Extreme water: Aggressive behaviour of water in the Earth's interior

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Earth is the only known planet that holds water in massive quantities and in all three phase states. But the earthly, omnipresent compound water has very unusual properties that become particularly evident when subjected to high pressure and high temperatures.

In the latest issue of the *Proceedings of the National Academy of Science* (*PNAS*), a German-Finnish-French team published what happens when water is subjected to pressure and temperature conditions such as those found in the deep Earth. At pressures above 22 MPa and temperatures above 374°C, beyond the critical point, water turns into a very aggressive solvent, a fact that is crucial for the physical chemistry of Earth's mantle and crust.

"Without water in Earth's interior there would be no material cycles and no tectonics. But how the water affects processes in the upper mantle and crust is still subject of intense research", said Dr. Max Wilke from the GFZ German Research Centre for Geosciences, who carried out the experiments along with his colleague Dr. Christian Schmidt and a team from the TU Dortmund. To this end, the research team brought the water to the laboratory. First, the microscopic structure of water as a function of pressure and temperature was studied by means of X-ray Raman scattering. For that purpose, the diamond anvil cells of the GFZ were used at the European Synchrotron Radiation Facility ESRF in Grenoble. Inside the cell, a very small sample of water was enclosed, heated and brought to high temperatures and pressures. The data analysis was based on molecular dynamics simulations by the GFZ scientists

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"The study shows that the structure of water continuously develops from an ordered, polymerized structure to a disordered, marginally polymerized structure at supercritical conditions," explains Max Wilke. "The knowledge of these structural properties of water in the deep earth is an important basis for the understanding of chemical distribution processes during metamorphic and magmatic processes." This study provides an improved estimate of the behavior of water under extreme conditions during geochemical and geological processes. It is believed that the unique properties of supercritical water also control the behavior of magma.

More information: Sahle, J. et al. (2013) Microscopic structure of water at elevated temperatures and pressures. *PNAS*. www.pnas.org/cgi/doi/10.1073/pnas.1220301110

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