Unique tectonics on Venus modeled in lab to explain coronae

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Venus imaged by the Magellan spacecraft. Credit: NASA/JPL

(Phys.org)—A trio of planetary scientists has created a physical model of part of the surface of Venus and in so doing may have solved the mystery of tectonics on Venus. In their paper published in the journal *Nature Geoscience*, Ann Davaille, Suzanne Smrekar and Steve Tomlinson with Université Paris-Sud, the Jet Propulsion Lab at Caltech and the University of California, describe their model and what they believe it revealed.

For many years, planetary scientists have been frustrated by their inability to better understand the major processes that impact the structure of Venus's crust, i.e. its tectonics. Probes sent to study the planet have returned data that has allowed for creating maps of the surface, but that has only heightened the problem, because it appears there is no plate movement (the large number of craters suggest there is no churning). But trenches have also been observed that are similar to those seen with Earth's subduction zones. Compounding the problem is the fact that all of the factors that go into defining how a planet's crust look are too complex to be modeled on a computer accurately. In this new effort, the researchers took a different approach—they created a physical model.

The model the team built was simple. They placed a quantity of finely ground sand in a bowl, added some water and then heated it from below. The team was not looking to recreate the entire Venus landscape, or even a portion of it. Instead, they were looking to explain the way that coronae (volcanic-tectonic looking features) are formed. Coronae are circular depressions with bulges in the middle surrounded by trenches.

In heating their bowl of mud, the researchers noted that a crust formed due to evaporation at the surface and then bulges formed as hot parts below the crust forced their way upward. Eventually, the material that was pushed from below (similar to Earth mantle plumes) pierced the surface and leaked out onto the surrounding surface (rather like a pie in the oven). As material leaked out, pressure was relieved, causing the bulge to deflate even as more material made its way through the puncture wound, which soon hardened, creating a small bulge in the center of a depression surrounded by trenches.

The researchers report that comparing their model to maps of Venus's surface depicting coronae showed them to be very similar, suggesting they may finally have solved the mystery of how coronae are formed.

More information: A. Davaille et al. Experimental and observational evidence for plume-induced subduction on Venus, *Nature Geoscience* (2017). DOI: 10.1038/ngeo2928

Abstract
Why Venus lacks plate tectonics remains an unanswered question in terrestrial planet evolution. There is observational evidence for subduction—a requirement for plate tectonics—on Venus, but it is unclear why the features have characteristics of both mantle plumes and subduction zones. One explanation is that mantle plumes trigger subduction. Here we compare laboratory experiments of plume-induced subduction in a colloidal solution of nanoparticles to observations of proposed subduction sites on Venus. The experimental fluids are heated from below to produce upwelling plumes, which in turn produce tensile fractures in the lithosphere-like skin that forms on the upper surface. Plume material upwells through the fractures and spreads above the skin, analogous to volcanic flooding, and leads to bending and eventual subduction of the skin along arcuate segments. The segments are analogous to the semi-circular trenches seen at two proposed sites of plume-triggered subduction at Quetzalpetlatl and Artemis coronae. Other

experimental deformation structures and subsurface density variations are also consistent with topography, radar and gravity data for Venus. Scaling analysis suggests that this regime with limited, plume-induced subduction is favoured by a hot lithosphere, such as that found on early Earth or present-day Venus.

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