Study proposes explanation for migration of volcanic activity on Mars

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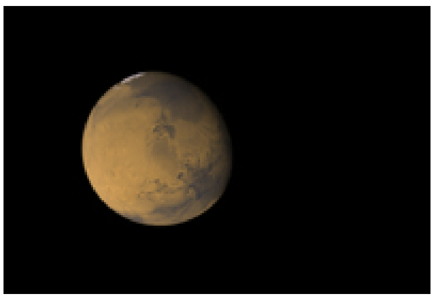

Picture a ball. It's an ordinary ball in every way except that it is roughly 4,300 miles in diameter and is moving through the cold of space some 35 million miles from Earth, and hurtling around the sun in just less than two Earth years. This is Mars.

After a first glance at the Martian surface, one may quickly notice two striking global-scale features. The first is the three-mile elevation difference between the northern lowlands and southern highlands, known as the Crustal Dichotomy, which got the name because the highlands and lowlands are underlain by thick and thin crust, respectively. The second feature is the vast area of high elevation with numerous volcanoes near the equator covering a quarter of the Martian surface, known as the Tharsis Rise.

For a moment consider the tectonic plates that make up the crust of the Earth, including the way they move around the planet, rising from below as molten rock and dipping back down under the surface to melt and complete the chain. Earth is the only planet known to scientists that has this mechanism for moving huge sections of the planet's surface great distances. This movement accounts for, among other things, the chain of land masses that form the Hawaiian Islands. As the Pacific Plate moves over a plume of molten rock, the islands formed, one after another.

This is not the case on Mars, which appears to have a single plate that encapsulates the entire planet like the shell of an egg. But Shijie Zhong, associate professor of physics at the University of Colorado at Boulder, thinks this shell-like plate might be moving, driven by a powerful, single plume of hot material affecting the area of the thickened crust of the Crustal Dichotomy. This would explain the migration of volcanic activity in the Tharsis Rise region of the formation of Tharsis, he said.

The possibility of a large-scale, horizontal motion of the outer shell of Mars or similar terrestrial planets and moons has not been previously demonstrated, Zhong said. Using three-dimensional numerical models to simulate the slow churning of Mars' interior in response to the cooling of the planet, Zhong shows in the Dec. 14 issue of *Nature Geoscience* that a single plume of hot material rising through the planet's interior led to the earliest volcanism in the highlands region of the Crustal Dichotomy, simultaneously triggering rotation of the outer shell. As the shell moved southward over the stationary plume -- like a sheet of cardboard over a candle -- it shifted the location of the volcanism and created the Tharsis Rise.

Zhong said a very specific set of circumstances had to fall into place to get rotation of the outer shell to occur. First, he said an area of thickened crust needed to form on the planet's surface. "It is almost universally accepted that the Crustal Dichotomy with the thickened crust in the highlands formed in the first few hundred million years of Mars' existence, and the Tharsis Rise was only formed a few hundred million years later," said Zhong.

Scientists know this because the Tharsis region is nearly devoid of impact sites, unlike the pockmarked surface of the Crustal Dichotomy. "You don't see so many craters," said Zhong. "It's been resurfaced."

Within this smooth environment, obvious features pop from the surface. Volcanoes, in a straight line, mark the Tharsis Rise. One, Olympus Mons -- a still active volcano -- reaches 15 miles into the Martian sky.

"All the faulting, tectonics and volcanics on Mars in the last 4 billion years happen here, in the Tharsis Rise region," said Zhong.

The second condition is the one-plume convection in the mantle. For the last 10 years, Zhong and his collaborators have studied physical mechanisms for one-plume convection to explain hemispherically asymmetric structures known to have existed for terrestrial planets, including the Crustal Dichotomy and Tharsis Rise on Mars, Supercontinents Pangea and Rodinia on Earth, and mare basalts on the Moon.

Zhong's theory is that a single plume of hot material is jetting from the core of Mars out toward the surface. Where it breaks through, on the Tharsis Rise, it causes volcanoes. But it is the affect that the rising, super-heated material has on the neighboring Crustal Dichotomy's thickened shell that makes the shell of Mars move relative to the underlying mantle and the plume.

"The mechanism I'm describing here is a path to unify the two major features of Mars: the Tharsis Rise and the Crustal Dichotomy," said Zhong.

Source: University of Colorado at Boulder