern ice cap.

On Earth, large ice sheets are shaped mainly by ice flow. But on Mars, according to this latest research, other forces have shaped, and continue to shape, the polar ice caps.

The northern ice cap is a stack of ice and dust layers up to two miles (three kilometers) deep covering an area slightly larger than Texas. Analyzing radar data on a computer, scientists can peel back the layers like an onion to reveal how the ice cap evolved over time.

One of the most distinctive features of the northern ice cap is Chasma Boreale, a canyon about as long as the Grand Canyon but deeper and wider. Some scientists have suggested Chasma Boreale was created when volcanic heat melted the bottom of the ice sheet and triggered a catastrophic flood. Others have suggested strong polar winds, called katabatics, carved the canyon out of a dome of ice.



Morphology of the north polar region of Mars. Spiral troughs are seen throughout the ice-rich polar cap (quasi-circular dome at center), and Chasma

Boreale is the large canyon dividing the polar cap into two lobes. Chasma Boreale is the size of the Grand Canyon in the US and up to 2 kilometers deep. Shaded-relief image based on Mars Orbiter Laser Altimeter data. Credit: NASA/GSFC

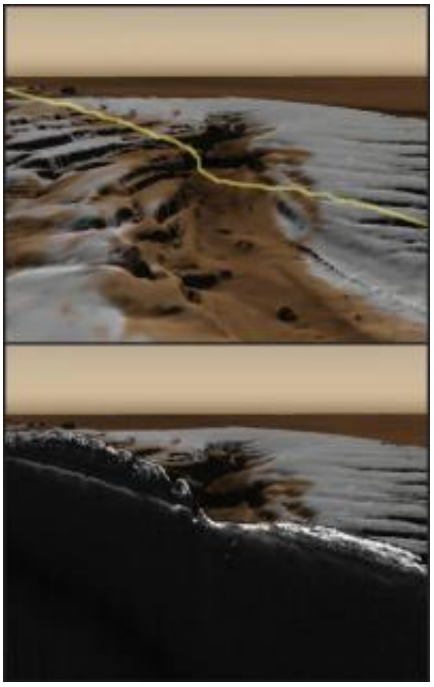
Other enigmatic features are troughs that spiral outward from the center of the ice cap like a gigantic pinwheel. Since they were discovered in 1972, scientists have proposed several hypotheses for how they formed. One suggested that as the planet spins, ice closer to the poles moves slower than ice farther from the poles, causing the semi-fluid ice to crack. Another used an elaborate mathematical model to suggest how increased solar heating in certain areas and lateral heat conduction could cause the troughs to self assemble.

It turns out both the spiral troughs and Chasma Boreale were created and shaped primarily by wind. But rather than being cut into existing ice very recently, the features formed over millions of years as the ice sheet itself grew. By influencing wind patterns, the topography of underlying, older ice controlled where and how the features grew. Topography is the three-dimensional shape of a surface, including peaks, valleys, slopes and plains.

Before this research, conventional wisdom held that the northern ice cap of Mars was made of many relatively flat layers like a layered cake. It was assumed some climate information would be recorded in the layers, limited to what could be gained from layer thickness and dust content. This research, however, reveals many complex features—including layers that change in thickness and orientation, or abruptly disappear in some places—making it a virtual gold mine of climate information.

"Nobody realized that there would be such complex structures in the

layers," says Holt, lead author of the paper focusing on Chasma Boreale. "The layers record a history of ice accumulation, erosion and wind transport. From that, we can recover a history of climate that's much more detailed than anybody expected."



The top panel shows a perspective view of northern polar cap of Mars, looking up Chasma Boreale. The yellow line indicates ground track of SHARAD in orbit. The bottom panel shows a cutaway view of same, showing subsurface layers as viewed by SHARAD. Detailed mapping of layers over many orbits reveals the history of ice accumulation and chasma formation. Credit: NASA/Caltech/JPL/E. DeJong/J. Craig/M. Stetson

The spiral trough results vindicate an early explanation that had fallen out of favor in parts of the Mars scientific community. Alan Howard, a researcher at the University of Virginia, proposed just such a process in 1982 based solely on images of the surface from the Viking mission.

"He only had Viking images with relatively low resolution," says Isaac Smith, doctoral student and lead author on the spiral trough paper. Holt is second author on the trough paper. "Many people proposed other hypotheses suggesting he was wrong. But when you look at a hypothetical cross section from his paper, it looks almost exactly like what we see in the radar data."

Why are the troughs spiral shaped? First, katabatic winds are caused by relatively cold, dense air that rolls down from the poles and out over the ice cap. Second, as they blow down, they are deflected by the Coriolis force, which is caused by the planet's spinning in space. On Earth, this is what causes hurricanes to spin opposite directions in opposite hemispheres. This force twists the winds—and the troughs they create—into spiral shapes.

These breakthroughs were made possible by a new instrument called Shallow Radar (SHARAD). Similar instruments have been used on aircraft in Antarctica and Greenland, but before its use at Mars, some scientists were skeptical it would be able to collect useful data from orbit. Holt is a Co-Investigator on SHARAD.

"These anomalous features have gone unexplained for 40 years because we have not been able to see what lies beneath the surface," said Roberto Seu, team leader for the SHARAD instrument. "It is gratifying to me that with this new instrument we can finally explain them."

More information: For a gallery of images, go to: www.jsg.utexas.edu/galleries/m … rs_north_pole052610/

Provided by University of Texas at Austin