CLIMATE CHANGE INCREASING VOLCANIC AND EARTHQUAKE ACTIVITY

"The heat required goes far beyond anything we expect from human-induced climate change, but things like volcanic activity and changes in the sun's luminosity could lead to this level of heating," said lead author Adrian Lenardic, associate professor of Earth science at Rice University. "Our goal was to establish an upper limit of naturally generated climate variation beyond which the entire solid planet would respond."

Lenardic said the research team wanted to better understand the differences between the Earth and Venus and establish the potential range of conditions that could exist on Earth-like planets beyond the solar system. The team includes Lenardic and co-authors Mark Jellinek of the University of British Columbia in Vancouver and Louis Moresi of Monash University in Clayton, Australia. The research is available online from the journal Earth and Planetary Science Letters.

The findings may explain why Venus evolved differently from Earth. The two planets are close in size and geological makeup, but Venus' carbon dioxide-rich atmosphere is almost 100 times more dense than the Earth's and acts like a blanket. As a result, Venus' surface temperature is hotter than that of even Mercury, which is twice as close to the sun.

The Earth's crust -- along with carbon trapped on the oceans' floors -- gets returned to the interior of the Earth when free-floating sections of crust called tectonic plates slide beneath one another and return to the Earth's mantle. The mantle is a flowing layer of rock that extends from the planet's outer core, about 1,800 miles below the surface, to within about 30 miles of the surface, just below the crust.

"We found the Earth's plate tectonics could become unstable if the surface temperature rose by 100 degrees Fahrenheit or more for a few million years," Lenardic said. "The time period and the rise in temperatures, while drastic for humans, are not unreasonable on a geologic scale, particularly compared to what scientists previously thought would be required to affect a planet's geodynamics."

Conventional wisdom holds that plate tectonics is both stable and self-correcting, but that view relies on the assumption that excess heat from the Earth's mantle can efficiently escape through the crust. The stress generated by flowing mantle helps keep tectonic plates in motion, and the mantle can become less viscous if it heats up. The new findings show that prolonged heating of a planet's crust via rising atmospheric temperatures can heat the deep inside of the planet and shut down tectonic plate movement.

"We found a corresponding spike in volcanic activity could accompany the initial locking of the tectonic plates," Lenardic said. "This may explain the large percentage of volcanic plains that we find on Venus."

Venus' surface, which shows no outward signs of tectonic activity, is bone dry and heavily scarred with volcanoes. Scientists have long believed that Venus' crust, lacking water to help lubricate tectonic plate boundaries, is too rigid for active plate tectonics.

Lenardic said one of the most significant findings in the new study is that the atmospheric heating needed to shut down plate tectonics is considerably less than the critical temperature beyond which free water could exist on the Earth's surface.

"The water doesn't have to boil away for irrevocable heating to occur," Lenardic said. "The cycle of heating can be kicked off long before that happens. All that's required is enough prolonged surface heating to cause a feedback loop in the planet's mantle convection cycle."

The research was supported by the National Science Foundation and the Canadian Institute for Advanced Research.