Researchers use multispectral images to reveal origin and evolution of Mercury

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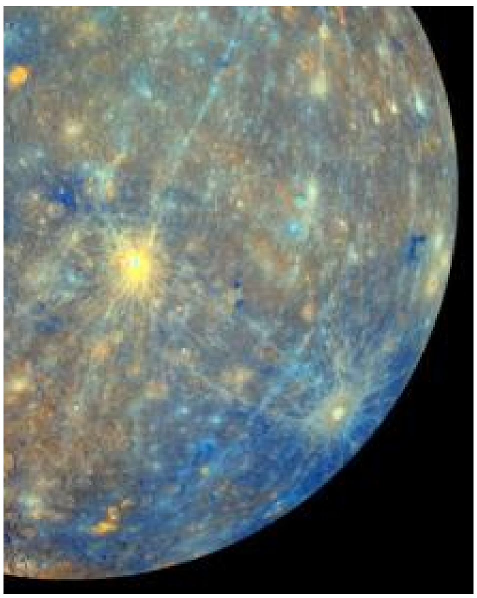
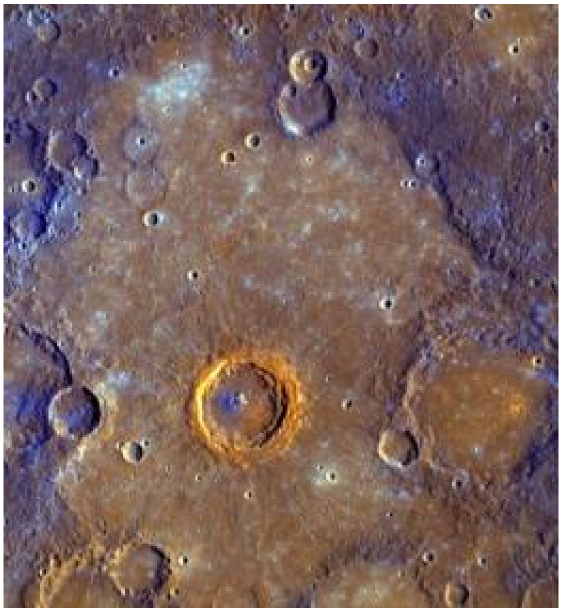


This is a mosaic of images collected by MESSENGER as it departed Mercury on October 6, 2008. The Wide Angle Camera on MESSENGER imaged the surface through 11 color filters ranging in wavelength from 430 to 1020 nm. A principal component analysis of the 11 sets of images helps to highlight subtle color differences. The second principal component, first principal component, and a ratio of the 430 nm to 1020 nm wavelengths are combined here in a red-green-blue composite. Impact craters that formed relatively recently, such as Kuiper (62 km in diameter, yellow crater near center), have contrasting ejecta and rays because they excavated fresh material. As it sits on the surface, this fresh crater material will gradually alter its color until it matches the background material. Other impact craters, such as those with ejecta that appear blue in this color scheme, have color contrasts because they excavated compositionally distinct material from below the surface. Lermontov crater (152 km in diameter), near the top left, appears orange and is thought to contain pyroclastic deposits resulting from explosive volcanic activity in the past. Credit: Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Arizona State University/Carnegie Institute of Washington

Up until last year globes of Mercury were blank on one side. The Mariner 10 spacecraft explored the small planet in three flybys (1974-1975), but since no more than half was ever seen it remained the least understood of the four terrestrial planets - Mercury, Venus, Earth and Mars.

On Oct. 6, 2008, the MErcury Surface, Space ENvironment, GEochemistry, and Ranging spacecraft, better known as MESSENGER, made its second close-approach flyby of Mercury. More than 30 years later MESSENGER has revealed Mercury in almost its entirety for the first time. Using high-resolution and multispectral images, researchers have not only constructed a nearly complete globe, they have also started the difficult process of determining the composition of the planet's crust and chronicling its origin and evolution.

Mercury's interior is thought to generally resemble that of the Earth and Mars - however, Mercury's core is anomalously large leading to it sometimes being called the iron planet. With its ancient craters and smooth plains both covered in a fine-grained gray soil (or regolith), the surface of Mercury superficially resembles the surface of the Moon. Unlike Earth's crust, which is constantly changing and evolving due to processes such as plate tectonics, the crust is relatively static on the Moon and Mercury. The bulk of Mercury's crust formed long ago and preserves a record of early events that shaped it and the subsequent forces that modified it.



Just after MESSENGER's closest approach to Mercury (200 km above the surface), high-resolution color images of Mercury were obtained (500 meters per pixel). These images help to highlight compositional variations within the crust, both horizontally and vertically. At the center, a crater 68 km in diameter exposes the stratigraphy of the region. Material with higher reflectance and a steeper spectral slope (bright orange in this view) is exposed in the ejecta near the crater rim. This material was most likely excavated from a smooth plains unit that was buried by the lower-reflectance plains unit seen surrounding the crater. A portion of the crater's central peak exposes material that is lower in reflectance and has a shallower spectral slope (blue in this color scheme); this material was uplifted by the cratering process from a depth of as much as 10 km. Similar material that can be seen near the edges of the image represents the degraded rim and ejecta of an ancient basin. Credit: Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Arizona State University/Carnegie Institute of Washington

"Mercury's surface tells us something fundamental about how the planet formed and evolved," said Brett Denevi, a postdoctoral research associate in the School of Earth and Space Exploration at Arizona State University. "Some of the little evidence that we had prior to

MESSENGER seemed to indicate that the composition of Mercury's crust was similar to that of the Moon, leading to the presumption that it had formed in the same manner, with any volcanism that may have occurred being only a secondary component," she said.

While the highlands on the Moon are thought to have formed as the result of a global magma ocean, where less dense minerals floated to the surface to form the crust, evidence now points to a mercurian crust that formed in a manner more similar to the crust of Mars than to that of the Moon.

Denevi's research, which appears in the May 1 issue of *Science*, confirms that volcanism on Mercury was widespread, visible across nearly the entire planet, and that much of the crust may have formed in repeated volcanic eruptions.

Denevi, the lead author on the paper, processed and analyzed the images and spectra. To help determine how much of Mercury's surface was comprised of smooth plains she constructed maps by observing overlapping and abutting relations of different landforms. Denevi also compared spectra of Earth and lunar rocks and soils to constrain the maximum amounts of iron- and titanium-bearing minerals that could be on the surface.

Through mapping of the major geologic terrain types, Denevi and her colleagues distinguished three major terrain types on Mercury: smooth plains, intermediate terrain and low-reflectance material (LRM). "Of the three, smooth plains are a key terrain type," she said. "The smooth plains cover approximately 40 percent of the surface, and the majority is probably of volcanic origin." The extent of smooth plains is greater than on the Moon, where volcanic plains cover less than 20 percent of the surface.

MESSENGER's cameras - one high-resolution narrow-angle camera (NAC) and one multispectral wide-angle camera (WAC) - made this detailed exploration of Mercury's surface possible. Mark Robinson, another member of the research team and professor in the School of Earth and Space Exploration in ASU's College of Liberal Arts and Science, is involved with MESSENGER's imaging experiment and is principal investigator for three cameras onboard the Lunar Reconnaissance Orbiter (LRO) spacecraft slated to launch in June.

"MESSENGER provides us with three close encounters of Mercury; the final flyby will happen this fall. What we are seeing now is just a preview of the kinds of data we will acquire in 2011 when MESSENGER finally settles into its mapping orbit about Mercury," said Robinson. "MESSENGER results so far tell us that Mercury had a very complex volcanic and tectonic history early on, but at some point volcanism shut off and still later tectonic deformation probably ceased. Though Mercury has some superficial similarities with the Moon we now know it evolved in a different manner, perhaps more similar to Mars."

The wide-angle camera takes 11 images in a row of the same spot, each using a different filter that allows only certain wavelengths of light to pass through. These filters include wavelengths of light that are visible to the human eye but also longer wavelengths that humans can't see.

"Minerals reflect sunlight in unique ways at different wavelengths," explained Denevi. "Some reflect a lot of light in the visible but less in the near-infrared, so looking at the light that is reflected from Mercury's surface in different colors can help constrain what minerals are present on the surface."

There are areas on Mercury's surface that reflect comparatively little light at any of the wavelengths observed, and those areas are designated as low-reflectance material. Some of the dark units seen on the crust are consistent with high concentrations of iron- and titanium-bearing oxide minerals being excavated from below the surface. Oxide minerals that contain iron and titanium have extremely low reflectance and match what is seen on Mercury. However, this is not a unique solution, so researchers will use information from other instruments on Mercury, such as the Gamma-Ray and Neutron Spectrometer, to determine if the elements are iron and titanium. However, the team will have to wait until MESSENGER is in its mapping orbit about Mercury to fully settle these important composition questions.

"These materials are thought to originate at depth because we see them mainly in the ejecta of impact craters," Denevi explained. "Impact craters provide a great way to probe to the subsurface because impacts dig up material that we normally wouldn't be able to see and expose it on the surface."

"Before we can begin to understand the new planets being discovered around other stars we need to understand Earth and how it became the way it is today," said Denevi. To understand Earth, humans need to know how Mercury, Venus and Mars formed. The four planets are very different, and because Mercury is an extreme case, it is the key to that understanding.

Source: Arizona State University (news : web)