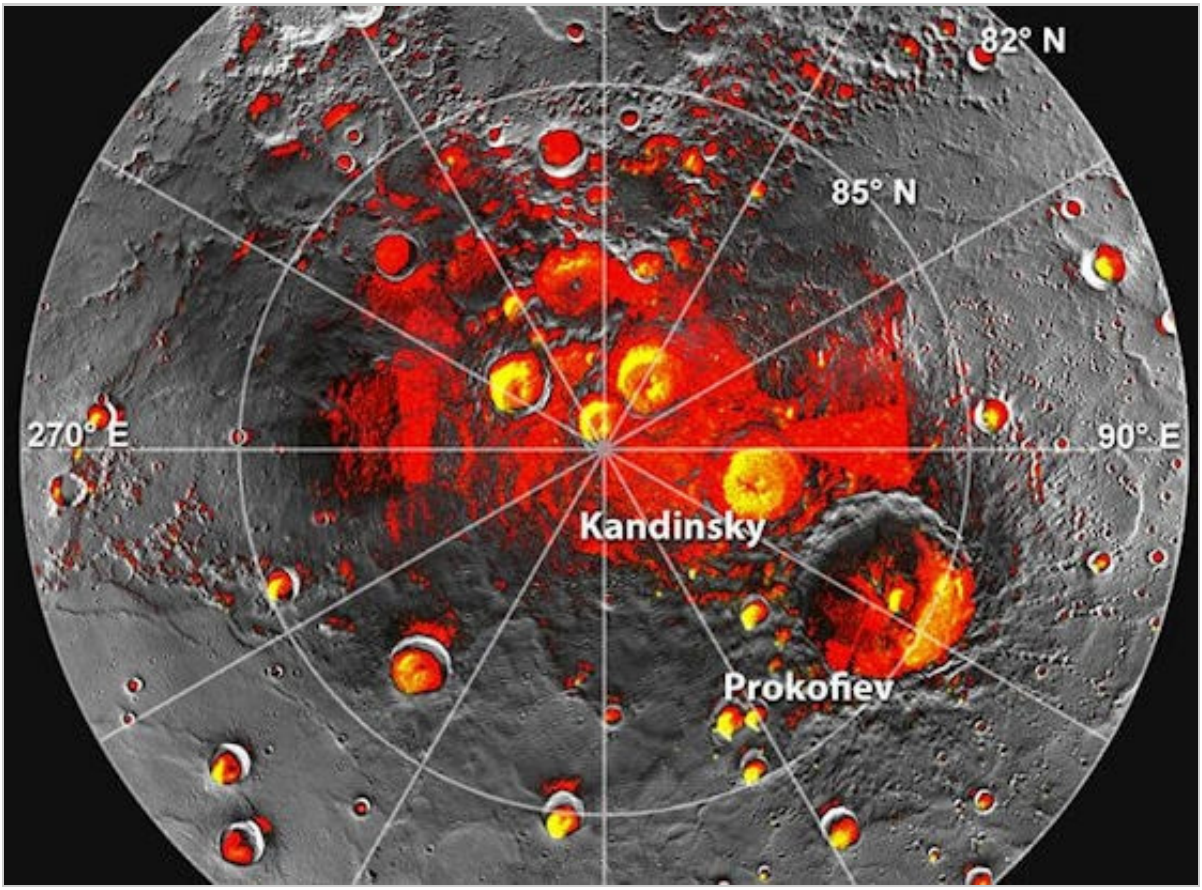
New Evidence for Ice on Mercury

Nov. 29, 2012: New data from NASA's MESSENGER spacecraft suggest that there's enough ice on Mercury to encase the entire US capitol.

"The new data indicate the water ice in Mercury's polar regions, if spread over an area the size of Washington, D.C., would be more than 2 miles thick," said David Lawrence, a MESSENGER participating scientist at the Johns Hopkins University Applied Physics Laboratory (APL) in Laurel, Md., and lead author of one of three papers describing the findings in the online edition of Science Express.



Mercury's north pole. Red denotes areas that are in shadow in all images acquired by MESSENGER to date. (The mapping of shadows is still incomplete near the pole.) Yellow shows the locations of bright polar deposits imaged by Earth-based radar. Updated from N. L. Chabot et al., Journal of Geophysical Research, 117, doi: 10.1029/2012JE004172 (2012). [more]

Given its proximity to the Sun, Mercury would seem to be an unlikely place to find ice. But the tilt of Mercury's rotational axis is almost zero -- less than one degree -- so there are pockets at the planet's poles that never see sunlight. Scientists suggested decades ago that water ice might be trapped in those shadowed areas at Mercury's poles.

The idea received a boost in 1991, when the Arecibo radio telescope in Puerto Rico detected unusually radar-bright patches at Mercury's poles, spots that reflected radio waves in the way one would expect if there were water ice. Many of these patches corresponded to the location of large impact craters mapped by the Mariner 10 spacecraft in the 1970s. But researchers weren't sure if the radar-bright patches detected by Arecibo corresponded to shadowly

places in the craters.

MESSENGER's arrival at Mercury last year changed that. Images from the spacecraft's Mercury Dual Imaging System taken in 2011 and earlier this year show that radar-bright features at Mercury's north and south poles are within shadowed regions on Mercury's surface.

Now, the newest data from MESSENGER confirm that water ice is the major constituent of Mercury's north polar deposits. In the coldest places, the ice is exposed on the surface. In slightly warmer spots, some kind of dark insulating material appears to cover the ice.

MESSENGER uses neutron spectroscopy to measure average hydrogen concentrations within Mercury's radar-bright regions. Ice concentrations are derived, in turn, from the hydrogen measurements. This is possible because water, or H_2O, is two parts hydrogen.

"The neutron data indicate that Mercury's radar-bright polar deposits contain, on average, a hydrogen-rich layer more than tens of centimeters thick beneath a surficial layer 10 to 20 centimeters thick that is less rich in hydrogen," says Lawrence. "The buried layer has a hydrogen content consistent with nearly pure water ice."

Data from MESSENGER's Mercury Laser Altimeter (MLA) -- which has fired more than 10 million laser pulses at Mercury to make detailed maps of the planet's topography -- corroborate the ice hypothesis, writes Gregory Neumann of the NASA Goddard Flight Center. In a second paper, Neumann and his colleagues report that the first laser measurements of the shadowed north polar regions reveal irregular dark and bright deposits near Mercury's north pole.

"Nobody had seen these dark regions on Mercury before, so they were mysterious at first," Neumann says.

Neumann suggests that both the dark and bright materials were brought to Mercury by comets or asteroids, a finding corroborated in a third paper led by David Paige of the University of California, Los Angeles.

"The dark material is likely a mix of complex organic compounds delivered to Mercury by the impacts of comets and volatile-rich asteroids, the same objects that likely delivered water to the innermost planet," Paige says.

This dark insulating material is a new wrinkle to the story, adds Sean Solomon of the Columbia University's Lamont-Doherty Earth Observatory, principal investigator of the MESSENGER mission. "For more than 20 years the jury has been deliberating on whether the planet closest to the Sun hosts abundant water ice in its permanently shadowed polar regions. MESSENGER has now supplied a unanimous affirmative verdict."

"But the new observations have also raised new questions," adds Solomon. "Do the dark materials in the polar deposits consist mostly of organic compounds? What kind of chemical reactions has that material experienced? Are there any regions on or within Mercury that might have both liquid water and organic compounds? Only with the continued exploration of Mercury can we hope to make progress on these new questions."

Stay tuned to Science@NASA for answers.

Production editor: Dr. Tony Phillips | Credit: Science@NASA