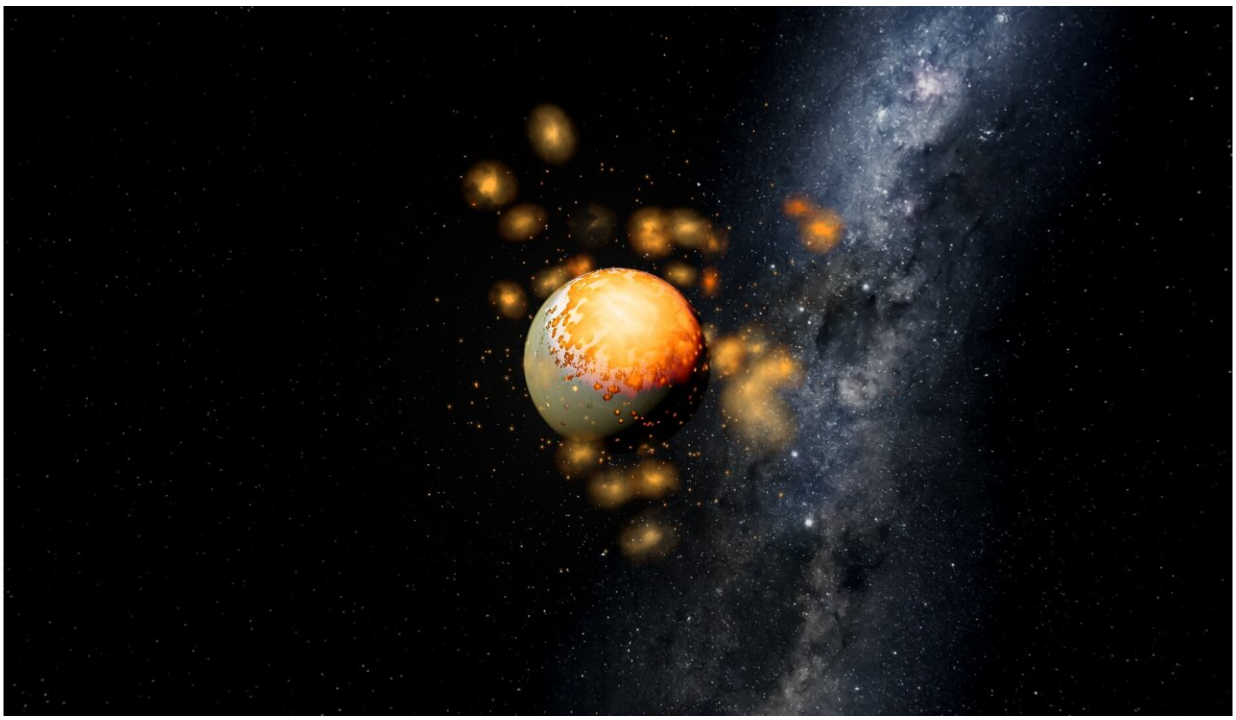
Researchers find ancient, high-energy impacts could have fueled Venus volcanism

July 20 2023



An SwRI-led team compared the early impact history of Venus and Earth, determining that Venus experienced higher-energy impacts creating a superheated core. Models show these conditions could create Venus' extended volcanism and younger surface. Credit: Southwest Research Institute

A Southwest Research Institute-led team has modeled the early impact history of Venus to explain how Earth's sister planet has maintained a youthful surface despite lacking plate tectonics. The team compared the early collision histories of the two bodies and determined that Venus likely experienced higher-speed, higher-energy impacts creating a superheated core that promoted extended volcanism and resurfaced the planet.

"One of the mysteries of the inner solar system is that, despite their similar size and bulk density, Earth and Venus operate in strikingly distinct ways, particularly affecting the processes that move materials through a planet," said Dr. Simone Marchi, lead author of a new paper about these findings in *Nature Astronomy*.

The Earth's shifting plates continuously reshape its surface as chunks of the crust collides to form mountains ranges, and in places promote volcanism. Venus has more volcanos than any other planet in the solar system but has only one continuous plate for its surface. More than 80,000 volcanos—60 times more than Earth—have played a major role in renewing the planet's surface through floods of lava, which may continue to this day. Previous simulations struggled to create scenarios to support this level of volcanism.

"Our latest models show that long-lived volcanism driven by early, energetic collisions on Venus offer a compelling explanation for its young surface age," said Professor Jun Korenaga, a co-author from Yale University. "This massive volcanic activity is fueled by a superheated core, resulting in vigorous internal melting."

Earth and Venus formed in the same neighborhood of the solar system as solid materials collided with each other and gradually combined to form the two rocky planets. The slight differences in the planets' distances from the sun changed their impact histories, particularly the number and outcome of these events.

These differences arise because Venus is closer to the sun and moves faster around it, energizing impact conditions. In addition, the tail of collisional growth is typically dominated by impactors originating from beyond Earth's orbit that require higher orbital eccentricities to collide with Venus rather than Earth, resulting in more powerful impacts.

"Higher impact velocities melt more silicate, melting as much as 82% of Venus' mantle," said Dr. Raluca Rufu, a Sagan Fellow and SwRI co-author. "This produces a mixed mantle of molten materials redistributed globally and a superheated core."

If impacts on Venus had significantly higher velocity than on Earth, a few large impacts could have had drastically different outcomes, with important implications for the subsequent geophysical evolution. The multidisciplinary team combined expertise in large-scale collision modeling and geodynamic processes to assess the consequences of those collisions for the long-term evolution of Venus.

"Venus internal conditions are not well known, and before considering the role of energetic impacts, geodynamical models required special conditions to achieve the massive volcanism we see at Venus," Korenaga said. "Once you input energetic impact scenarios into the model, it easily comes up with the extensive and extended volcanism without really tweaking the parameters."

And the timing of this new explanation is serendipitous. In 2021, NASA committed to two new Venus missions, VERITAS and DAVINCI, while the European Space Agency is planning one called EnVision.

"Interest in Venus is high right now," Marchi said. "These findings will have synergy with the upcoming missions, and the mission data could help confirm the findings."

More information: Simone Marchi et al, Long-lived volcanic resurfacing of Venus driven by early collisions, *Nature Astronomy* (2023). DOI: 10.1038/s41550-023-02037-2. www.nature.com/articles/s41550-023-02037-2

Provided by Southwest Research Institute