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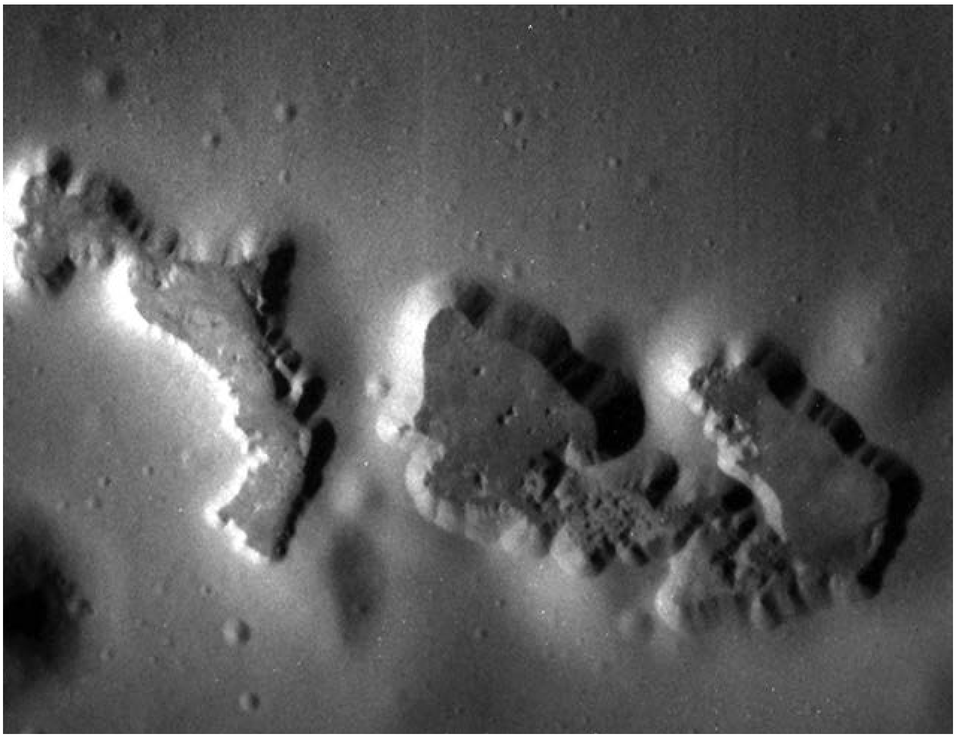
AGU American Geophysical Union

Unprecedented Views of Mercury Constrain Hollow Formation



Blewett et al. [2016]

This is perhaps the best-quality and highest-resolution image of hollows obtained by the Mercury Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) mission. The morphology is very crisp, with flat floors and straight wall profiles. The hollows are about 21 meters deep. No impact craters are visible on the floors of the hollows, even though many small craters occur on the surroundings. The lack of impact craters suggests that the hollows are very young compared with most of Mercury's surface. The edges of the image are about 1.6 kilometers long, and illumination is from the right.

Blewett et al. [2016]

The Mercury impact crater de Graft, 68 kilometers in diameter. MESSENGER images taken though color filters at 996-, 749-, and 430-nanometer wavelength were combined as red-green-blue. The high-reflectance area of the floor (which appears here as white) consists of hollows, shallow depressions that likely form through a process of volatile loss. The dark blue central peak complex is composed of low-reflectance material, which may include remnants of Mercury's early graphite-bearing crust. The yellowish crater rim material originated at shallower depths and has a composition distinct from central peak material. The crater ray that crosses de Graft from the upper right to lower left originated at the Hokusai crater, approximately 1600 kilometers to the northeast.

One of the key results of the Mercury Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) mission was the discovery of thousands of "hollows"—shallow, fresh-looking depressions up to a few kilometers wide—scattered across the planet's surface. Although several lines of evidence indicate that these features form as a result of the loss of volatile materials present in surface rocks and are exposed by impacts, the specific process driving this loss is not yet known.

Now, using new morphological observations from unprecedented high-resolution MESSENGER images, *Blewett et al.* have proposed a new model for the formation and growth of hollows. The team used measurements of shadow lengths to calculate the depth of more than 2500 hollows and found that the depressions' average depth was just 24 meters, substantially less than the typical thickness of the layer of dark volatile-rich material in which the features are most often found.

This material, known as "low-reflectance material" (LRM), is generally kilometers thick, much thicker than the depth of the hollows. Thus, the researchers' finding of consistently shallow hollow depths across the planet suggests that the hollows' shapes are not controlled by the thickness of the host LRM. In other words, the hollows don't burn all the way down through the volatile-bearing dark material and stop once they reach the bottom of this layer.

Rather, the authors argue, a volatile-depleted "lag" deposit, which protects the underlying material once it becomes sufficiently thick, may inhibit deep hollows from forming. The frequent occurrence of hollows on the walls and central peaks of impact craters, locations too steep for lag to develop, is consistent with this proposed view.

The researchers conclude that the hollows' formation and growth may be due to the volatilization of carbon. Recent evidence indicates that carbon in the form of graphite is an important constituent of Mercury's crust. The loss of carbon, they suggest, could occur through either the process of ion "sputtering" or the conversion of graphite to methane via proton bombardment. This carbon loss may create the hollows.

In addition, because of the presence of hollows within several impact craters with ray systems, the team was able to estimate a lower limit for their rate of horizontal growth, which likely occurs via the retreat of scarps that form the hollows' walls. This retreat occurs at a rate of 1 centimeter per 10,000 years, which places an additional constraint on the formation and history of Mercury's mysterious landforms. (*Journal of Geophysical Research: Planets*, https://doi.org/10.1002/2016JE005070, 2016) **—Terri Cook, Freelance Writer**