New model will help find Earth-like exoplanets

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Credit: University of St Andrews

A new category of planet, known as eggshell planets, which orbit distant stars, have ultra-thin crusts too thin to sustain tectonics and will be hostile to life, according to a new international study involving the

University of St Andrews.

A new computational model, developed by an international team of geologists based in the U.S., Switzerland, France and St Andrews, published in the *Journal of Geophysical Research: Planets* today will help identify whether newly discovered planets could support Earth-like plate tectonics adding a new geological dimension to exoplanet classification.

Dr. Sami Mikhail, of the School of Earth and Environmental Sciences at the University of St Andrews, said that "In effect, the new model provides a template with which to predict the nature of plate tectonics on exoworlds. You could say that we're hunting for a new Goldilocks parameter, but instead of the right temperature for water we want to explore the right conditions for plate tectonics."

Earth-like subduction zone plate tectonics are thought to be an important component of planetary habitability, and not just because they are the most Earth-like of all geological processes known to science.

The knock-on effects of plate tectonics are enhanced with volcanism and chemical weathering which have both endured for billions of years. These two factors, combined with the presence of some water, have regulated Earth's climate, and keep Earth habitable.

Dr. Mikhail added that "Earth is unique in the Solar System. However, there are only three other rocky planets—Mercury, Venus and Mars—and they are also distinct from one another."

"Astronomers have discovered more than 4000 planets orbiting other stars, known as exoplanets. Are any of these Earth-like? What does Earth-like mean? And how representative are the planets of our Solar System to the wider cosmos?"

The research team ran a large set of computer models to see how various combinations of planetary and stellar properties influence the thickness of a planetary body's outer layer. These predicted that worlds that are small, old, or far from their star likely have thick, rigid layers but, in some circumstances, planets might have an outer brittle layer only a few kilometers thick.

These worlds, named 'eggshell planets', might resemble the lowlands on Venus, and the term could potentially apply to at least three such extrasolar planets already known.

The outer layer of a rocky planetary body is generally rigid and behaves in a brittle manner. The thickness of this layer is important in governing numerous aspects of that body's geological character, including whether it can support plate tectonics and even retain habitable conditions at the surface.

Factors inherent to the planet, such as size, interior temperature, composition, and even climate affect the thickness of this outer layer, but so too do factors specific to the host star, including how luminous and far away it is.

The study considered several factors, including the size of the exoplanet, the distance from the host star, the surface temperature, and the internal temperature.

The team found that the surface temperature was more important than all other factors—including the internal temperature of the planet.

The team found that some known exoplanets should have unexpectedly thin crusts, which they termed 'eggshell planets'. These planets have brittle crusts of only one kilometer in depth, whereas Earth and Mars are crusty down to depths of 40 and 100km respectively.

The team believes the model should be used to predict which exoplanets are given telescope time for planned and future investigations that aim to determine the chemistry of the atmospheres around a given exoplanet, in the quest to find evidence of active geochemical processes and signatures left by putative biology beyond our Solar System.

More information: Paul K. Byrne et al, The Effects of Planetary and Stellar Parameters on Brittle Lithospheric Thickness, *Journal of Geophysical Research: Planets* (2021). DOI: 10.1029/2021JE006952

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