Proto-planet was shaped by massive collisions

Simulations suggest cause of Vesta's lopsided form.

Geoff Brumfiel

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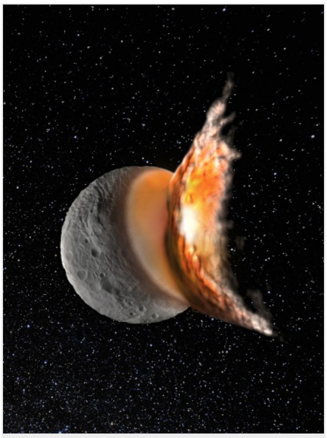
One of the largest bodies in the asteroid belt between Mars and Jupiter may have been the victim of a double hit and run. Models suggest that Vesta has been hit twice by planetary-scale objects, leaving huge scars on its surface.



Martin Jutzi

A massive collision (artist's impression) might have left Vesta in its present lopsided shape.

But the theorized smash is causing a clash among scientists, who disagree over what it might say about Vesta's structure. A paper describing the models is published today in *Nature*[1].

Scientists think that Vesta, which is some 530 kilometres in diameter, formed more than 4.5 billion years ago, just a few million years after the Solar System began. It seems to be covered in volcanic rock similar to that seen on Earth, and a huge crater in its southern hemisphere hints at a violent past.

"You really wouldn't call it a crater — it's more like it's missing most of its southern hemisphere," says Erik Asphaug, a planetary physicist at Arizona State University in Tempe. The 1-billion-year-old feature — named Rheasilvia after the mythical Roman vestal priestess Rhea Silvia, mother of Rome's founder Romulus and his twin brother Remus — partially obliterates a second, even older crater, almost as large.

Double trouble

Asphaug and his colleagues think that a pair of primordial pummellings may explain Vesta's dramatic scars. The team ran three-dimensional computer simulations to try to recreate details of the two craters. They started with a spherical Vesta and hit it with two rocks, each more than 60 kilometres across.

Nature Podcast

Erik Asphaug tells Geoff Brumfiel what the 3D simulations reveal about the evolution of Vesta’s dramatic landscape.

You may need a more recent browser or to install the latest version of the Adobe Flash Plugin.

The modelled impacts produced a body that looked a lot like Vesta, but offered a surprise. According to the predictions, the collisions should have ejected material from 100 kilometres below Vesta's surface, turning the body inside out. However, Asphaug says, on the surface "we don't see what we classically think of as interior materials".

In particular, there is no sign of olivine, a type of rock that exists in Earth's mantle and has been thought to lie inside Vesta. That, says Asphaug's team, suggests that Vesta's crust is at least 100 kilometres thick, and that its mantle and core are smaller than had been thought. Asphaug thinks that Vesta resembles the early stages of development of planets in the Solar System, so the model could change scientists' understanding of how rocky planets such as Earth formed.

Contrary collisions

But other scientists are not necessarily buying it. The computer simulation "does not reproduce the Vesta I see", says Christopher Russell, a planetary scientist at the University of California, Los Angeles, and principal investigator of NASA's Dawn mission, which orbited Vesta in 2011–12. He says that, contrary to the model's predictions, Vesta seems to have survived the collisions without turning inside out. And, he adds, debris piles around the craters are too small to reconcile with a deep impact.

For these reasons, he feels that the paper's prediction of a 100-kilometre-deep impact is almost certainly wrong. "Of course if it were correct, it would be revolutionary, something that is true for almost every incorrect idea," he says.

The model isn't perfect, agrees Maria Cristina De Sanctis, a planetary scientist at the Italian National Institute for Astrophysics in Rome. But, she says, the shape that it predicts matches Vesta reasonably well. Perhaps the olivine is mixed with other materials that make it difficult to detect, she suggests. Overall, "it seems to me it's a good model".

Despite the criticisms, Asphaug stands by his version of how Vesta got its scars. "We're pretty confident in the deep-digging aspect of our results," he says.

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References

1. Jutzi, M., Asphaug, E., Gillet, P., Barrat, J.-A. & Benz, W. *Nature* **494**, 207–210 (2013).