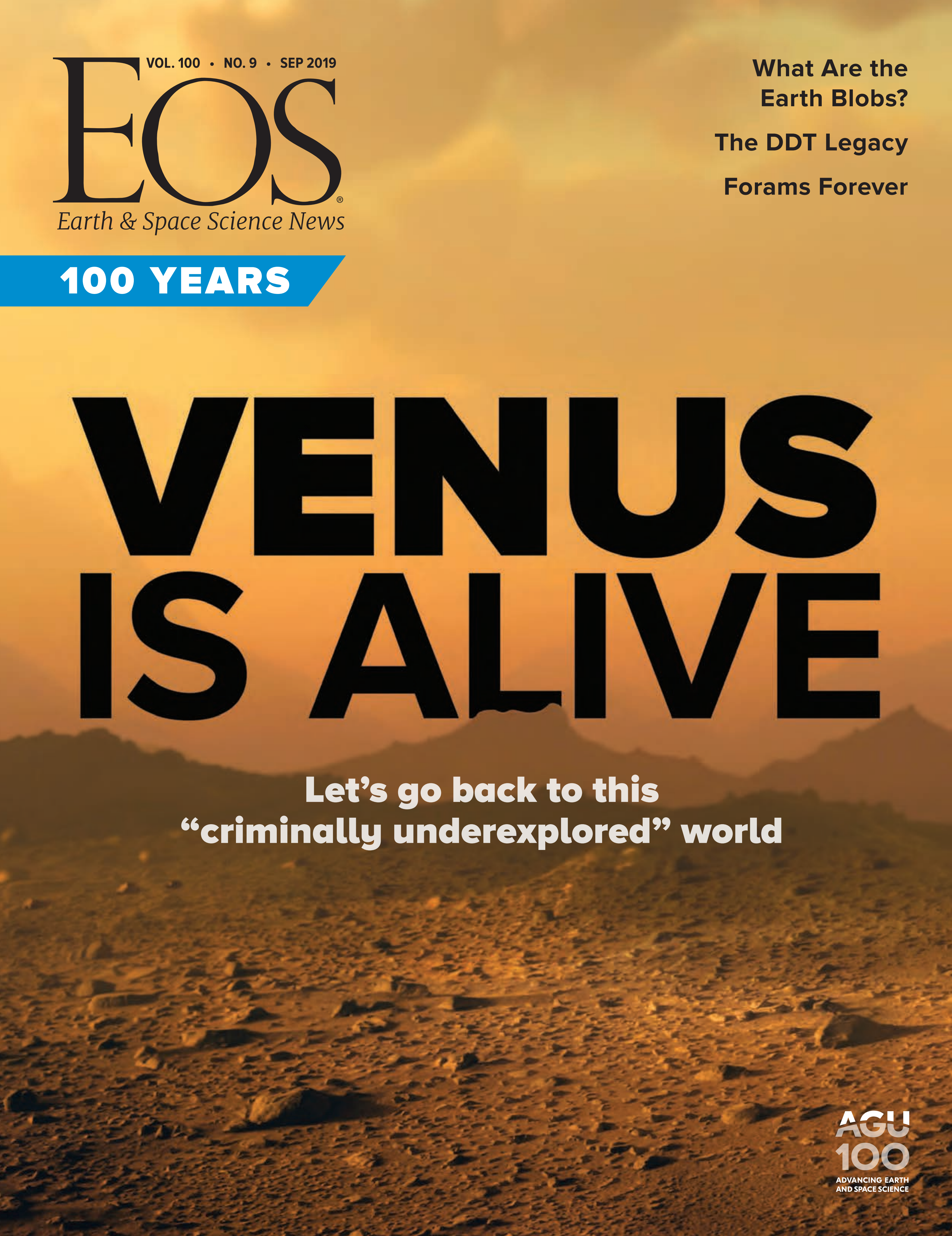

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How the Moon Got Its Concentric Rings

The Moon is pockmarked with impact craters from collisions with meteorites and asteroids, some as big as 1,000 kilometers in diameter. These massive impact craters contain three or more concentric rings, a mysterious feature that has long intrigued scientists interested in how Earth's early surface and those of other planets evolved. A new study, in which scientists simulated an asteroid bigger than New York City slamming into a Moon-like object, explores how such rings form.

Billions of years ago, Earth looked a lot like the Moon: riddled with craters from impacts with asteroids and other space debris. Many of these craters have been erased or eroded by the atmosphere and the water owing over Earth's surface, so scientists must look to the atmosphereless Moon to reconstruct how different crater feat res are created.

Researchers already know a lot about how relatively small, simple impact craters form. When a projectile hits its target, it transfers its kinetic energy to the planet or moon, creating powerful shock waves that ripple through the rock. The projectile simultaneously melts and vaporizes, launching molten and solid rock called ejecta hundreds of kilometers away. Then the remaining ejecta rings the crater site and slumps inward, forming a smooth bowl.

On the Moon, this process seems to hold for craters smaller than 20 kilometers in diameter. As impact craters get bigger, however, they grow more complex, eventually forming multiple concentric rings. For example, one of the Moon's most famous impact craters—the nearly 1,000-kilometer-wide Orientale basin—has three distinctive, bull's-eye-like rings that have long confounded scientists.

To get a fresh perspective on this complex crater structure, *Johnson et al.* took advantage of data from NASA's Gravity Recovery and Interior Laboratory (GRAIL) mission: two washing machine–sized spacecraft that orbit the Moon and produce a high-resolution map of its gravitational field. Using this new, 10-kilometer-scale data, the authors were able to build a high-resolution computer model of a 64-kilometer-diameter asteroid hurtling into a Moon-like object at 15 kilometers per second.

The team found that the dominant hypothesis for how concentric rings form in impact craters, known as ring tectonic theory, appears to be correct. In this hypothesis, rings are formed as rock flows inward d ring crater collapse, dragging the base of the lithosphere—a planet's or moon's rigid, outermost rock shell—and creating a distinctive pattern of faults in the rock, forming rings.

A view from Lunar Orbiter 4 of the Orientale basin on the Moon. Credit: NASA

By tweaking different variables within the simulation, the researchers discovered that factors such as the interior temperature of the Moon, the strength of the lithosphere, and the thickness of its crust affect ring loc -tions and spacing. They were able to reproduce the approximate spacing and offset of Orientale's rings, bolstering both the model's credibility and ring tectonic theory itself, the authors report. (*Journal of Geophysical Research: Planets,* https://doi.org/10.1029/2018JE005765, 2018) **—Emily Underwood, Freelance Writer**