You're beautiful, Vesta

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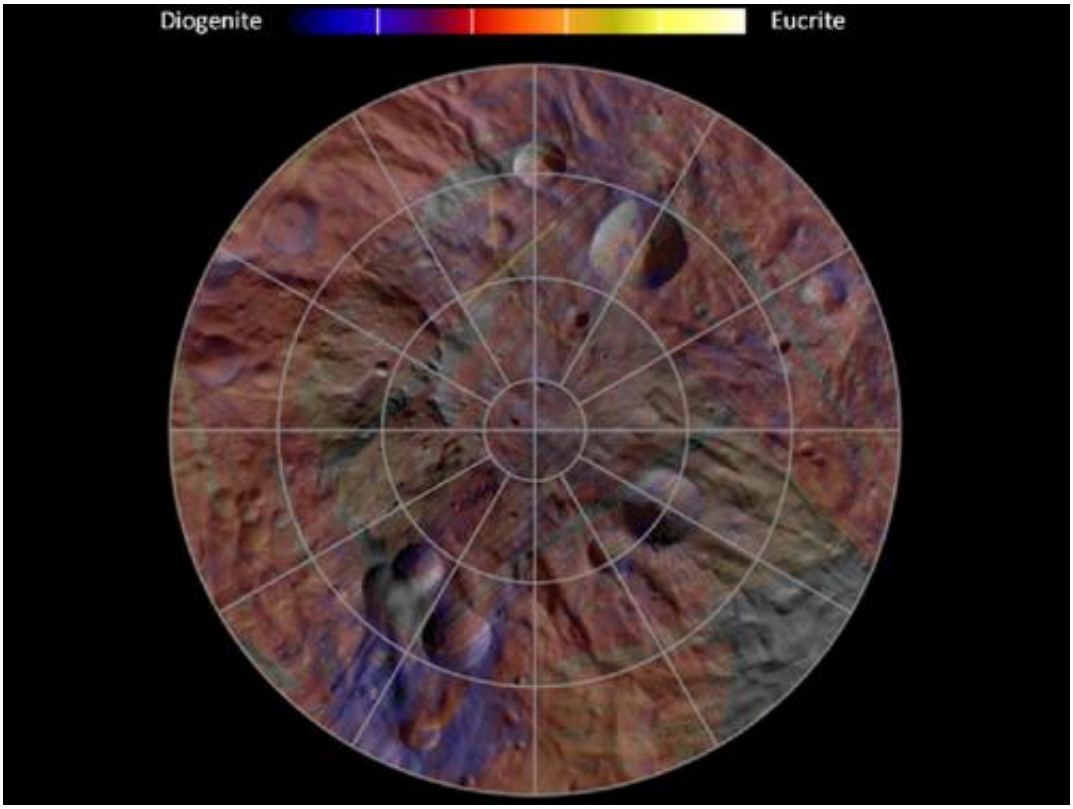

This image, made from data obtained by NASA's Dawn spacecraft, shows the mineral distribution in the southern hemisphere of the giant asteroid Vesta. Image credit: NASA/JPL-Caltech/UCLA/INAF/MPS/DLR/IDA

When UCLA's Christopher T. Russell looks at the images of the protoplanet Vesta produced by NASA's Dawn mission, he talks about beauty as much as he talks about science.

"Vesta looks like a little planet. It has a beautiful surface, much more varied and diverse than we expected," said Russell, a professor in UCLA's Department of Earth and Space Sciences and the Dawn mission's principal investigator. "We knew Vesta's surface had some variation in color, but we did not expect the diversity that we see or the clarity of the colors and textures, or their distinct boundaries. We didn't find gold on Vesta, but it is still a gold mine."

Dawn has been orbiting Vesta and collecting data on the protoplanet's surface since July 2011. Vesta, which is in the doughnut-shaped asteroid belt between Mars and Jupiter, is currently some 321 million miles from Earth.

The journal *Science* publishes six papers about Vesta on May 11. Russell is a co-author on all of them.

Russell and his scientific team expected to find a large crater on Vesta, but they were surprised to find two, with the larger one essentially on top of the smaller. The smaller crater covers roughly the distance from Los Angeles to Monterey, Calif.; the larger one would stretch from L.A. to San Francisco.

"When we got to Vesta, we found two very large impacts, both in the southern region," Russell said. "One dates at about a billion years ago, and the other at least 2 billion years ago. Seeing two was a real discovery, and getting their ages is even better. The ages look like they correspond to the dates when we think rocks were blasted off Vesta; some came all the way to Earth. The large size of the craters can easily account for the material that came off, to fall as meteorites and many smaller 'Vestoids' that are like very large boulders."

Many of the so-called Vestoids are approximately one-half mile to five

miles across, and there may be thousands of them throughout the asteroid belt, Russell said. Named for the ancient Roman goddess of the hearth, Vesta has been bombarded by comets, meteoroids and its smaller siblings for 4.5 billion years.

Among the other new discoveries reported in *Science*:

- Vesta has large mountains — the largest is more than twice the size of Mount Everest — which were formed by a major impact to the protoplanet's surface. Scientists thought most of Vesta outside the south polar region might be flat like the moon, yet some of the craters outside that region formed on very steep slopes and have nearly vertical sides, with landslides often occurring in the regolith, the deep layer of crushed rock on the surface.
- The Dawn mission has witnessed a pattern of minerals exposed by deep gashes created by space-rock impacts to Vesta. This might support the idea that Vesta was once molten inside and had a sub-surface magma ocean.
- Vesta has an iron core, formed during the period in which the protoplanet was molten, at the earliest epoch of the solar system; Dawn's measurements of Vesta's gravitational field have confirmed this. This finding was expected because meteorites from Vesta have less iron than the solar nebula from which planetary building blocks formed. That the iron is indeed sequestered in Vesta's core confirms thinking that Vesta separated into layers when it formed, and this starting composition allows scientists to constrain early solar system models.
- Vesta's surface contains many bright spots of varying size. A real surprise is that Vesta also has some areas as dark as coal. The dark and light markings form intricate patterns suggesting the

> dominance of impact processes in creating mixed layers in Vesta's regolith.

"It looks like an artist has painted the craters in fancy patterns," Russell said. "It is beautiful, and surprising."

Dawn has obtained more than 20,000 images of Vesta and millions of spectra, or data collected from different wavelengths of radiation.

"Everything is working," Russell said proudly.

Studies of meteorites found on Earth that are linked to Vesta suggest that Vesta formed from interstellar gas and dust during the solar system's first 2 to 5 million years.

"Vesta has been recording the history of the solar system from the beginning," Russell said. "We are going back to the beginning of the solar system — more than 4.5 billion years ago. We're going back further than ever before on the surface of a body."

The Dawn mission, which launched in September 2007, has been as close as 125 miles from the surface of Vesta, which has an average diameter of approximately 330 miles.

Dawn has a high-quality camera, along with a back-up; a visible and near-infrared mapping spectrometer to identify minerals on the surface; and a gamma ray and neutron spectrometer to reveal the abundance of elements such as iron and hydrogen, possibly from water, in the soil. Dawn also probes Vesta's gravity using extremely precise navigation.

The study of Vesta, however, is only half of Dawn's mission. The spacecraft will also conduct a detailed study of the structure and composition of the dwarf planet Ceres. Vesta and Ceres are the most

massive objects in the main asteroid belt between Mars and Jupiter. Dawn's goals include determining the shape, size, composition, internal structure, and tectonic and thermal evolution of both objects, and the mission is expected to reveal the conditions under which each of them formed.

Dawn, the second scientific mission to be powered by an advanced NASA technology known as ion propulsion, is the first NASA mission to orbit two solar system targets beyond the moon.

After orbiting Vesta, Dawn will leave for its nearly three-year journey to Ceres, which could harbor substantial water or ice beneath its rock crust — and possibly life. The spacecraft will rendezvous with Ceres and begin orbiting in 2015, conducting studies and observations for at least five months.

"I want to squeeze every last image out of Vesta before we leave," Russell said. "We will be analyzing Vesta's surface properties at least until we get to Ceres."

Provided by University of California, Los Angeles