On the Cover:
The behavior of frosts on Mars may sound like an arcane subject for study, but when you consider that those frosts are made of carbon dioxide and water, and that water is a key to life, the importance becomes clear. This is a crater near Mars' north polar cap, which, like Earth's, maintains a permanent covering of frozen water. This crater also retains a permanent layer of frost, unlike other craters of similar size, shape and location. Why some craters defrost while others don't is one of the many enigmas of Mars.

Image: Mike Melin

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Contact Us
Mailing Address: The Planetary Society, 65 North Catalina Avenue, Pasadena, CA 91106-2301
General Calls: 818-793-5100
Sales Calls Only: 818-793-1875
E-mail: tps@genie.com
World Wide Web Home Page: http://planetary.org/tps/

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Editor: CHARLENE M. ANDERSON
Assistant Editor: DONNA ESCANDON STEVENS
Production Editor: MICHAEL HAGGERTY
Technical Editor: JAMES D. BURRE
Copy Editor: GLORIA J. JOYCE
Art Director: BARBARA S. SMITH

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A Martian Enigma

To understand Mars, its atmosphere and surface features, we need to have a better idea about the behavior of volatile substances, such as water and carbon dioxide. As the dominant constituent of the atmosphere (95 percent), carbon dioxide plays a major role on Mars. But water is also a major player: We see evidence of its past abundance in the huge channels carved into the martian surface by ancient floods. Even today, on this frozen desert world, water plays a role. For example, the permanent north polar cap is made primarily of water ice. Both carbon dioxide and water frequently freeze out of the thin atmosphere to form frosts. When and where these frosts appear, and their relationship to the sand dunes found in Mars' polar regions, are among the most enigmatic phenomena we've yet seen on the Red Planet.

This digital image mosaic of the northern polar region, compiled from Viking orbiter data, shows the perennial ice cap (center) on top of layered deposits—alternating layers of dust and ice accumulated over the martian centuries. A darker field of dunes entirely surrounds the polar cap. At the top are outliers of frost that all lie above a line drawn between 90 and 270 degrees west longitude. The frosted dunes examined in more detail on these pages are marked in small boxes.

Mars is a sandy world, and dunes are common sights on the floors of impact craters. Compare this image with the image on the cover. Both were taken during the summer, and each image is of an area 25 kilometers (16 miles) across. This crater lies at 78.7 degrees north latitude, 28 degrees west longitude, at the boundary between the layered polar deposits and the circumpolar dune field. The crater shown in the cover image lies at 70.5 degrees north latitude, 257 degrees west longitude, within the region of frost outliers. The crater in this image is defrosted, whereas the crater in the cover image has frost even during the warmest time of the year.

These are close-ups of the defrosted dunes in the image above and the frosted dunes shown on the cover. The dune fields are very similar in size and shape, and the amount of sand is probably similar as well. There is frost apparent in the left image, but mostly around the margin of the field.

The dune sands may remain cooler longer than surrounding rock, and their porosity and permeability may enable them to trap volatiles such as water vapor. But why does frost remain on one dune field but not on the other? There may be differences in the amount of ice trapped or in wind patterns or in dune materials. But none of these differences would explain why all the frost outliers, including the frosted dunes, lie between 90 and 270 degrees west longitude. That's why the behavior of these frosted dunes is an enigma—one that's waiting to be solved by our exploration of Mars.

Information and images courtesy of Michael Malin