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Geological Activity on Ceres

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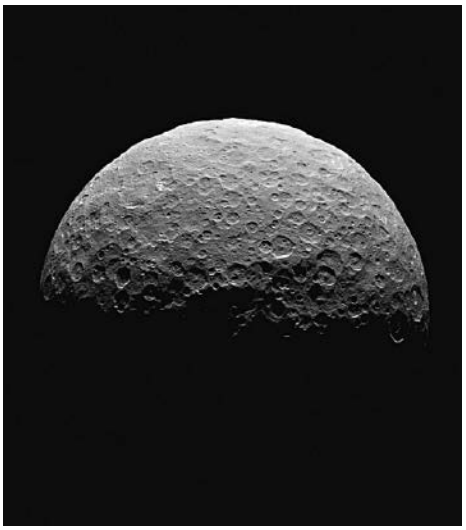
New Findings Suggest Dwarf Planet Ceres Is Geologically Active



NASA/JPL-Caltech/UCLA/MPS/DLR/IDA

NASA's Dawn probe entered Ceres's orbit on 6 March 2015. This image, taken in mid-April of that year, shows Ceres's northern end.

When scientists got their first close-up glimpse of Ceres in 2015, they expected to find a large, inert rock orbiting along with the millions of other inert rocks in the asteroid belt. What they did not expect was evidence of geologic activity on the dwarf planet's dark surface.

In a suite of six papers published on 1 September in *Science*, scientists from the Dawn mission, which has a spacecraft circling Ceres, catalog a bounty of surface features pointing to one conclusion: "Ceres appears to be geologically active," said Carol Raymond, the mission's deputy principal investigator. The Dawn spacecraft entered Ceres's orbit in March 2015.

Volcanic Ice

One of these surface features is a 17-kilometer-wide, 4-kilometer-high volcano that once erupted ice. This "cryovolcano" rises half the height of Earth's Mount Everest in the Himalayas.

The researchers spotted the cryovolcano using Dawn's Framing Camera, which took images of 99% of the dwarf planet's surface. The feature's angled slopes with flow-like structures and concave summit are reminiscent of lava domes on Earth, said Ottaviano Ruesch, a postdoctoral researcher at NASA's Goddard Space Flight Center and lead author on the paper detailing the feature (see http://bit.ly/cryovolcanism).

Ruesch compared the Ceres prominence to a lava dome found in Washington State's Mount St. Helens volcanic crater. Although features of cryovolcanic origin have been spotted on other bodies in the solar system, the newly named Ahuna Mons on Ceres stands out as the first observed cryovolcanic dome, he said.

On Earth, lava domes form when sticky, viscous, molten rock bubbles slowly to the surface, solidifies, and piles up around the vent. On Ceres, where temperatures average about 160 K (−113°C), volatile, rich, salty water "erupts," the researchers suggest. The presence of salts on Ceres lowers the freezing temperature of water, said Ruesch. The lowered freezing temperature keeps the water a liquid that slowly rises to Ceres's surface. There it solidifies and has piled up into a 4-kilometer-high mound.

Although Ahuna Mons is no longer active, by analyzing the number of craters around the feature, scientists estimate that it's only about 200 million years old, Ruesch said, which is considered geologically young.

Bright Spots

Ceres sports well-known bright spots on its surface—the newly released findings point to these as signs of more geologic activity, Raymond said. The team had already established that Ceres's bright spots are composed mainly of sodium carbonate, a salt found abundantly at the bottom of Earth's oceans. Because no crashing asteroid could have brought this material to the dwarf planet, the scientists suspect that it rose to the surface from within.

On Earth, we know how magma rises to the surface: The hot interior transfers heat to rock above it, which rises as it becomes more buoyant; meanwhile, colder rocks farther away sink down to be reheated. This process continues until hot, molten rock breaks through the stiff, cold crust.

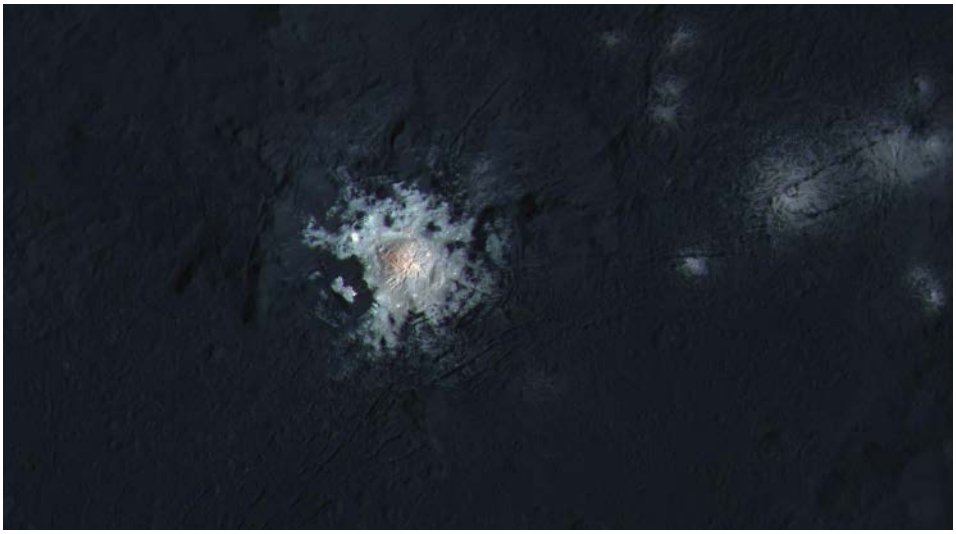
In a similar fashion, the bright spots may represent patches where brines upwelled, spilled out onto the surface, and dried, leaving the salts behind. But in Ceres's case, the Dawn team isn't quite sure how the melted brine moves upward.

"We have, we believe, some partially melted brines at depth," Raymond said, but "we don't have an obvious mechanism by which those cryomagmas can get to the surface."

Impacts and Flows

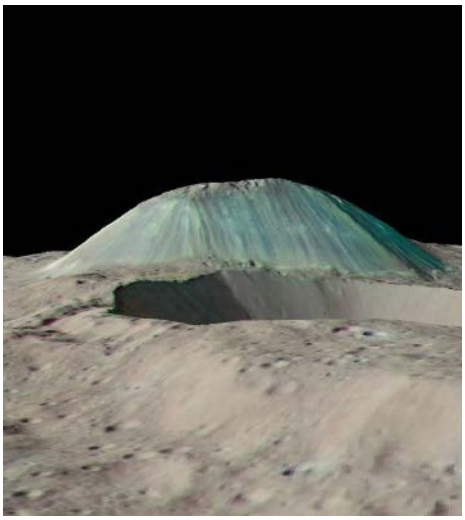
Evidence for other bursts of geologic activity shows up near impact craters, as detailed in another paper on the dwarf planet's geomorphology (see http://bit.ly/geo-morph).

On a geologically inactive world, an impact would hurl material into the air that would then settle down around the crater. But on Ceres, features in the vicinity of many impact



NASA/JPL-Caltech/UCLA/MPS/DLR/IDA/PSI/LPI

Enhanced color view of the bright spot within Ceres's 92-kilometer-wide Occator crater. The image was produced by overlaying high-resolution images obtained in February 2016 with color images obtained in 2015.



NASA/JPL-Caltech/MPS/DLR/IDA

In a false-color image from the Dawn probe's Framing Camera, blue streaks on Ceres's cryovolcano Ahuna Mons indicate a chemical composition different from the rest of the landscape.

craters suggest that material flowed for many tens of kilometers, indicating that the crust contains some ice, which melted from the crash of an incoming meteor.

The researchers spotted many extensive examples of such impact-induced flow that lasted longer than would be expected on an inert world, said Chris Russell, Dawn's principal investigator.

Landslides also appear to occur on Ceres, as evidenced by the team's discovery of surface water ice on the steep slopes inside a crater called Oxo (see http://bit.ly/H2O-exposed). Dawn data suggest that a pliable, ice-rich layer lies underneath the stiffer, rocky surface. Because ice would sublimate from an inert planet's surface within roughly a century, finding exposed ice raises the possibility that a series of landslides or very slow slippage of the surface is currently exposing fresh ice.

"We have no idea how long [the landslide] has been active," Russell said. But the fact that Dawn scientists see ice suggests that the process is ongoing, he noted.

A Dynamic World

The team expected to find a completely cooled-off, geologically dead world, with possible features of past activity, Raymond said.

"Finding evidence for ongoing activity is surprising," she continued, "and it's clearly giving us a lot to think about in terms of how this body works."

By **JoAnna Wendel,** Staff Writer

Next President Must Name Science Leaders Fast, Report Urges

The next U.S. president should move quickly to appoint a nationally recognized scientist or engineer as science adviser, according to a recent set of recommendations from an academic policy think tank on the presidential transition.

The incoming administration should also rapidly install a leadership team for the White House Office of Science and Technology Policy (OSTP) and ensure that the office has access and resources to help integrate science and technology (S&T) advice at the White House and across federal agencies, according to "The Vital Role of the White House Office of Science and Technology Policy in the New Administration" (see http://bit.ly/vital-role).

The Baker Institute for Public Policy at Rice University in Houston, Texas, issued the recommendations on 14 September.

Why Focus on OSTP?

The document says that "the next administration will need to address a number of public policy challenges necessitating immediate S&T expertise," including environmental concerns and natural disasters. It adds that "the presidential transition is a critical period for ensuring S&T is responsibly and effectively represented in policymaking in the White House."

The Rice University recommendations call OSTP "the one place in the federal government that focuses on the efficiency and impact of the collective federal S&T effort." It urges the White House to have OSTP promptly draft an administration strategy paper on S&T goals. The new president should also seek counsel from the White House science adviser, who heads OSTP, in filling other senior positions relating to S&T.

Steering Clear of Policy Recommendations

The Rice document avoids providing the next administration with guidance about how to deal with specific S&T issues, although the conclusion lists a sampling of policy areas warranting attention, including climate change.

"It's a nonpartisan document. What we are trying to say, in a way that doesn't create kneejerk reactions, negative reactions, is [that climate change] is a very important issue," said Baker Institute senior fellow Neal Lane at a 14 September briefing. Lane was OSTP director and science adviser to President Bill Clinton from 1998 to 2001.

> Science and technology "are embedded in almost every issue that the president deals with."

Lane told *Eos* that because of the significance of climate change and because there are laws, regulations, and international agreements about it, "whatever your political stripe is coming in, you're going to have to deal with [climate change]. It's just a fact. That's how we tried to treat it, and not use this document to try to push a priority in some area of health care, some biomedical or geosciences [area], or anything else."

Science and Technology Embedded in Issues

At the briefing, Rush Holt, CEO of the American Association for the Advancement of Science in Washington, D. C., said that science and technology "are embedded in almost every issue that the president deals with," including issues not traditionally associated with science such as justice, diplomacy, and social welfare. "We want this person and this office fully integrated in that process, for the president's own good, and for the country's," he said.

Norman Augustine, retired chairman and CEO of the aerospace company Lockheed Martin, said that the Rice recommendations deserve serious consideration. Now is "a very critical moment in the nation's history" for U.S. research and competitiveness, he asserted, because of falling funding as other nations are increasing their investments.

Although neither Augustine nor Holt was a contributor to the recommendations, they reviewed them and appeared at the briefing to show their support, a Rice spokesperson said.

Specifically regarding space research, Augustine—who once advised OSTP on the subject—told *Eos* that a new administration should resist the temptation to "start from scratch" in defining NASA's goals. He added that NASA's goals should be matched with adequate funding and other resources. "If we don't, it's just a way to waste money," he said.

By **Randy Showstack,** Staff Writer