Evidence of liquid water lakes under polar ice caps on Mars

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A team of astronomers using data collected from the Mars Express spacecraft have published 29 low-frequency radar images collected between May 2012 and December 2015. Taken together, they reveal a change in the structure and the composition of the material beneath the surface of Mars' south pole that so far has only one explanation: the presence of liquid water under the surface of the red planet. This is a milestone in the 54 years of Mars space exploration.

This discovery also comes after 15 years of intellectual labor by the hundreds of researchers, engineers and technicians who operate Mars Express and analyze the data it sends back, as well as the thousands more that operate the other five Martian orbiters and two rovers. Each mission has both learned from previous missions and informed those that came after. It was only through the work of the past 17 years of a constant robotic presence making scientific discoveries—including many previous hints of underground water—that a stable body of liquid water on Mars could have been found.

The data were collected by a team from the Italian Space Agency led by Roberto Orosei, using the Mars Advanced Radar for Subsurface and Ionosphere Sounding instrument. They focused on a region below the surface of Mars' southern polar ice cap, an area suspected for the past 31 years to have an underground lake. The team used techniques like those of satellites orbiting Earth that have detected liquid water underneath ice sheets in Antarctica and Greenland. Through their three-and-a-half-year effort and 29 passes over the targeted area, they discovered a 20-kilometer-wide lake located 1.5 kilometers below the surface.

One of the telling aspects of the data collected is that in every image, the radio waves produce an echo, indicating a pocket of material with a different density than the surrounding region. When the researchers looked more closely at the pattern of the echo, they realized that the shape of the newly discovered material had a rough bottom and a smooth top. Further data indicated that the pocket of material is most likely a cavern, one with the right temperature and pressure to hold liquid water.

To confirm this hypothesis, Orosei and his team generated a variety of physical models that could explain the radio wave signals being detected. They looked at the composition of the material of the Martian polar ice caps, the temperatures and pressures below the surface, possible layers of carbon dioxide ice and different shapes of the cavern. In the process of this systematic analysis, not only did the researchers confirm their original idea, they also showed that the water is partially saturated with sediments from the surrounding materials.

The research also determined that the specific region studied is not particularly unique. The conditions that allow for liquid water to exist under this 20-kilometer region should exist elsewhere on the planet, meaning that there are likely many pools of subsurface water on Mars. Follow-up studies are already underway. Nathaniel Putzig, an astronomer who works on NASA's Mars Reconnaissance Orbiter, has already planned out an analysis similar to Orosei to confirm the data and to deepen the study of the Martian ice caps.

The search for water on Mars goes back to an 1877 observation by Italian astronomer Giovanni Schiaparelli, in which he noted a series of *canali* on Mars. While these were later shown to be optical illusions, they were mistranslated and popularized as canals. This was taken up by Percival Lowell, who used the idea of canals to promote the idea in his book *Mars and its Canals*(1906) that there was a vast and lush ecosystem on Mars, complete with life intelligent enough to make planet-spanning canals to take water from the poles to irrigate canals.

Subsequent observations soon showed his ideas to be false, and they were conclusively put to rest in 1964 when

Mariner 4 completed the first fly-by of Mars, with the first images of another planet sent back to Earth from deep space. They revealed an arid world, with no geological activity, marked by craters and encased in a thin shell of carbon dioxide. While it was not the Mars anyone imagined, in many ways this increased the planet's allure. For the first time, there were images of an alien world, one that the inhabitants of Earth knew basically nothing about. Proposals for follow-up missions were almost immediately submitted to NASA.

Among the most famous missions were Viking 1 and 2, which landed on Mars in 1975 and were tasked primarily with looking for life on Mars. They were not the first successful landing—that credit belongs to the Soviet Union's Mars 3 lander—but they were the first landers to complete their task, which was to directly sample the surrounding soil, rocks and air while looking for signs of life. Though they did not find signs of even microorganisms, the images and data they transmitted back to Earth shaped both the scientific understanding and popular conception of the red planet.

While many subsequent missions were being planned, it took nearly two decades before spacecraft again visited Mars. The end of the Apollo Program in 1973 signaled the end of the momentum given to space exploration generated by the US-Soviet space race. At that point, the intellectual energy used for basic science was largely directed back into militaristic pursuits, starving the space program of both countries of funds and labor. Twenty-one years passed before another US space probe would successfully enter Martian orbit, NASA's Mars Global Surveyor in 1996.

Twenty-two years later, as with every discovery of liquid water on another world, one inevitably asks: Is there life? Has matter evolved enough elsewhere in our Solar System to become as complex as it is on Earth? It's worth finding out.