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PLANETARY SCIENCE RESEARCH UPDATE

Liquid water discovered beneath Mars' south pole

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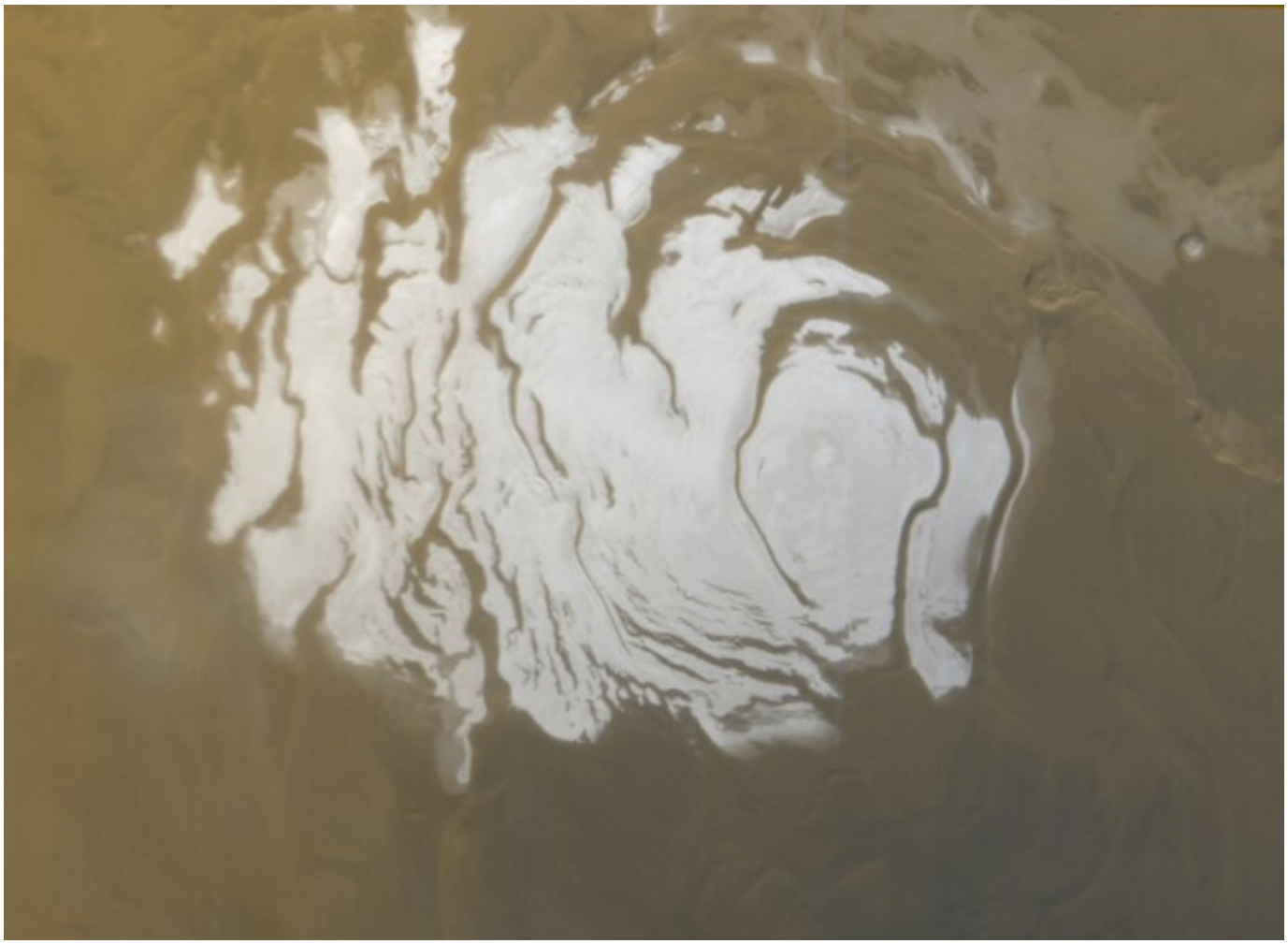

What lies beneath: liquid water has been discovered below Mars' south polar ice cap by an instrument on the European Space Agency's Mars Express orbiter (Courtesy: NASA)

A radar instrument on a European mission to Mars has discovered liquid water beneath the red planet's south polar ice cap, raising intriguing possibilities for both astrobiology and studies of Mars' past climate. The discovery of liquid water on Mars has huge consequences for the search for life on

the red planet, and could also unveil characteristics of the ancient environment in which it formed before the water was covered with ice.

We already know that Mars was once a wet planet and that its climate billions of years ago could support large amounts of liquid water – as shown by the myriad ancient river channels, floodplains and lake beds that can be seen on its surface. Today, however, the temperature and pressure at the planet's surface is too low to permit the existence of liquid water. In 2006 planetary scientists operating the camera on board NASA's Mars Global Surveyor observed changes in gullies that they attributed to liquid water flows, but the HiRISE camera on the Mars Reconnaissance Orbiter has since revealed that these flows are small avalanches of dry material instead.

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> Roberto Orosei

Then, in 2011, HiRISE began to spy the seasonal appearance of dark streaks, called recurring slope lineae (RSL). These, too, were attributed to flows of liquid water, but recent evidence suggests that RSL are another by-product of dry avalanches.

While scientists have so far concluded that water does not exist on the Martian surface, Stephen Clifford of the Planetary Science Institute proposed in 1987 that liquid water could lie underneath the ice caps. However, evidence for that "hidden" water has eluded scientists, until now.

Lakes of brine

The sub-surface liquid water was detected by the Mars Advanced Radar for Subsurface and Ionosphere Sounding instrument (MARSIS) on board the European Space Agency's Mars Express orbiter. The water resides in a 20 km-wide area, 1.5 km beneath Planum Australe, a large plain in Mars' south polar region.

The key to identifying the water is a property called dielectric permittivity. This is a measure of how an electromagnetic wave, such as a radar pulse, is attenuated as it travels through a medium. Liquid water is a much stronger attenuator and absorber of radar than ice, and the contrast in dielectric permittivity is highest at the interface between a layer of liquid water and a layer of water-ice – producing a radar echo that can be detected. "On Earth, it's almost a given that if a ground-penetrating radar spots stronger reflections from the sub-surface than from the surface of the polar ice, then you are seeing liquid water," Roberto Orosei from the Istituto Nazionale di Astrofisica in Bologna, Italy, who led the research, told *Physics World*.

The water below the ice cap must be at least tens of centimetres deep for MARSIS to detect, but it is

not clear whether the body of water exists as a deep lake, like Lake Vostok on Earth, or as a shallow layer. Anja Diez, of the Norwegian Polar Institute, points out that all options are currently on the table, since Antarctic sub-glacial pockets of liquid water can come in many forms. "In Antarctica the water can exist because the temperatures below the kilometre-thick ice can reach melting point," she says. On Mars the temperatures below the ice cap are much lower but, according to Diez, the liquid water could instead exist as a brine that would lower the freezing point of the water.

The existence of brine on Mars is likely because of the existence of perchlorate salts. In 2008, NASA's Phoenix Mars lander found magnesium, calcium and sodium perchlorate in the Martian topsoil, and it has since been found to be widespread across the red planet. While the exact temperature of the discovered liquid water is unknown, laboratory experiments have shown that in some conditions briny water can remain liquid down to −70 °C.

Attempts to detect the water with another instrument on MRO — the Shallow Radar (SHARAD) instrument — have so far proven fruitless. SHARAD operates at a higher frequency, 15 to 25 MHz compared to the 5 MHz of MARSIS, and the higher the frequency, the higher the attenuation of the signal. Yet while Orosei says his team were "extremely surprised" that SHARAD did not see anything, team member Sebastian Lauro of the Università Roma Tre in Rome believes this could be because SHARAD cannot penetrate to the depth needed to detect the liquid-ice interface.

Forthcoming missions to Mars will carry high-frequency radar, which is used to image ground ice. However, according to Nathaniel Putzig of the Planetary Science Institute in Arizona, who leads the US contribution to SHARAD, this latest finding could also renew interest in lower frequency radar to study the presence of water beneath Mars.

The research is published in the journal *Science*.

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