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A surprisingly geologically active Venus – evidence for recent volcanic and tectonic activity

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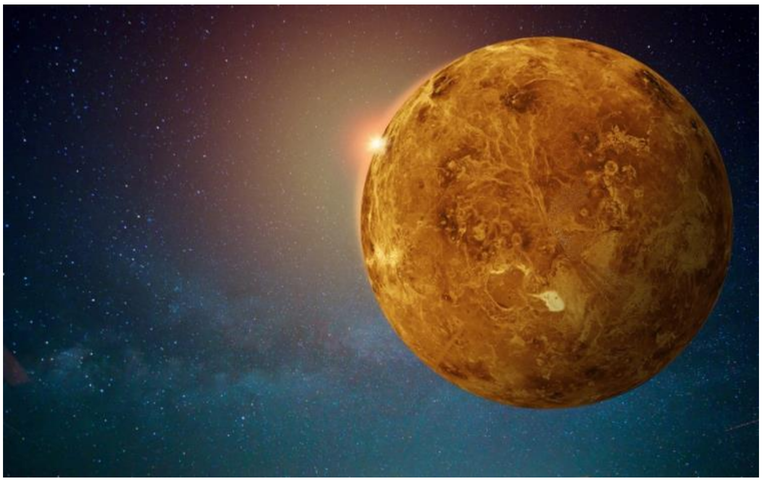
The surface of Venus is littered with ring-shaped structures called "coronae", whose formation is often linked to tectonic and volcanic activity in the past. Yet, using computer simulations that mimic their formation, we show how these structures provide unique insights into the present-day dynamics of Venus' interior. We identify dozens of locations on Venus with rising magma underneath.



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Our neighboring planet Venus is often called Earth's "twin" due to similarities in size, mass, and chemical makeup, but it's also considered to be an unusual planet that scientists are still trying to understand. Whereas Earth's environment can host life, that of Venus is typically described as hellish: its surface roasts at temperatures of hundreds of degrees Celsius and is cloaked by a crushingly thick atmosphere under a suffocating layer of acid clouds.

Venus also has no plate tectonics, the process that shapes Earth's geology. Nevertheless, the surface of Venus is scarred with many tectonic and volcanic structures, but it remains unclear just how and when these these structures were formed. Understanding the geology at play on Venus is key for understanding processes that may have taken place in Earth's early history, and the evolution of rocky planets in general.

It was long thought that the planet has been "geologically dead" for hundreds of millions of years. Recent discoveries, however, reopened the debate of Venus' puzzling geology by identifying recently active volcanoes on the planet. We contribute to this debate by arguing that the mysterious corona structures on the surface of Venus bear testimony for ongoing turbulent processes in Venus' interior.

Coronae (Latin for 'crowns', singular corona) are large ring-shaped features on the surface of Venus with traces of tectonic and volcanic activity. With their peculiar shapes, and especially their huge dimensions (from 60 to over 1000 kilometers wide), coronae are unlike any volcanoes we see nowadays on Earth. They have formed where rising hot magma from deep within the planet makes its way up through the planet's mantle and crust. This rising, hot material may destroy patches of the planet's surface and create the unique corona structures. Scientists originally thought coronae were ancient structures, ranging in age from tens to hundreds of millions of years. However, coronae exhibit a large variety of structures and shapes, and the reason behind this diversity remains unclear. We systematically ran 3D computer models that mimic the formation of coronae to establish a link between the variation in surface shape and the processes at work beneath.

The new simulations show that a corona's shape depends on the thickness and strength of the crust where the magma strikes it. Above all, the simulations show that these shapes are directly related to how active the column of magma beneath the surface is. In the computer models, the shape of a corona changes drastically over time, as the hot, rising magma slowly cools down and solidifies. As a result, we found tell-tale signs showing whether a region is geologically active or not. For example, we learned that deep trenches and outer rises signify activity, whereas a raised rim with an inner depression points to inactivity.

Guided by the conclusions of these simulations, we classified over a hundred of large coronae on Venus into two main groups: those that have formed above an active region of magma that is currently rising and carrying molten material, and those above a region that has already cooled down and become inactive. This was done by looking at the shapes of coronae using topography data from NASA's Magellan mission, that took place between 1989 and 1994.

This assessment revealed many regions of ongoing magma activity on the planet, mostly arranged in a belt in Venus' southern hemisphere. These results present new evidence for widespread recent geological activity on the surface of Venus. This changes the view of Venus from a mostly inactive planet to one whose interior is still churning and can feed many active volcanoes!

There are still many unanswered questions when it comes to Venus' geology. For example, why are the active regions arranged in a belt, and what does this mean for processes deep below the surface? To study these questions, and to give further justification for our hypothesis, we need new data. However, most geological data of Venus mainly comes from the Magellan mission, which took place over 25 years ago. This data is therefore outdated, and its low resolution makes it difficult to be used for sophisticated comparisons with simulations. In fact, among us, many planetary scientists have been expressing the necessity of acquiring new and improved data of the planet.

Fortunately, both NASA and ESA have answered to this appeal and not one, but three new planetary scientific missions to Venus were recently selected. Out of these, NASA's VERITAS and ESA's EnVision missions will have a special focus on Venus' geological evolution, and possible present-day volcanic activity. A future era of Venus science awaits, and these new missions have the potential to fulfill major gaps in our knowledge of the planet. How and why did Earth and Venus take such different evolutionary paths, even though they started out with the same composition? What are the physical mechanisms responsible for Venus' geologic activity? Why is Earth habitable, and Venus not? We are beyond thrilled that we are going back to Venus, a planet which appears to be slowly revealing its secrets. Let's uncover these secrets, shall we?