High-speed impacts may have shaped Venus' history

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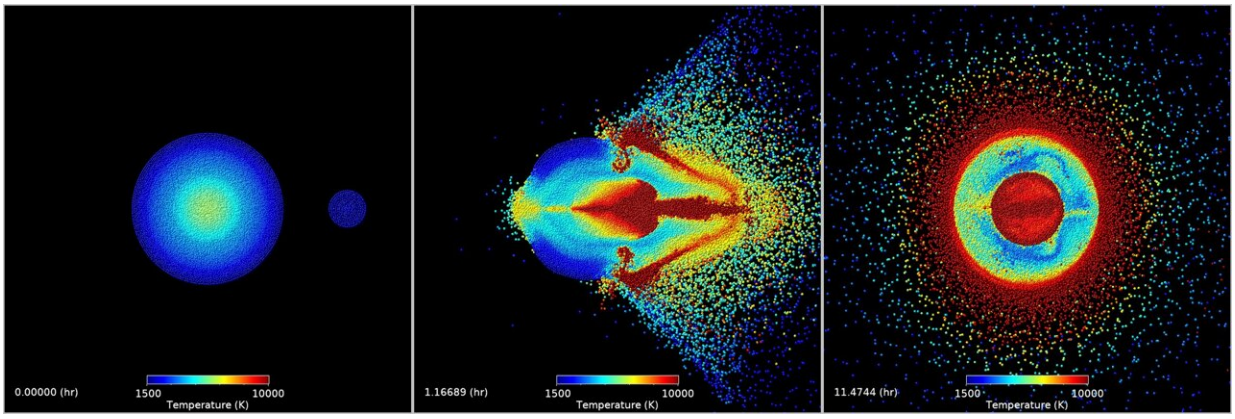

An example of a smoothed particle hydrodynamics impact simulation of a large planetesimal striking a Venus-like planet. The middle and right panels show Venus 1 hour and 11 hours after impact. Colors indicate temperature. Credit: Southwest Research Institute/Simone Marchi & Raluca Rufu.

New modeling suggests large, high-speed impacts during Venus' early history could reconcile the differences between Venus and its rocky sister planet, Earth.

The two planets are alike in many ways. They have similar sizes, masses and densities, and they are relatively similar distances from the Sun. Yet some key differences—such as habitability, atmospheric composition and plate tectonics—have remain unexplained.

High-speed impacts could help explain why Earth is habitable while Venus is not, according to new research being presented at the AGU Fall Meeting 2021.

"Early on, in the beginning of the Solar System, the impactors would have been immense," said Simone Marchi, a planetary scientist at Southwest Research Institute, who will be presenting the study on Thursday, 16 December at 9:10 a.m. CST. "If an early impactor was larger than, say, a few hundred kilometers in diameter, it could have affected the deep interior of a planet, along with its surface and atmosphere. These colossal collisions would basically affect everything about a planet."

Recent work from a different research group showed impactors during Venus' late accretionary phase, around 4.5 to 4.0 billion years ago, could have hit the planet at much higher speeds, on average, than those colliding with Earth. More than one-quarter of collisions with Venus would have occurred at velocities of at least 30 kilometers per second (about 67,100 miles per hour).

The new research demonstrates the large, high-speed impacts on Venus lead to twice as much mantle melting than impact-induced melting on Earth. High-speed impactors hitting Venus at a shallow angle would have resulted in complete melting of the mantle, according to the new research.

When even just one of these massive, high-velocity impactors hit Venus, it would have interrupted and essentially reset the planet's evolution, according to Marchi. Venus could have gone from a solid rocky body to a molten mess in moments, altering the mineralogy and physical structure of the planet's interior and surface. Any pre-existing atmosphere would have been largely blasted away and replaced by volatile gasses emerging from the melt. A single high-speed impact

could have ultimately determined whether or not tectonic plates formed, which is an important aspect of habitability.

While large impacts likely pummeled both Earth and Venus, the latter could have undergone substantial more melting and disruption due to the high speed of its impacts, setting the planets on divergent evolutionary pathways. For both planets, and the Solar System as a whole, these early collisions had big consequences on their habitability—or lack thereof—today.

"These collisions were responsible for shaping the Solar System. It's not a stretch of the imagination to say that lacking these processes, we would live in a completely different environment, and perhaps we wouldn't be here," Marchi said. "We need to ask how much of the planet we live on today was shaped by these early, violent events."

More information: Paper presentation: agu.confex.com/agu/fm21/meetin … app.cgi/Paper/891443

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