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Astronomers May Have Found The First Evidence For Tectonic Activity On An Exoplanet

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Science
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On Earth, the heat generated from the radioactive decay of elements in Earth's mantle drives convection currents, pushing and dragging large plates

of Earth's crust around. When the plates collide, mountains form, and parts of Earth's crust are recycled into the mantle. When the plates are pushed apart, the partially molten mantle rises upward to fill the gap. Plate tectonics is an essential part of the cycle that brings material from the planet's interior to the surface and the atmosphere, and then transports it back beneath the Earth's crust. Tectonics thus has a vital influence on the energy and matter transfer that ultimately makes Earth habitable.

Until now, researchers have found no evidence of global tectonic activity on planets outside our solar system. A team of researchers led by Tobias Meier from the Center for Space and Habitability (CSH) at the University of Bern and with the participation of ETH Zurich, the University of Oxford, and the National Center of Competence in Research NCCR PlanetS has now found evidence of the flow patterns inside a planet, located 45 light-years from Earth: LHS 3844b. Their results were published in *The Astrophysical Journal Letters*.

LHS 3844b is an exoplanet orbiting the red dwarf star LHS 3844, discovered using the Transiting Exoplanet Survey Satellite. It orbits its parent star once every 11 hours, and its radius is 1.32 times that of Earth. It has a low albedo, indicating that its surface may resemble that of the Moon or Mercury.

"Observing signs of tectonic activity is very difficult, because they are usually hidden beneath an atmosphere", Meier explains. However, recent results suggested that LHS 3844b probably does not have an atmosphere. Slightly larger than Earth and likely similarly rocky, it orbits around its star so closely that one side of the planet is gravitationally locked towards its sun. One hemisphere of the planet is in constant daylight and the other in permanent night. With no atmosphere shielding it from the intense radiation, the surface gets blisteringly hot: it can reach up to 800 degrees Celsius on the dayside. Common rocks, like granite and basalt, melt at temperatures of 900 to 1,200 degrees Celsius. The night side, on the other hand, is freezing. Temperatures there might fall below minus 250 degrees

Celsius. "We thought that this severe temperature contrast might affect material flow in the planet's interior", Meier recalls.

Cool rocks are brittle and tend to break, becoming much more liquid-like as they heat up. The team ran computer simulations with different strengths of material and internal heating sources, such as heat from the planet's core and the decay of radioactive elements. The simulations also included the large temperature contrast on the surface imposed by the host star.

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"Most simulations showed that there was only upwards flow on one side of the planet and downwards flow on the other. Material therefore flowed from one hemisphere to the other", Meier reports. Surprisingly, the direction was not always the same. "Based on what we are used to from Earth, you would expect the material on the hot dayside to be lighter and therefore flow upwards and vice versa", co-author Dan Bower at the University of Bern and the NCCR PlanetS explains. Yet, some of the teams' simulations also showed the opposite flow direction. "This initially counter-intuitive result is due to the change in viscosity with temperature: cold material is stiffer and therefore doesn't want to bend, break or subduct into the interior. Warm material, however, is less viscous - so even solid rock becomes more mobile when heated - and can readily flow towards the planet's interior", Bower elaborates. Either way, these results show how a planetary surface and interior can exchange material under conditions very different from those on Earth.

As a result, the researchers suggest that LHS 3844b could have one entire hemisphere covered in volcanoes comparable to terrestrial volcanism as

found in Hawaii and Iceland. Here mantle-plumes form very hot lava with low viscosity.

"Our simulations show how such patterns could manifest, but it would require more detailed observations to verify," says Meier.

"For example, with a higher-resolution map of surface temperature that could point to enhanced outgassing from volcanism, or detection of volcanic gases. This is something we hope future research will help us to understand."

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